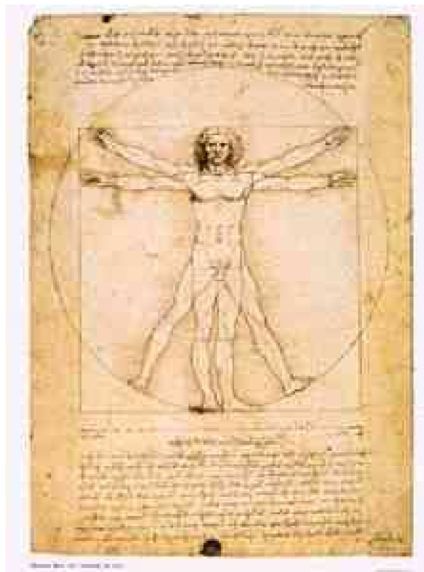
Information: A Fundamental Construct

Robert B. Allen



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Dedication

Acknowledgments

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Photo and Figure Credits

(to be completed)

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Information

Figure 1.1: Representation and reality[8]. (check permission) (redraw)

1.1. Information and Representation

1.1.1. Information tells us about the World

Information tells us about the world. It helps us interact with others, make decisions and perhaps entertain us We may learn about the world from direct observation. I may see that you're wearing red shoes today. Or, we may learn about he world from other people. For instance, we watch the television to find out who won the big game. Or, we might ask a friend "Where are my shoes"?

Information also helps people work better. It helps a farmer find best practices for growing crops and it helps an office worker keep in touch with colleagues. Information is critical to significant decisions ranging from health care to international policy.

Information can be personal or an ideosyncratic, or widely applicable to all human beings. It can be used immediately and lost or stored and accessed for later use. It may be stored in books, in databases, or in photos for years before it accessed. Information necessarily involves a model to organize and interact with it. Representation as structure vs function.

1.1.2. Representations and Abstractions

Representations go hand-in-hand with information, they hold the information. They are abstractions with filter out details. We take an expansive view of the scope of information. We do not make the usual distinction between data sand information. Rather, than making a simple binary distinction we propose that such information is evaluated in many different ways and that it's best to consider the variety of techniques separately. Because information helps people to make predictions about their environment, it is natural to develop systems for them to organize, access, and use information. Representations are used for search engines, planning, problem solving, and design.

Representations hold potential information. Representation is the logical content but by our definition information reflects the world in some way. Representations differ greatly in their completely, in their stability, and in their accessibility for human inspection and understanding. A representation captures some aspect of the world as an "abstraction". Fig. 1.2 shows stages in the development and use of a representation. Every representation is accompanied by techniques for using or reconstructing its content, and the "model" is the combination of the representation with those routines.

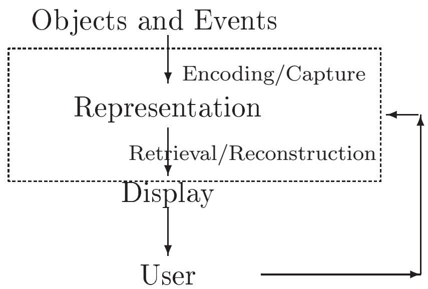

Figure 1.2: The components of a very simple information system. Information processing occurs both during encoding and during retrieval. The box shows the "model" which is the combination of the representation and associated information processing.

Every representation leaves something out. Thus, there may be a "representational bias". Placing items into a category that is not a perfect fit creates representational bias. That is, the representational system affects what is captured. The properties of the category are assumed to belong to that item. Alternatively, important events which do not fit into any category may simply be ignored (4.3.0). Some information which does not fit neutrally into the representation. It may not come packaged the way we need it, it may be squeezed into categories into a category where it doesn't fit, or may simply be lost. Moreover, categories are not always useful; people can over-generalize.

Indeed, the need for the distinction between categorical and numerical representations is debated. Categorical representations are essential for symbolic processing but numerical processing could approximate traditional categories. Still others emphasize processes. Even sequences of DNA can serve as representations.

Static Representations

Categories are abstractions. Mathematical functions are also abstractions. The points in the graph on the left of Fig. 1.3 are well described by a straight line.

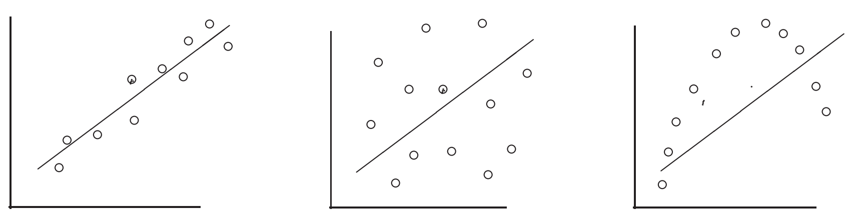

Figure 1.3: A straight line can be an effective representation to describe a set of data points (left). However, the line is less satisfactory if the points are scattered (center) or if a curved line may be a better representation (right). A representation that fits curved lines will be more complex.

Math and logic may be thought of as meta-representation frameworks. Mathematical equations are one type of representation. One basic distinction is between discrete (symbolic) and continuous representations.

Representing and Modeling Events, Sequences, and Processes

The terms representation and model may be used interchangeably. We make the distinction that a representation is static while a model is dynamic or, at least, is used to describe a dynamic process. A computer program or simulation may use the model to generate a result for a given set of conditions.

Events and sets of events. Process models. Knowledge as an embedded process. Procedures (such as recipes) programs, and simulations.

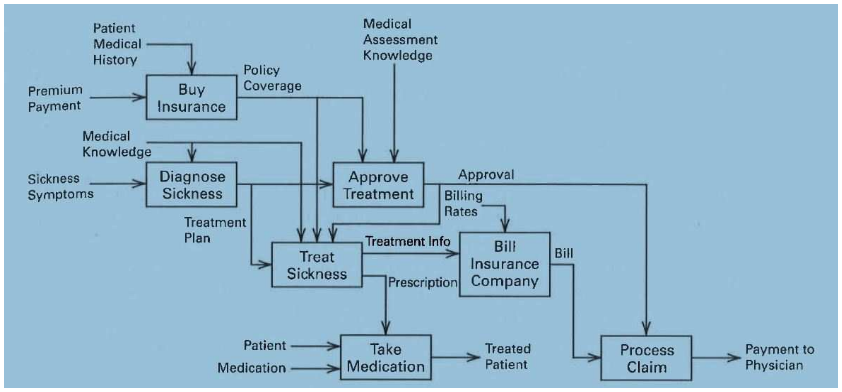

Figure 1.4: Modeling tools may also be used to complete specific tasks without emulating a natural processes. (check permission)

Ingredients	**Directions**
$2\frac{3}{4}$ cups all-purpose flour 1 tsp. baking soda $\frac{1}{2}$ tsp. baking powder 1 cup butter, softened $1\frac{1}{2}$ cups white sugar 1 egg 1 tsp/ vanilla extract	**Step 1.** Preheat oven to 375 degrees F (190 degrees C). In a small bowl, stir together flour, baking soda, and baking powder. Set aside. **Step 2.** In a large bowl, cream together the butter and sugar until smooth. Beat in egg and vanilla. Gradually blend in the dry ingredients. Roll rounded teaspoonfuls of dough into balls, and place onto ungreased cookie sheets. **Step 3.** Bake 8 to 10 minutes in the preheated oven, or until golden. Let stand on cookie sheet two minutes before removing to cool on wire racks.

Figure 1.5: Example of a procedure. In this case, a recipe for cookies. (check permission)

Accountability for the processes from sources such as organizational control, professional oversight, legal restrictions, and political processes.

Modeling as description or modeling as prediction. A process can store (or encode) information if it causes actions to be more effective. Presumably, there is necessarily a limited context in which a model applies. The ability of a model to match complex activities depends on how well the representation and processing match the task.

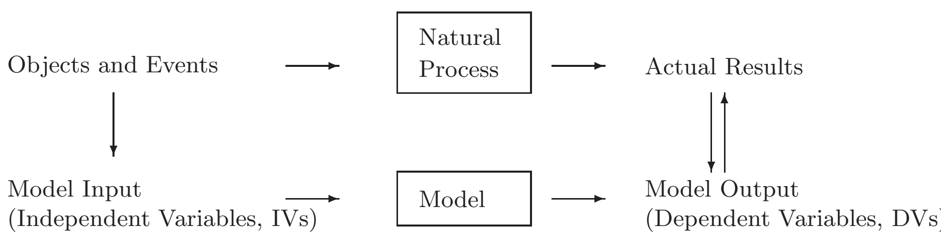

Figure 1.6: A simple model may emulate a natural process. Given the same input (the IVs), the output of a model (i.e., the DVs) should match the output of the natural process it is emulating.

There are many possible features on which to focus so the first step is the identification and selection of features.

Simulations as information resources which need metadata. The actual results become a goal or a target. Nonetheless, these models reflect natural situations. model may be abstracted and used to generate new responses for situations beyond those from which it was originally developed. Many of these environments and systems are too complex to model accurately, and many details are lost. It is helpful to develop several related models, each of which specializes in different aspects of the same task. Later, we will consider applications of models such as student models, domain models, and task models. For each model, there may be multiple levels of goals or targets and these may even conflict with each other.

Abstractions of Processes

Any representation can be considered an abstraction, it leaves out details. However, the idea of abstraction usually refers to increasingly general systems for solutions to handle a family of related situations. Tools for developing such procedures and processes. Abstraction of properties. Abstraction of processes. Abstraction of behavior. Workflows are instances of process abstractions.

1.1.3. Structure, Languages, and Context

Information Structure and Information Architecture

Information architecture is a broad term which suggests a design plan for the structure and accessibility of information. This involves aspects of the layout and the conceptual structure (6.3.5, 7.3.1). Typically, the information architecture applies across and help to provide continuity to an entire web site. Wireframes as schematics for a page and site. Wikipedia as conceptual organizing system.

Structure is broad but essential. We have already seen examples of information structure in taxonomies of classes but they many also be organized by rote systems such as alphabetical order.

Another common type of information structure in based on attributes. Tables present attribute values for instances of a category. Many of these structures are used in visualization (9.6.5, 11.2.5). There is a challenge of matching the presentation structure to the conceptual structure. There are multiple structures. Intentional structure versus derived structure. Furthermore, structure can support interactivity. Visualization (11.2.5). Hierarchies.

Building intranets and doing enterprise content management. Implement lifecycle.

Natural Languages

Natural languages, those languages used by human beings, combine symbols in a complex structure. Compare the sentence “The robber was described as a tall man with a black mustache weighing 150 pounds” with “The robber was described as a tall man weighing 150 pounds with a black mustache”. In the first sentence, common sense aside, the structure suggests that the robber’s mustache weighed 150 pounds. The second sentence, composed of the exact same words, conveys a more plausible, though perhaps less amusing, meaning (6.2.3). Structure, especially that of a natural language, is referred to as “syntax”. Syntax is contrasted with “semantics,” or meaning.

Language allows people to communicate complex information. At the level of culture and society, language and writing are related to the development of complex social organizations that are composed of semi-autonomous units coordinated for a goal. Symbols may be combined into larger meaningful units. Sometimes, the composition of symbols simply modifies the original and sometimes it creates a much richer meaning such as discourse, explanations, and narrative. Convseumersation as a model for interactivity.

Understanding

Understanding the *Dilbert* cartoon in Fig. 1.7 seems easy, but to even begin to understand this cartoon, the reader must know that the speakers are in an office, that the man in the suit is the boss, that networking is a mysterious art to the layperson, and that rodeos are held in places where there is hay. In short, without the proper context, a reader would have trouble even understanding this cartoon, much less finding it funny. Beyond what is covered in the representations. Not everything is in words. Pragmatics. Discourse macro-structures.

Individual words (or symbols) have very little meaning in isolation, rather, their meaning comes from their relationship to other things. A smile may indicate a greeting in one context and irony in another. When a situation is described by a sign or a set of symbols, many of the subtleties of its context are

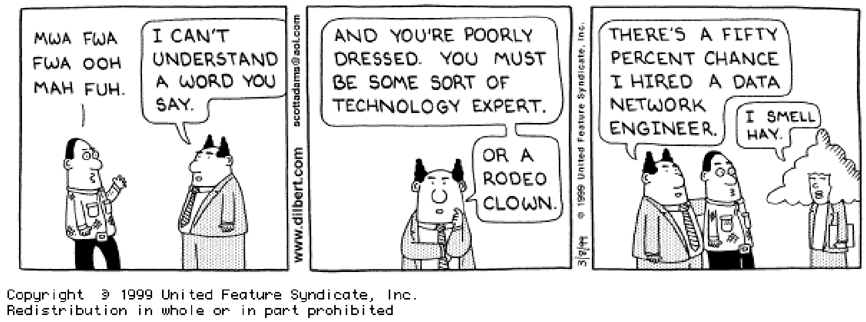

Figure 1.7: Note how much context must be inferred to understand the pictures. (redraw)(check permission).

lost. Consider how a personal photo seems hollow in comparison to the original event or meaningless to a stranger; that is because much of the context is missing. However, by its nature, context is difficult to represent accurately. User engagement with information resources and making meaning.

Understanding can measured by the ability to behave and respond appropriately in novel situations.

1.1.4. Concepts, Signs, and Symbols

Concepts

Concepts are the units of thinking. They are often related to words but they not map directly to individual words (Fig. 1.8). Concepts model could be similar to category prototypes (2.1.3);

As units of meaning, concepts are Meaning, semiotics, and signs. Relationship to belief systems (4.5.0).

Two senses of conceptual models. As described above, models attempt to represent some process in the world. Some models are physical (e.g., an airplane in a wind tunnel) but other models are purely conceptual. Conceptual models are used for description and design. For instance, data models (3.9.0) are used to describe databases. UML and OO modeling for conceptual models. Even equations. But, these are discrete models based on entities. Representing semantics rather than surface level. Conceptual-dependency theory.

Implicit conceptual models. Belief systems. Navigation. Discourse communities.

Signs and Signals

On one hand, it's obvious that a picture is not the same as the object it represents. On the other hand, we may not make that distinction clear. Semiotics. Graphical semiotics. For instance, maps (9.10.5) rely heavily on the relationship of symbols to physical space.

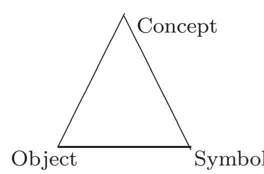

Figure 1.8: here is a view of the relationship of symbols, objects, and concepts. Meaning triangle (adapted from Sowa). In this viewpoint, symbols are distinguished from Concepts. However, other models do not propose such a strong separation of concepts from symbols.

Strctured Descriptions

Descriptions of information or physical objects.

1.2. Interactivity

When a person interacts with an information system by making a query or by following a hyperlink, they retrieve resources that are presented by the system, combination with other resources.

1.2.1. Interacting with People and Computers

Information behavior later. Interactor's model. Experience management not just for entertainment but also for learning and therapy.

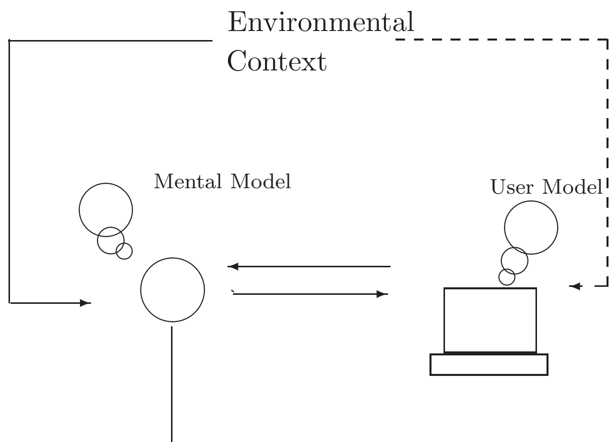

Figure 1.9: In a conversation, each participant between a user and an information system. The user and information system may tailor their responses to each other. Moreover, they may be affected by the environmental context. We would say the user has a mental model of the computer and that the computer has a user model. (smaller)

Speaker A	**Speaker B**
How do I get to Berlin?	
	You should take the 10 o'clock train.
Do I need a passport?	
	No, not anymore.

Figure 1.10: Interaction with an information system may be viewed as a type of dialog. Here we could imagine that Speaker B was natural language interface. Beyond verbal interaction, all types of interfaces need to have properties of a dialog.

The sequence of the interaction.

People interact with information all the time. Most of this information is routine but some types of information are critical. People may work hard to get the information they need. This can be interacting with information systems but it can also be interacting with other people. Furthermore, individuals and groups spend a great deal of time organizing information. Task-oriented versus leisure-oriented information behaviors. There are many aspects of information behavior and information use beyond information retrieval which we consider in other chapters.

Mixed initiative dialogs. Virtual events. Rendering speed.

A lot of what people do is social. Information is the glue that makes human social interaction unique. Language use is instrumental. To varying degrees, people often try to take advantage of situations.

When two people interact, each forms a model of the other and uses that model to interpret what the other means. One person may come to understand the other person's sense of humor, and when they are joking and when they are not. Indeed, this model formation is a property of all mutually interactive systems including people interacting with computers. Human beings have developed language as a system to transmit information from one person to another. The key turning in the lock to announce the mother coming home is a good predictor of her arrival, but it is not intended to announce the arrival; that is, she does not intend to use the sound of the key as a signal of her arrival. However, the mother might call the child's name or say "I'm home." That is an intentional, direct transmission of information through language. For language to communicate information successfully, there must be agreement about the meaning of symbols. Although this agreement is largely defined by the arbitrary assignations of meaning to words or phrases, as may be defined in a dictionary, agreement is also based on shared experiences, including cultural expectations and education. A message such as "This is the end of the line" may mean one thing to the sender and something entirely different to the recipient (Fig. 1.11). Social systems are extremely complex and can be adaptive.

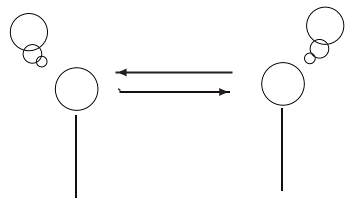

Figure 1.11: Communication is an exchange of information between people, but it does not result in both participants having exactly the same interpretation. One part of the interaction is consideration of the motives of the other participant in the interaction.

Mobile phones minimize the possibility of getting away from work. Timing and nature of work.

Argumentation, social media, and interaction.

Social Rules and Norms Norms Self presentation constrained by norms Norms and conversational maxims. We describe the conscious violation of norms for gain as gamesmanship.

1.2.2. Discourse and Narrartive

We described language briefly. Doing things with language.

Tasks, work, activities. Explanation, narrative, argumentation, and The focus in on what is conceptually meaningful rather than what is easily structured and manipulated.

Genres.

Indeed, narrative seems to be a way that people analyze the world. Narrative stories. Events and processes. Narratives are a way of organizing the world. Narrative. Causation. Building conceptual models. Stories and indicators of what is important to people – an indicator of a essential gist. Representing characters. Drama and cyber-drama (11.5.3). Dynamic storytelling.

1.2.3. Information and Social Organization

Information is interwoven with social interaction; the development of information systems affects the development. The exchange of information is a fundamental human activity. The shading and timing of that information exchange for personal benefit is also typically human of complex social organization (Fig. 1.13). The importance of information in modern society is evident in the many information-intensive social institutions such as schools and libraries as well as the prominence of information services in government. Science is a set of procedures for generating knowledge has shaped our technological society. Similarly, the ease of collection and dissemination of large amounts of data greatly increases social complexity. Social needs help determine the ways information systems are developed so that there is a socio-technical interaction. Open Society.

An information-based society depends on being able to trust the work of professional journalists, records keepers, and scientists.

Constraints and the Strength of Weak Ties

If there are enough weak ties, cumulatively they may exert a strong effect. Network of connections. Biological bases. Situatedness of social interaction. Context. But, this does not imply that they are arbitrary. They may be viewed as complex systems. Numerical models are better for describing constraints and probabilities. Processes from personal decisions to language comprehension to economics may be described as balancing complex constraints.

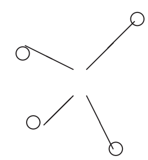

Figure 1.12: Constraint network. (redraw) (check permission)

Culture

The way that information is presented and used can have lasting impact on both the actions of a societal group and its consciousness. Fables can provide simple and easily remembered lessons that become part of society's collective cultural heritage. This can be contentious because of the difficulty of defining culture (5.8.2) and cultural artifacts. Culture as shared understandings. Culture is most closely associated with aspects of fundamental human needs.

Information systems have indirect effects on the user and the user's organization or social context. Ambiguities in what aspects of culture need to be preserved. Collective memory.

Culturnomics. Indicators of culture.

Meme.

Information technologies and systems interact with human culture. Writing and civilization developed simultaneously. Papyrus allowed early libraries to develop, the transistor radio encouraged the development of rock-and-roll, and the computer and computing networks, among many other effects, have created video games and made long-distance communication easy. Stored information helps people to make good predictions.

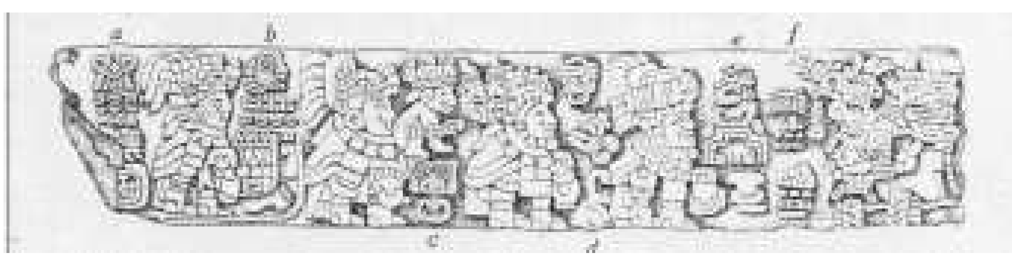

Figure 1.13: Written language is associated with the development of complex social structures. In this case, written Mayan, accompanied urban development in Central America. (check permission)

Social Policy

Policy statements guidelines for shaping society. Freedom of information is interdependent with market economics and democracy. Indeed, information is almost always developed to facilitate meeting human needs. In a social situation, essential information about the situation is obscured either by sheer complexity or by intentional manipulation of appearances. This tendency may be corrected by transparency and disclosure. Cultural factors and freedom of information. Behavioral insights into framing policy.

1.2.4. Planning, Design, and Designed Environments

Models capture and then may be used to reproduce some aspect of the world. However, models can also be used for generating novel scenarios. This can be through design. Design is seeking a preferred state [11]. Handling complexity with design. Creating structure and processes not just artifacts. Designing individual features versus seeing the whole. Design as an essential part of engineering (9.4.4). Secondary design (reuse for an unexpected purpose). Ambient design incorporates technology into the users environment. For instance, a colored light in your home might indicate the outside temperature.

Figure 1.14: Maya animation Tool. (check permission)

Abstractions focus attention on specific features. but in other regions they can also lead to poor outcomes. Over-reliance on one set of conditions may lead to disruption when conditions change. “Design continues in use.” Practice-base design. Manipulate, build, and apply information for physical objects. Social-technical systems. Creating artifacts and environments for collaboration. Collaborative design activity (3.8.0).

Coordination. Articulation.

1.3. Systems

Many different types of systems. Static versus adaptive systems. Goal-oriented systems.

1.3.1. Entities, Discrete Systems, Sub-systems, and System Analysis

General systems theory. Circulatory system, Respiratory system. Systems and processes interactions among the components. Complex environments may be modeled as systems[15]. There could be environmental systems, social systems, and medical systems. A system is a representation that integrates individual components and coordinates the interaction among these components. People often fail to understand the complexity of systems. This complexity amplifies the tendency to focus on details. In many cases, the person should focus on analyzing the interplay of factors. Systems may be entirely self-contained; these are called closed systems. By comparison, open systems interact with their environment. While it possible to understand the behavior of complex systems when the environment is relatively stable, by the very definition of open systems, it is always possible that the environment will change and the system will react in very unpredictable ways.

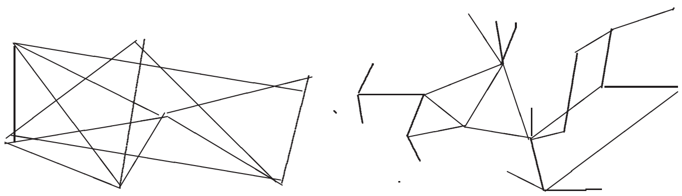

Figure 1.15: A closed system (left) has clear boundaries whereas an open system (right) interacts and merges into its environment. A organization situated in society is an example of an open system in which the external forces of the society affect the organizational processes. (check permission) (redraw)

Systems can be often decomposed into sub-systems. The human body is said to have a circulatory system, a reproductive system, a nervous system, and a respiratory system Though, the boundaries between these sub-systems are not always very clear. Systems use information for control but more broadly, many systems process, store, and allow retrieval of information. System analysis attempts to determine the components and relationship of the components of systems. Systems analysis is applied for requirements specification (7.9.1). Describing and re-designing systems. This may include attempts to develop models of the organization.

Systems as flows and procedures. System analysis is the study and description of systems which is widely used in organizational design and change. Yet, most system-analysis models do not consider non-linearity.

Control Systems and Adaptive Systems

Control systems which respond to and provide information about other parts of systems are common in many systems.

Information may be used for automated process monitoring and adaptation. Simple notion of control from a signal. The information may signal when to move to a new state or the basic model has simple feedback with a controller (Fig. 1.16).

It is common for such systems attempt to attempt maintain current conditions (i.e., homeostasis). An example is that people eat when they are hungry presumably with the goal of keeping their blood sugar stable. In traditional control theory, this is known as a control point. Another example is a thermostat. In a thermostat there is a set point - a target temperature. In systems without such targets, it's possible for the system to run out of control. Cybernetics and mechanisms of control [16]. Traditional view of feedback controls a single parameter but with computing systems, the controller itself can be modified. Fig. 1.16 shows one adaptive element (left) and coupled adaptive elements (right).

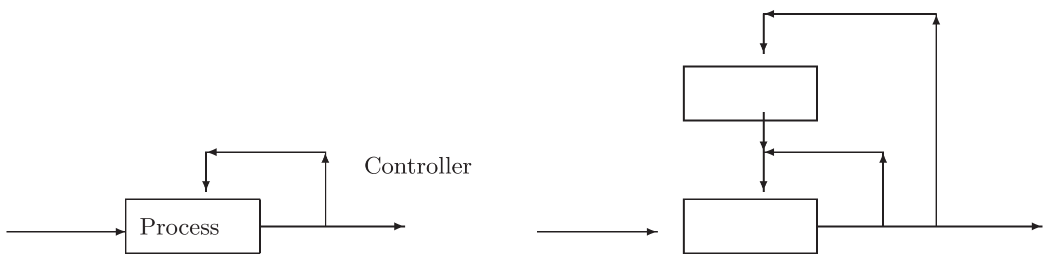

Figure 1.16: Feedback uses the output of a process to affect how to control that process. In simple feedback systems such as a thermostat, the controller has a highly predictable control function. However, many complex systems have adaptively at many different levels. One way that might happen is with a double loop model as shown on the right.

Dynamical Systems

Dynamical systems (-A.10.2). Feedback models such as those in Fig. 1.16 allow only limited adaptation. Beyond simple adaptation, learning is a change in a representation. This may be through a conscious process of knowledge discovery. Or, it can be more spontaneous. The information which has been received is captured by the representation. Learning requires an adaptive representation. Some models are adaptive; they adjust representations and processes to match changing conditions (Fig. 1.17). By comparison to most adaptive systems, human learning is particularly complex and people seem to have multi-layered and highly adaptive representations.

In some cases, two complex systems or subsystems interact with each other. When this interaction changes both of them, they are said to be co-evolving (Fig. 1.18).

1.3.2. Complex Systems

Many systems and very complex with many feedback loops. Some of those will eventually reach an equilibrium while others will not.

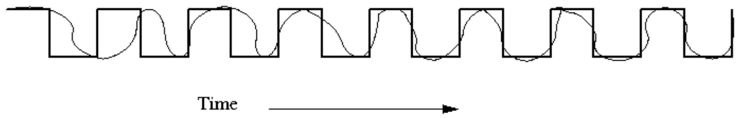

Figure 1.17: Imagine a system that produces a regular pattern (dark line) across time and a model that is trying to adapt to it (light line). The model will be successful at matching the target only if it has an adequate representation and learning algorithms. In this example, by the end of the sequence, the model seems to have learned the phase but has trouble matching the sharp angles of the original pattern.

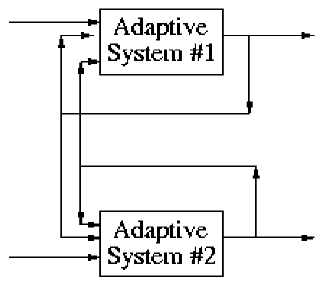

Figure 1.18: Co-evolving systems.

Complex systems can survive in equilibrium for long periods. In other cases, they are notoriously unstable[12]. But, even among complex systems, there are different levels of fluidity.

Complex systems typically are non-linear models which show emergence, that is they show a sudden shift to a new rich structure. An emergent property is one which is not readily predicted from the lower-level elements.

Complex systems may hit a tipping point. Attempts to control complex systems can lead to unintended consequences. Risk that complex systems may fail catastrophically.

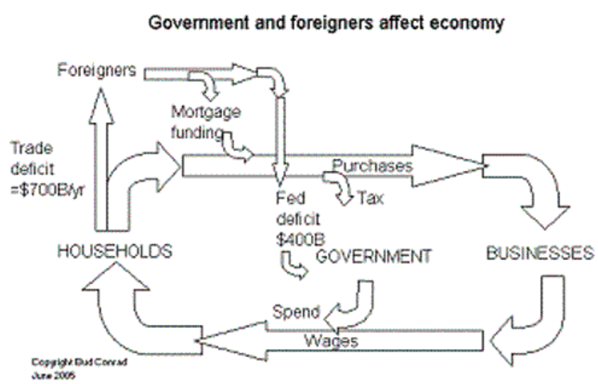

Figure 1.19: A small example of complex system. Complex systems have many feedback loops and non-obvious behavior. Indeed, these systems behave like multi-loop feedback mechanisms. They adapt in a way that maintains the overall stasis; but when change occurs, it is precipitous. (check permission)(redraw)

Simulation and prediction.

Agent-based models for psychology, sociology, alife.

Emergent structures.

1.3.3. Self-Organizing Systems

In some cases, very complex and highly structured systems seem to arise spontaneously where there is no central control. Coordinated group behavior such as packs and flocking (Fig. 1.20). Three rules of flocking[9]: Separation, Alignment, Cohesion. Human society itself may be seen as a complex adaptive system but it is extraordinarily complex and adaptive.

Figure 1.20: (left) Swarm intelligence can be seen in the coordination of flying bats leaving a cave; although each individual is acting independently.‘ The entire group has creates a coherent structure. (right) Building by autonomous termites. (check permission)

More formally, we can say that some complex systems develop a stable equilibrium without external control. Other systems are completely chaotic and never develop a stable pattern. Fig. 1.21 shows a tube dancer which is a plastic tube placed on top of a powerful fan.

Emergent systems have high-level regularities which emerge from seemingly random patterns at lower levels. There are many examples. Culture and society are complex systems. Biology, economics, and even society itself are examples; typically, these structure incentives. But, many of these very complex systems are not stable. We can see evidence of this instability in the failure of the economic system. The may show chaotic behavior (-A.10.2). Further, the environment in which they exist may be changing. In other words, the structures are poorly defined and the data flow among them is uneven. Indeed, it is the nature of complex systems that they will eventually become unstable and fail[5]. Some complex systems can be self-aware and self-healing. That is, they monitor aspects of their status and can compensate. Self-replicating technologies.

Figure 1.21: Complex adaptive systems are like the “tube dancer” in that they are continually changing shape in ways that almost impossible to predict. The tube dancer has a fan under a nylon tube. As the fan runs, the dancer inflates and develops a shape but the fan isn’t strong enough to keep it totally inflated and it collapses eventually forming into a new, but related shape. (check permission)

1.4. Information Resources, Information Processing, and Information Systems

1.4.1. Information Resources

When information is captured and managed, it becomes an information resource. When the environment is stable, and the effective representations employed, information can help people adapt to new situations. When we save representations, they can become information resources. Because it is so useful and because it can be applied across situations, information can be collected and organized into information resources. Moreover, information systems are developed to manage and present the information resources. They are all supported by and must serve social needs.

There many different stimuli in almost any environment but some environments are particularly rich in information. Organizing activities. Organizing social groups.

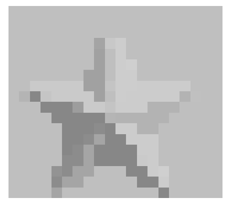

Figure 1.22: In information-rich environments, there and many possible choices and and many details to be considered about each choice. (check permission)

From captured representations to information resources. We distinguish between information representations and resources. Information resources differ most fundamentally in terms of their representations but they also differ in the ways the information is captured and the ways it used. Information resources include works such as documents, aggregations such as databases, distributed content such as neural networks, and model-based simulations. Publishing.

Types of Information Resources

Documents (2.3.1).

Repositories For any task, a single information resource such as a recipe and a book may be all that's needed. The ecology does not does not develop spontaneously but is based on specification and implementation of policies.

Information environments should support complex activities such as critical thinking, design, and science. These also introduce a new set of representational frameworks. The structure is an essential aspect of an information resource. Such organizational structures may range from hierarchical or data-flow models. By adding secondary representations such as summaries, links, and descriptions. The needs of users for information can be supported either by interfaces that allow the users to explore the available information, or by interaction with other people who may be able to help them.

There are pragmatic needs for information management. For instance, it is essential that a doctor's patient records are available in an emergency.

Description and access. Developing approaches for finding information.

Information systems manage sets of information resources. Resources evolve and, in fact, entire areas evolve (Fig. 1.24). So the information systems cannot be static. The policies for their management involves tradeoffs. Collections of objects have common descriptive themes. A simple collection may aggregate objects such as the sea shells picked up at the beach. However, more formal collections try to select objects; they might include a range of different shell types. Formal collections of information resources are managed by information institutions (7.2.1), and the items in a collection may be selected

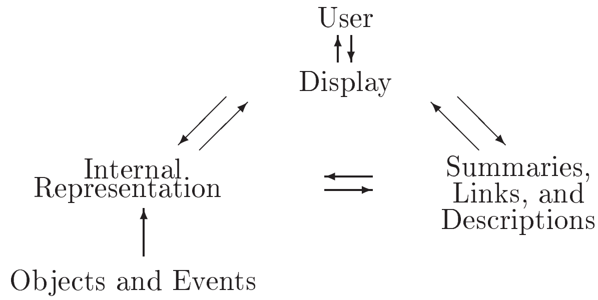

Figure 1.23: Related information resources are collected and aids like summaries, links, and descriptions are useful in retrieval of resources from those collections. Multiple representations.

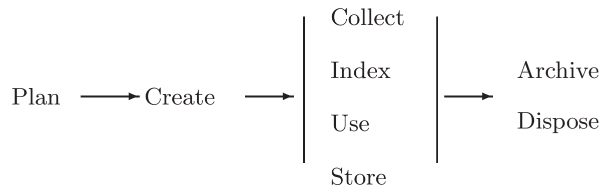

Figure 1.24: Information resources have a lifecycle which starts with planning and ends with disposal of the resource (though a small amount may be kept forever). In some cases, an old version is replaced by newer versions. In a broader perspective, parts of the older documents documents are reused and "lifecycle may be seen as a continuum.

with some common theme. A collection could consist of books by a certain author, or it may attempt to provide all the important viewpoints on a given issue. With regard to information, this means that collections attempt to provide a variety of perspectives on certain topics. A bibliography is a list of records that survey the issues surrounding a given topic, whether or not the collection actually has those records. Bibliographies are usually generated in response to specific user requests. They may be either "descriptive" or "systematic". Tagging the structure of documents with XML.

Beyond ensuring accuracy, an information system should provide useful content; thus, the information manager must understand the needs and capabilities of the user population. Content in an information system is often associated with specific tasks; when those tasks are complete, the content can be discarded. Even material that is not task-oriented becomes dated and should be removed. The lifecycle for content is illustrated in Fig. 1.24. The management of information content necessarily involves trade-offs and judgment about selection, access, organization, and preservation. It should also be recalled that while information resources can be managed with a lifecycle approach, those resources may well have value outside that what is normally considered the lifecycle[14].

1.4.2. Modeling Tools and Environments

Programming environments.

Reuse and interoperability. Interoperability at many levels. Levels of interoperability.

Applies to networks, Programming languages. Composable simulations. Services.

Agent models.

1.4.3. Information Behavior (Human Information Interaction)

How people use information. These include leisure reading (10.2.0) personal information management (4.11.0) and plagiarism (5.12.3). Cultural factors in information behavior. (5.9.1). Principle of least effort [17].

Information is valuable for people and they react to it. In some cases, those reactions are simple and predictable. In other cases, the reactions are involved. Information is integral to the completion of tasks. The information a person uses to complete tasks often consists of formal resources (e.g., journal articles, books) and in other cases, the information is derived from databases and email messages). An information system can adapt to a user's interests, abilities, and roles. That is, it develops user models and task-models. Beyond supporting access to specific resources. Some users are engaged in complex intellectual activities.

Figure 1.25: Boy reading. (check permission)

Questioning and Sensemaking

A type of interactivity. People are continually evaluating their environment (Fig. 1.26). Searching for simple answers. Searching for comprehension. This is a type of interactivity.

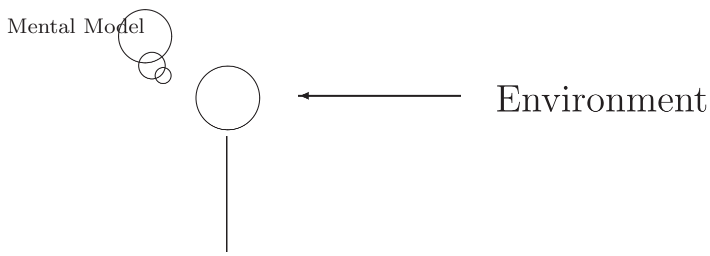

Figure 1.26: People actively interpret what is going on in the world based on their experiences. (Add "action")

Finding Information

A simple model is typical of most scholarly research in which a lot of background information is collected (Fig. 1.27). While these two models, focus on interaction with existing resources, information resources also include materials which are generated in the process of completing a task (Fig. 1.28). Such materials may be informal like as notes and annotations or relatively formal such as working papers. Understanding the tasks required of the user helps us to define information systems. This is very similar to the schematic for social interaction shown earlier and extended in Fig. 1.9. Some decisions, may involve extensive research ("look") while for others the person already knows the necessary information and doesn't need to acquire more. This model also describes collaborative interaction with information resources.

Figure 1.27: A very simple model for using information to complete tasks: $Look \rightarrow Decide \rightarrow Do$.

Figure 1.28: In still other cases, a significant information artifact is developed and the Developer may refer frequently to it.

Many systems for finding information.

Critical Thinking and Information Quality

Many types of inquiry. We need to worry about whether information is applicable within its profile. Emphasis on rationality. Authority. Quality from professional reputation standing behind it. Information security and assurance. Like the analysis required by organizational information systems (3.4.2).

History is presented in media. What do people accept as factual. Beliefs (4.5.0). The digital convergence means that it is increasingly easy to modify digital content. What do we trust? Users depend on the accuracy of content, whether it is news, scientific, scholarly information or official records or directions to the nearest restroom. However, there is a lot of incorrect information and often just plain distortion. Clearly, the picture in Fig. 1.29 is a fake, but other misleading information is well-disguised and intentionally deceptive. As consumers of information, we have to rely on the credibility of the source.

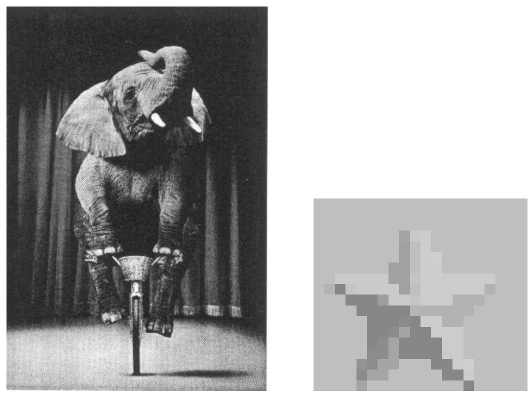

Figure 1.29: An obvious fake[2] (left) (check permission - HP) Other fakes are more nefarious (right) and may be the result of systematic dis-information efforts.

1.4.4. Information Processing

Extract and apply regularities. Information interfaces. Making effective interaction via understanding the context. Computation or information processing operates on representations. It can include the creation of representations and extraction of information from them. Indeed, the representations and algorithms for operating on them go hand-in-hand. Both required for the task to be accomplished. Human information processing is often more heuristic.

Waterfall process versus interactions with feedback into a knowledgenase.

Ideally, information can be generalized to situations beyond which it is collected. We can use such information to navigate novel situations. The representations and information processing techniques can be symbolic or numeric; that is, the representations can be comprised of symbols (e.g., language) or images (e.g., photos). When there are unstructured tasks with many possible outcomes, the synthesis of facts (i.e., inference) of information is often needed.

Classification, Recognition, and Recall

Classification. It helps to answer questions such as: “Is this person Bob Allen?” or “Is this car a Buick?” (2.1.1).

Recognition may occur as part of information capture or during retrieval. The identification of phonemes is a part of speech recognition systems (11.3.3). Recognition may simply mean identification or categorization. The opposite process is also found. Creating an instance from a model. Rendering. This is often useful for simulation.

Inference

Inference is the integration of information to reach a conclusion and is often a step towards action. Retrieval and inference. Inferences synthesize those fragments. If clear premises can be established, then logical rules can often be applied. However, it's often difficult to establish the premises so statistical inference must be used.

Even if we have an effective representation, we need to be able to operate on it. Information processing versus computing. An information system may "know" something (i.e., it is represented in the system) but not be able to retrieve it; this would be a "retrieval failure".

Types of inference: Deduction, Induction, Probabilistic, Statistical, Abduction, Defensible. Rules of thumb. Heuristics. Logic is one approach to inference; logic (-A.7.0) is a set of procedures for generating inferences from categories and attributes; one type of basic logical inference is the syllogism (Fig. 1.30). This type of reasoning is valid only if the category assignments are valid. A second type of inference is based on statistics or probability. We many infer that the sun will rise tomorrow based since it has risen every other day of our lives. Inferences made by humans are susceptible to cognitive distortions such attentional bias and poor ability to calculate probabilities. We will examine these models more systematically when we consider scientific modeling (9.2.0).

Assertion	If all animals breath and
Assertion	If Lassie is an animal
Inference	Then Lassie breathes.

Figure 1.30: When information is stored as attributes those attributes can often be combined to infer additional propositions. Inference may be logical or statistical. A syllogism is an example of deductive logical inference.

MHR interface. Automating simple tasks.

Analysis, Analytics, Data Science, and Informatics

Analysis involves extraction of many types of information and many inferences. The ability to collect and process large amounts of data makes huge difference in society. Large data sets Machine readable data. DOI for data sets. Existing metadata for scientific data. Linked and open data. Often integrated from different databases.

QUOTE Volume, velocity, variety, and veracity. Data collected from various sources can have different formats from structured data to text to network/graph data to image, etc. Veracity concerns the trustworthiness of the data as the various data sources can have different reliability. ENDQUTE

Exploring data. Continual cleaning and improving data. Data analysis platform. Unstructured data such text, audio, and video. Application of information science principles. Comprehensive information systems are now interwoven with many aspects of modern society. Thus, information management and use is now essential across many fields. Application domains for information management. Informatics. Domain specific applications for information processing and management. Domain specificity means that the data will be siloed and difficult to cross-reference.

Living analytics (5.10.1), Medical data sets (9.9.3), Business records (7.4.1), Scientific data sets (9.6.1), and Civic data (8.1.1).

Modeling complex systems. This often has a specific vocabulary system.

Medical informatics. Applications of information to a variety of domains. Chemical informatics. Human genomes project. Cancer genome. Chemical informatics. Community informatics.

Coordinating search across federated databases. Neuroinformatics framework. Standardized terminology for neural information.

Organizing the data deluge from sensors. Fig. 1.31

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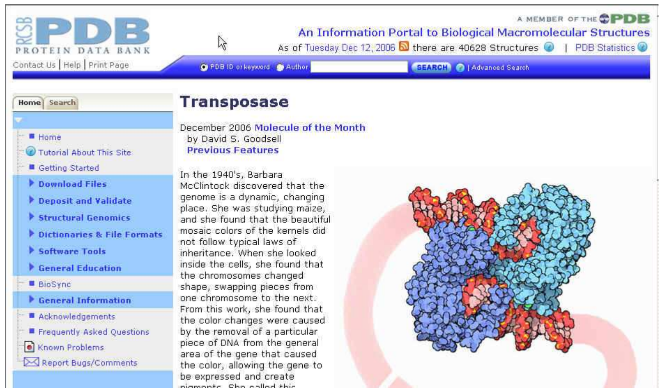

Figure 1.31: The Protein Data Bank (PDB) is a database with many facts about specific proteins. (check permission)

Visualization. Spreadsheet. Data mining. Informatics.

Figure 1.32: Large data sets have proven effective at forecasting everything from baseball to politics.

Data analysis organization. Coordinating with other organizational goals and with implementing the results of the data analysis.

1.4.5. Information Institutions and Professions

Scholarship

Stand somewhat apart from society to be able to make observations about it.

1.4.6. Information Systems and the Management of Information Resources

Variety and Use of Information Systems

Information systems process and manage information collection, storage, and delivery in order to serve the information need. Although the term "information system" is most often associated with organizational information systems, there are many types of information systems; search engines, collaborative systems, and databases. Information systems can be as diverse as airline reservation systems, digital libraries, Web servers, or virtual-reality environments. These types of systems add value to raw information in several ways: they make information easier to use, reduce noise, increase information product quality, increase adaptability, and save time and money [13]. We consider information systems more broadly than just those which serve businesses. Services science.

Some Canonical Information Systems

There are many types of information systems and sometimes they are not easy to disentangle and identify. Here we describe some common ones.

Databases Metadata bases information retrieval. Medical retrieval systems and GIS Systems. In some cases, those may include information processing. User interface for providing access. Information systems help information to show its greatest utility; they help people use information to direct their actions toward a desired outcome. To this end, it is helpful to consider one approximation of how information helps people to complete tasks. Given a goal, a person must *Look* for information relevant

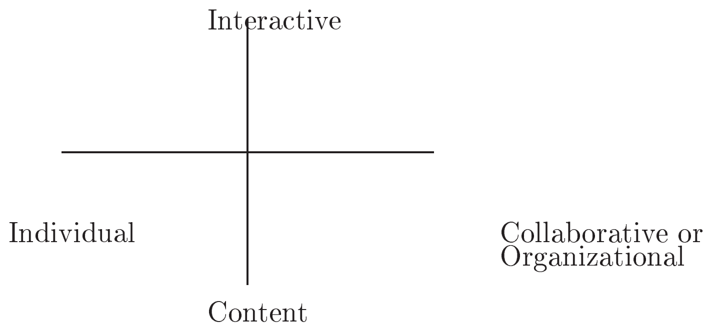

Figure 1.33: Dimensions of information systems.

to that goal and use that information to *Decide* on a course of action, which they then carry out, or *Do*. This may be summarized as *Look*→*Decide*→*Do*. For the completion of complex tasks, this sequence is often repeated as a cycle at various stages. More complex tasks interweave information and action at several levels (7.9.3). Where does the content come from? What makes the systems most effective?

Organizational Information Systems: Supporting and Modeling Reasoned Decisions Human interaction with information systems.

Decision Support Systems. BDI. Electronic records.

Organizational information systems Figure 1.34 must be coordinated with organizational goals and, thus, have complex management issues.

DSS	Decision support system
TPS	Transaction processing system
EIS	Executive information system
EKP	Emergent knowledge processes

Figure 1.34: Several types of organizational information systems.

The Web and Search The Web can be thought of as a framework for coordinating sets of information systems. In other-words as a common-use hypertext. Search and information retrieval systems.

Experiential Information Systems Movies, Games.

Metaverse. Mirror worlds.

Developing and Managing Information Systems

We have defined information systems broadly to include many approaches for providing information to people. An information system is more than a simple technology; it also consists of content and users. Designing, constructing or using an effective information system thus involves much more than simply writing a good piece of code or using the fastest computer; it requires all of these pieces, the task, the content, the users, and the system, to function as a coordinated whole. The following sections outline various issues for information storage and processing, use and impact, and content and system management. Developing a design.

When information systems are introduced or changed, they often disrupt existing practice. Making interaction easy. Indexing and user interfaces. Information resources should be easy to access and to use. Tools for access. Specifying the context in which an information system will operate. Services. Risks to information integrity.

The management of information systems and content should reflect the types of users and their needs. In addition to managing the information system should be distinguished from managing the content. To develop a useful information system, it is usually necessary combine human procedures and technology upgrades: detailed analysis of how the system will be used; a clear vision of the lifecycle of the entire system, as well as the content; audits and best practices guidelines; the incorporation of new technology; and wise information management (7.10.2). Systems also have a lifecycle (Fig. 1.35).

Figure 1.35: A simple model for the lifecycle of an information system. We will consider more complex development processes in later chapters. Note the similarity to other types of information systems.

The development and maintenance of a set of information resources, of the assignment of metadata, and of the underlying information system are often costly. A business model describes how these costs will be recouped. Among the most common business models are support for organizational activities direct payment (akin to a newspaper subscription), and public service (as in public libraries).

For an information system to be of value, the information that it contains must be managed. Decisions need to be made about what should be included, and also to whom the information should be available. Even when the system has been deployed, content often needs to be refreshed. Poor information management may result in information disasters[6] (Fig. 1.36).

> As NATO and the United States continue to deal with diplomatic fallout from Friday's Chinese embassy bombing in Belgrade, a senior U.S. intelligence official told Salon NewsNews that the CIA team in charge of choosing Yugoslav targets does not include any agents or experts with recent on-the-ground experience in Belgrade.
>
> Speaking on condition of anonymity Tuesday, the official said that no CIA officer with an up-to-date, walking familiarity with the Yugoslav capital was on the targeting team when China's embassy was mistakenly bombed Friday, killing three occupants and injuring 20 more. Nor, apparently, does the CIA have clandestine spotters in Belgrade helping verify targets picked from maps and satellite photos.
>
> The issue has taken on added gravity because the CIA has admitted it used a partially updated 4-year-old street map and "educated guesses" to select the target, which was thought to be a Yugoslav arms agency. In this case, the maps did not show that China had vacated its old property and built a new embassy elsewhere in 1996, even though American officials, from the U.S. ambassador to the semi-public chief of the CIA mission, frequented the embassy for events. The U.S. embassy in Belgrade was closed and its staff evacuated March 24.

Figure 1.36: One example of the problems caused by faulty information[1]. (check permission)

1.5. Infrastructure and Technology

While this text is about information content and people's interaction with that, it's clear that technology is interwoven and is a significant factor.

Interplay of technology with culture. e.g., electric guitars. Globalization.

Supporting infrastructure technologies. Complex logistics. Enabling the management of the power grid, the transportation network. Infrastructure.

1.5.1. Socio-Technical Systems

People affect technologies and technologies affect people. Socio-technical systems.

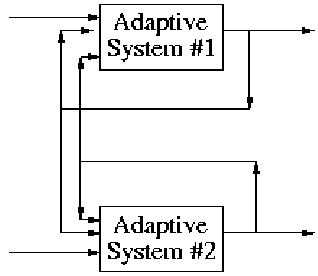

Figure 1.37: Socio-technical co-evolution.

1.5.2. Information Technology

While this text focuses on information systems rather than information technologies, it's worthwhile considering those technologies. Here, we use technology in the limited sense of hardware and software.

Mobility and Location Technologies
Repository Ecologies
Data storage, networking, metadata, analysis tools, institutional policies.

Coordinating sensors, information processing, memory. Furthermore, the system context needs to be considered. In the case of people, this would be the social environment. Sensors can report about the world without human observation (Fig. 1.38). Indeed, the proliferation of sensors has contributed to increased need for data management.

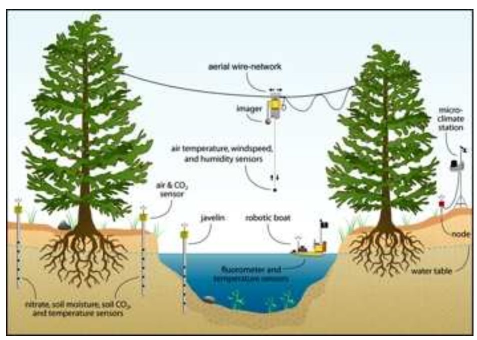

Figure 1.38: Sensors collect information from their environment. Here, a network of sensors monitors conditions in a forest. (check permission) (redraw)

Advances in technology also affect a system's viability. System development has become easier, and the systems can be more widely deployed. Certain elements of technology have also become much less expensive: Fig. 1.39 shows the change in disk prices as a function of time. Several other aspects of computers, such as the CPU, network speed, and display size are also changing rapidly. Indeed, this change has become predictable: the consistency of the change in CPU cycles was originally noted by the engineer Gordon Moore, so it is known as Moore's Law. This is pattern is driven both by technological developments but also by demand and economies of scale. Algorithms, Operating system. Cloud computing (7.7.2). Virtual machines.

"Half-life of facts".

Operating systems, network infrastructure, and systemic evaluations, or audits, can provide that security. In addition, standards complement infrastructure development and the improved infrastructure provided by hardware and networking is paralleled by greater standardization of content so it can be

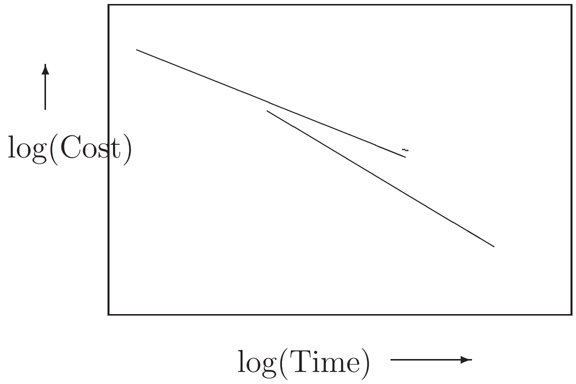

Figure 1.39: The cost per megabyte of storage keeps dropping (adapted from[7]).

exchanged readily. Not only are individual services able to operate, but they interoperate with other services more easily. Indeed, much of the success of the Web may be attributed to developing standards for exchanging content such as HTML, HTTP, and MIME.

Sensors primarily collect information (or data). Basic sensors don't process that information but pass it to a central processor to make inferences about it. The data from more complex sensor networks may be processed with sensor fusion in several layers.

Objects, XML, Java

1.5.3. Information Institutions and Infrastructure

Information is integral to a great deal of social complex social interaction. In a sense, it is the glue that holds organizations, communities, and even cultures together. Information is so important that large institutions for managing it have been developed. Balancing long-term needs of society for long-term interest in reliable information. Like all institutions these information institutions have routinized action. In this case, the routine helps to ensure the proper handling of the information. Given this central role, significant social institutions need to be developed. The way we identify and segment these institutions is itself a matter of social structuring (5.1.2). Institutions reflect legal, historical, and cultural traditions. Data management institutions ((sec:datainstitutions)).

Figure 1.40: One of the lions at the entrance to the Research Division of the New York Public Library. The reading room at the British Library.

1.6. The Language of Information

The concepts surrounding information are complex and inconsistently applied. Here, we discuss some of these ambiguities though we will encounter others throughout the text. This text has attempted to avoid taking strong theoretical positions. Rather, it emphasizes common phenomenon.

1.6.1. Data, Information, and Knowledge

We have adopted the simple definition of information as abstraction of the world that is held in a representation. Unlike most others, we don't start by making a strong distinction between data and information. Information is the content which fills models and representations whereas learning is a change in the structure of the representation. There are many other definitions of information[4]. In several ways, the representations are at least as important as the information which constitutes that information.

It is often claimed that there is a hierarchy from Data to Information to Knowledge, specifically, information and knowledge are said to include more context than data. However, the terms are used so inconsistently that the continuum is at t, only an approximation. Organization and structure are a type of information.

Data might include just a table of values whereas information and knowledge might be include a paragraph of text or knowledge in a person's head. Another dimension concerns the generality of the knowledge. Data or information is often about individual entities whereas knowledge more often concerns categories and classes. It is often thought to be part of a broader system. If that user realizes that they have a need for that piece of content, then at that point it ceases to be data and becomes information. The term knowledge is sometimes used to mean that an individual possesses the minimum amount of information necessary to accomplish a certain task, such as having the know-how to fix a flat bicycle tire[3].

Rather than trying to fit confusing terms such as ?data?, ?information?, and ?knowledge? it seems to be more useful to consider the way content is often processed. Distinctions may also be made about the context and richness of information but these three terms are used so loosely that they have lost most of their meaning (Fig. 1.41). Useful information and information quality. Attitudes as cognitive constructs. Complexity. Computing.

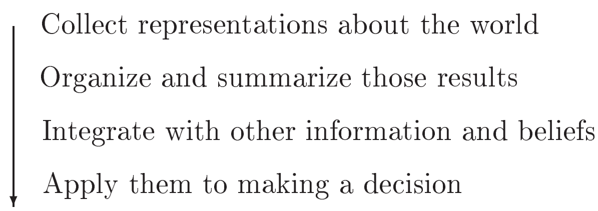

Figure 1.41: The information value chain describe important levels of activities for processing stored information. A great many services can be applied to information resources.

The simplest type of information is facts about the natural world which can confirmed and explained. By comparison, facts and constructs about the social interaction are generally much more subjective. We tend to have beliefs about such things. In fact, there is a lot of debate about what is real and what is epiphenomena given the fluid nature of social relationships. Because social systems are so complex and adaptive, it is difficult to make firm predictions about their behavior.

Information Defined by its Effect on Recipients

By the definition we have adopted, information is a property of the representation but one of the main principles for the DIKW approach, above is that information depends on its effect on the user. Indeed, the emphasis on the recipient is essential for personalized information services such as based on relevance. Potential information.

Information Reduces Uncertainty and Allows Accurate Predictions to be Made

A related definition of information is that it "reduces uncertainty". This is derived from Shannon[10] though we note several issues and implications. Information allows people to make effective predictions about the future. In this sense, information helps people to interact more effectively with our world, thus influencing the way we think and act. This definition focuses on the utility of information for a particular person; it has meaning because it helps a person construct their actions. The first, is that how we measure uncertainly. Shannon defined it in terms of bits (-A.1.1), but that is often difficult to apply in complex situations involving humans. A second difficulty is that although uncertainly may be reduced, that may not be mean the information is accurate.

If I believed somebody who told me that today is Tuesday when it is actually Wednesday, would we consider that information. There are several ways this puzzle could be addressed. Information may help a person to predict the future. Or, perhaps that information helps a person to make good decisions. Another important distinction is that information is a construct at the system level. Thus information as a non-physical interaction between two systems which results in a change of behavior of the receiving system.

Experiential technologies. What do we experience as reality?

1.6.2. Epistemology: Beliefs, Facts, Objectivity, and Reality

We generally think of a fact as a statement which conforms to perception of the external world. "This book is red." There are also fact based on definitions: such as " 2+2=4". There may also be abstract models: "Atoms are composed of protons, electrons, and neutrons". Even social definitions are included "Jane and Pat are married." In most cases, this is straightforward. However, it can be complicated when the observation of the external world is ambiguous or when the statements are about complex processes. Indeed, there is a long philosophical debate about the nature of the physical world and our perceptions of it.

How do we Know?

Knowing from direct sensation. Knowing from science (positivist). Knowledge in doing. In some cases, information may be embedded in procedures for getting things done.

However, we develop constructs beyond what is known by our immediate senses.

In general, daily life requires that we accept certain facts about our world; objects exist, we can affect the world around us, and we can gather data about that world. Truth, then, is congruence with the world. However, there are many ways that a statement can be confirmed in the context of world. In most cases, the statements are made in the context of a broad conceptual system such as a scientific or cultural analysis.

Even scientific "facts" aren't absolute. Historic facts (counter examples). But this is not to say that all social facts should be dismissed.

Disclosure of potential biases. Neutral viewpoint. Rather than attempting to determine an absolute truth about a situation "objectivity" is better thought of the practice or policy of avoiding overt personal references or personal interpretation to whatever extent that is possible. Rather, it objectivity can be thought of as following logical inferences and also of providing as many significant perspectives from many people in the population.

Journalism consists of policies which generally improve the quality and accuracy of news. Journalistic fairness rather than objectivity (1.6.2).

Rather than being objective in some absolute sense, journalists, for instance, attempt to maintain a neutral point of view Neutral viewpoint. with regard to their reporting of observable facts. Even if objectivity is not possible, a journalist may try to be an "honest broker" of information. For instance, they need to fairly represent opinions relevant to minorities in society. Another position is that and that news organizations should state their positions directly. Note that this is different from always presenting exactly two alternatives. Even if there is no absolute objectivity that does not imply that all alternatives are equally plausible. Relativism argues that there is no objectivity. How to make an objective presentation of information. Objectives weighted by population, by expertise, or by outliers. Computational journalism.

Common Sense and Intelligence

Common-sense. Watson computer program as common sense.

We have a rich language for describing human information processing activities, such as "thinking" and "creativity". There has always been extensive controversy about the definition of "intelligence". Can we separate the process from the content? Many skills associated with processing information are important for social success. These skills collectively may be called "intelligence". It is difficult to determine what processes are involved. Is it a general factor or is it situation?

Artificial intelligence. Often associated with attribute-based models. Turing test (11.10.4)[??] Is intelligence task-specific or is it general?

Economic capital, social capital, symbolic capital.

1.6.3. Theories and Frameworks

In this text, we have avoided taking strong theoretical positions. However, the theories can provide a lens with which to understand relationships.

General Systems Theory

Social Theories

Social theories are typically concerned with social structures and the function of social conventions. Structuration and adaptive structuration theory. Deconstructionism attempts counter structuralist approaches.

Structure-function. System theory or systemic action. Activity theories. Coherence and homeostasis. Social constructivist theories.

Society. Technology. Agency and action. Does the technology have agency. Situated action. Practical action. Structure vs Function. In some cases, we emphasize structure. For instance, in understanding natural language we might focus on syntax. In other cases, we emphasize function. In the case of natural language we might focus on how language is use to accomplish tasks rather than on how things are said.

Like the tube dancer, the are often many constraints in complex systems but there is also a lot of flexibility. Intervention in a complex adaptive system is often tricky.

Structure in representation, institutions. Function in rules.

Paradigms for Studying Information

Many fields involved in the study of science. Learning. Librarianship, business. Psychology There are many ways to study information. Social science (9.2.1).

Exercises

Short Definitions:

Abstraction
Compositionality
Context
Data
Digital convergence
Entertainment
Feedback
Homeostasis
Information
Information resource
Information value chain
Lifecycle (content)
Lifecycle (system)
Moore's Law
Objectivity
Positivism
Recognition
Relativism
Representation
Retrieval failure
Semantics
Structure
System
Top-down processing

Review Questions:

1. Explain how information relates to information systems. (1.1.1)
2. What makes a representation effective? (1.1.2)
3. Describe typical representation (1.1.2) for: a) music, b) images, c) video?
4. Distinguish between lifecycle of the content and the system lifecycle. (1.4.1)

5. How is recognition different from classification? (1.4.4, 2.1.2)
6. Identify three information sources in your school or university. How are they managed? (1.5.2)
7. Give an example of how an information system has transformed an organization. (1.5.2, 5.7.0)

Short-Essays and Hand-Worked Problems:

1. Describe several different senses in which a video program (e.g., a television sitcom) has "structure". ((sec:structure))
2. Identify three information systems and describe their representation, information processing techniques, content, and typical use. (1.1.2)
3. In what sense do the following employ representations: a book, a library collection, a library index, a video game. (1.1.2)
4. Give an example of failed information systems introduction in an organization. (1.2.3)
5. There is a saying that "content is king" which suggests that in a highly networked world, content is more valuable than the communication medium. Do you agree? Give an example. (1.4.0)
6. Interview a friend about a situation in which they needed to find information and the strategies they adopted to do that and the difficulties they may have encountered. (1.4.3)
7. Describe what types of inference techniques can be applied to the following types of representations: a data model, formal logic, numerical descriptions. (1.4.4, -A.7.0)
8. Estimate how many Web servers there are in the state or country where you live. Then, estimate the average number of pages on each server and the average number of bytes per page. Finally, calculate the approximate total number of bytes available. (1.5.2)
9. The Web is growing rapidly. Estimate how large your answer to the previous question will be in two more years. Explain how you derived this estimate. (1.5.2)
10. Write an equation for Moore's Law. (1.5.2)
11. As of this writing (2009) a fast CPU is about 4 Giga-Hertz. If Moore's Law continues to apply, how fast will processors be in 2020? (1.5.2)
12. Are video games an information genre? (1.6.0, 6.3.7, 11.7.0)
13. Does fiction convey information? Does a sculpture convey information? Does an antelope convey information? Explain. (1.6.1)
14. Flowers have evolved with distinctive shapes and colors to attract certain insects. Would you say the flowers have learned to convey information? (1.6.1)
15. Is gossip a type of information? (1.6.1)
16. If you were viewing a basketball game, would you say that information is inherent in the basketball game or is it there only for the players and the viewers? (1.6.1)
17. There are many difficulties with definitions of information (1.6.1). Give your definition of "information" and discuss the following puzzles:
    a) Do nerve impulses in your brain carry information?
    b) Where is the information in an organization?
    c) Distinguish between "information acquisition" and "learning".
    d) Distinguish between "information" and "entertainment".

Going Beyond:

1. Is it possible to estimate the total amount of information there is in the world? (1.6.1)
2. Can we have information without structure? (1.6.1)
3. Develop a model that could learn square-waves like the example in Fig. 1.17. (1.1.2)
4. Since somebody searching for information is necessarily in a different context from the person who created the information, how is the searcher ever be sure the context is correct? Is there a tendency to uncritically accept such information. (1.1.3, 5.12.0)
5. What is the connection between the development of the printing press and the rise of science in Renaissance Europe?
6. How important are language and words for defining expectations and social interactions? (1.4.3, 6.2.1)
7. Do you agree with the statement that "Whatever a person believes is true for that person". (1.4.3, 4.5.0)
8. List the information resources in your immediate environment. (1.5.2)
9. Keep an information diary for two hours while at your school. Describe what information resources you access. (1.5.2)
10. Does a computer program have intentions? (1.6.1)
11. What is common sense? (1.6.0)
12. What does it mean to understand what somebody else is saying? (1.6.1)
13. Are there always "two sides to every question"? (1.6.2)

14. What are some of the difficulties with the concept of "objectivity". (1.6.2)

Teaching Notes

Objectives and Skills: Introduce the concept of information as a fundamental construct. Representations. Modeling. Definitions.

Related Books

- American Library Association *Information Power*. Chicago, 1998.
- Chelton, M.K., and Cool, C. *Youth Information Seeking Behavior: Theories, Models, and Issues*. Scarecrow Press, Lanham MD, 2004.
- Ciborra, C.
- Brown, J.S. and Duguid, P. *Social Life of Information*. Harvard Business School Press, Boston, 2000. *The Labyrinth of Information: Challenging the Wisdom of Systems*, Oxford University Press, Oxford UK, 2002.
- Case, D.O. *Looking for Information: A Survey of Research on Information Seeking, Needs, and Behavior*. Academic Press, San Diego, 2002.
- Day, R. *The Modern Invention of Information: Discourse, History, Power*. Southern Illinois University Press, Carbondale IL, 2001.
- Dodsworth, C. *Digital Illusion: Entertaining the Future with High Technology*. Addison-Wesley, Boston, 1997.
- Eisenstein, E. *The Printing Revolution in Early Modern Europe*. Cambridge University Press, New York, 1983.
- Grafton, A. *The Footnote: A Curious History*. Harvard University Press, Cambridge MA, 1999.
- Latour, B. *Science in Action: How to Follow Scientists and Engineers through Society*. Harvard University Press, Cambridge MA, 1990.
- Pool, J. *Beyond Engineering: How Society Shapes Technology*. Oxford University Press, New York, 1997.
- Stefik, M. *Introduction to Knowledge Systems*. Morgan Kaufmann, San Francisco, 1995.
- Spinello, R.A. *Case Studies in Information and Computer Ethics*. Prentice Hall, Upper Saddle River NJ, 1996.
- von Beralanffy, L. *General Systems Theory: Foundations, Development, Applications*. George Braziller Inc., New York 1969.
- Whyte, J. *Crimes Against Logic*. McGraw Hill, New York, 2005.

Chapter 2.
Symbol-based Representations and Descriptions

Representations are the foundation of information systems. There are many possible representations. One important distinction for representations is whether they are discrete (qualitative) or continuous (quantitative). Qualitative representations are easier to work with and they seem to work for the way people use categories and language. Because of their connection to logic, they are also called symbolic representations. These also include explicit relationships between the concepts. Symbol processing has been very useful, but is not the only approach. Non-symbolic processing focuses on the similarity as an alternative to categories. Entity classes vs. instances.

English:	Dog
Spanish:	Perro
Scientific:	Canis Lupus
ASCII:	104 157 147

Figure 2.1: Some representations and descriptions for “dog”. Some are for a specific dog; others are for the class of dog. Some are symbol-based and some are not. (check permission)

Good representations capture important information in an effective way. Representations can provide information to users within an appropriate context; they can be copied and, in some cases decomposed and reassembled. In this chapter we focus on symbolic representations but there are also non-symbolic representations such as equations and distributed representations[8]. In addition, some representations now include behavioral elements and that allows many variations (3.9.3). In short, there are many alternatives to the symbol-based model and many reasons to criticize it, but it is so widely used that we need to start with it.

2.1. Categories and Classes

2.1.1. Categories and Classes are Representational Frameworks

When we interact with the world we encounter individual objects. But, those objects fall into groups. Some of the groups are ad hoc clusters say, all the objects which are on a desk. If the clustering seems important or if there is a similarity among the objects. we put them together in a category.

Figure 2.2: Grocery stores often use ad hoc categories for organizing their shelves. (check permission)

Natural lines of fracture versus artificial constructs. Classes and classification systems as a social artifact. classification of organisms ((sec:biologicalclassification)), of diseases (9.9.2), and of business (8.12.0). Categories are often based on ad hoc similarity but we are often interested sets of entities which fit a pre-defined system. Categories and classes usually involve similarity based on several attributes. Classifiers. Feature extraction is the process of determining which features to focus on when doing categorization or classification.

Categories are probably the simplest type of representation. Categories and classes make life easier, people do not have to judge individual situations separately. They can instead, categorize the situation and follow the rules which apply to it. Suppose you are organizing your kitchen. You would probably try to put similar things together: the spices on one shelf, the canned soups on another, and so on. Eventually, the categories help to simplify the complexity of the natural world. Rather than remembering or communicating every detail about a complex situation, the categories provide sufficient detail to allow a person to develop reasonable expectations about that situation. Categorization is the first step in knowledge representation. To create a database, for instance, we must categorize to what entity class each entity belongs (3.9.1). Later, we will consider related topics such as categories in human information processing. Classification is the process of assigning objects to classes. Classes are formalized than categories and are often based on consensus from members of a group.

2.1.2. Categories and Classes as Defined by Attributes: Aristotelian Categories

The simplest type of categories, "Aristotelian categories," are determined solely by attributes or characteristics inherent to the items to be included in the group. These "defining attributes", those attributes that define whether or not an item can be included in an Aristotelian category, must be universal for the entire category. That is, all the members of an Aristotelian category must share all of the defining attributes that make up that category. This leads us to distinguish between attributes that are required for category membership, i.e., defining attributes, and attributes which, though often associated with a category, are not required for membership in that category. These are called "characteristic attributes".

Where do the attributes come from? Scientific knowledge is often thought of as identifying attributes and processes and Aristotle is regarded as one of the founders of scientific reasoning (9.2.0). In some cases, classes are based on underlying processes such as evolution being the basis of biological classifications (9.8.1). Formally, Aristotelian categories are defined as a conjunction of attributes. Such attributes should be able to be combined and they could be used for logical inference.

While a category system may be very useful for one community or for one application, it may leave out aspects which are crucial for other applications. Not every object fits neatly into a category; sometimes there has to be a forced fit; such categorization is biased by the available choices for representations.

Classes extend categories by applying a conceptual framework. They are "top-down". A classification could be based on counties of the world. Classification should be differentiated from categorization or clustering which are purely data dependent. Typically, classes are based on a formal classification system while categories are based just on ad hoc similarity [16].

2.1.3. Other Approaches to Categories

Figure 2.3: Plato (left) and Aristotle (right) shown in a detail from *The School of Athens* by Raphael. Plato is pointing upward to signify his belief in prototypes (Platonic Ideals) whereas Aristotle gestures to the ground to indicate his emphasis on empirical attributes. (check permission)

While models based on Aristotelian categories dominate many information-system applications such as databases, many other models have been proposed for categories although these are not often employed in information systems. These also move away from simple models of symbol processing. Categories as used by people don't always seem to follow the Aristotelian approach. We will discuss the implications of

this more when we consider human cognition (4.3.0). Is a whale a fish? Although whales are mammals based on attributes such as feeding milk to their young many people think of them as fish. People don't seem to use purely attribute-defined categories; rather, they seem to interact with entities as "prototypes". A prototype is an idealized form. This is Plato's approach and unlike Aristotle's approach in which an object is either entirely in or out of a category, there is a degree of similarity or typicality in category membership. That is that some attributes are more typical than others. The distinction has implications across many areas of information systems. Similarity rather than attribute-based.
Generally, Aristotelian categories have been very successful in natural science and are the basis of much of out thinking about laws. However, in addition, to the alternative Plato presents, there are several concerns about the nature of Aristotelian categories (Fig. 2.4). Statistical analyses and categories. Not linearly separable. Several of these other approaches can be modeled with non-symbolic methods such as neural networks. The role of protoypes in categorization and language processing remains widely debated [Lakoff-WFDT].

Label	Description	Example
Continuous	Some attributes do not have distinct boundaries.	An example is colors. Even seemingly distinct attributes may be continuous (Fig. 2.5).
Abstract	Some categories we cannot define with specific attributes.	Beauty. Many social categories.
Functional	Defined by function rather than by attributes.	Is a tree branch a chair (Fig. 2.6)? Are all tree branches chairs?
Radial	Radial categories are extended from a central example or prototype (Fig. 2.7). These are the result of analogy and metaphor.	
Family Resemblance	Some categories do not seem well defined by a single set of attributes[38]. These are thought to show similarity like the resemblance among members of a family so these are termed "family resemblance" categories. No one attribute is always associated with the categories. That is, these are a disjunction of conjunctions.	The definition of games (Fig. 2.8).

Figure 2.4: A variety of other issues for categories.

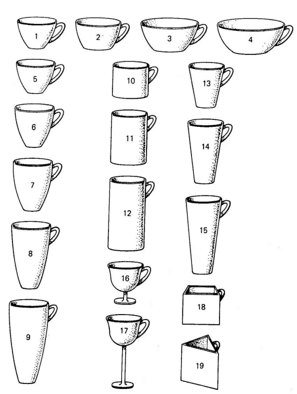

Figure 2.5: At what point does a cup become a glass, a goblet, or a jug? (check permission)(redraw)

2.1.4. Semantic Relationships among Classes

Classes can be part of a larger set of inter-related concepts. there are other concepts and relationships among them. Some common types of relationships can be identified. Indeed, relationships are so important that many of their attributes can be described. From very general to very specific. Related concepts versus named relationships. Binary, n-ary. Relationship among composite objects. [?]. From

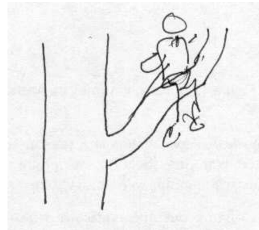

Figure 2.6: Is a tree branch a "chair"? A category may be defined by its function.

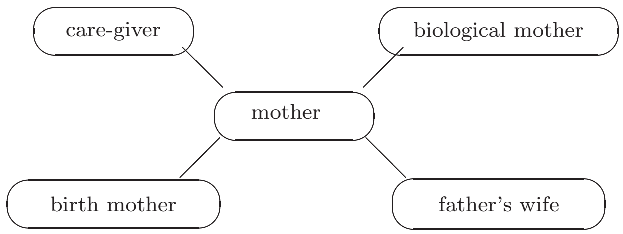

Figure 2.7: Sets of radial categories have a central theme and related concepts, but the related concepts are not differentiated by simple attributes.

game	**chess**	**soccer**	**card solitaire**	**Farmville**
teams		x		
physical space and activity		x		
competitive	x	x		

Figure 2.8: No single set of attributes seems to define a "game". Rather, there are subsets of attributes which games possess. (not finished)

semantic relationships to semantic networks. Recent activity in identifying semantic relationships with FrameNet (6.2.3).

Grouping allows complex objects to be understood and organized more easily by reducing their complexity. Another way to simplify the complexity of the natural world is through grouping. We have already seen, hierarchy and aggregation are illustrated in Fig. 2.9. Hierarchies show "is-a" relationships while aggregations show "has-a" or "part-of" relationships. Aggregation groups together objects that are part of a broader conceptual unit. Another type of relationship among objects is an ordering.

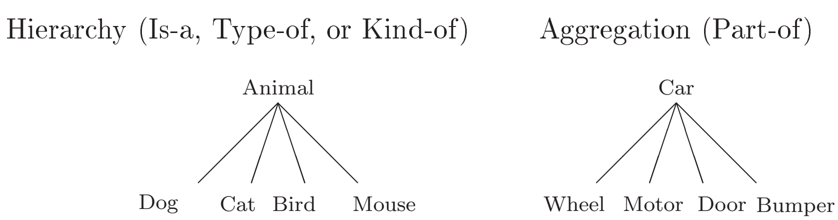

Figure 2.9: Two types of grouping relationships: hierarchy and aggregation.

Inheritance

In hierarchical relationships attributes may be carried, or inherited, from more general classes to more specific ones. An animal is the "parent" of a bird and a bird is the "parent" of a canary. Inheritance is an efficient way to store information because characteristics (such as laying eggs) do not need to be stored with every instance, but only with the parents. By continuing with this logic, we might get even more specific and refer to a particular canary. By doing so, we would move from types (of birds) to tokens (specific examples). This is also similar to networks of concepts ((sec:conceptualnetwork)).

Partonomies

Several ways in being part-of. Parts within levels. System analysis.

Semantic Network

Semantic relationships explicitly describe the inter-relatedness of concepts (Fig. 6.17).

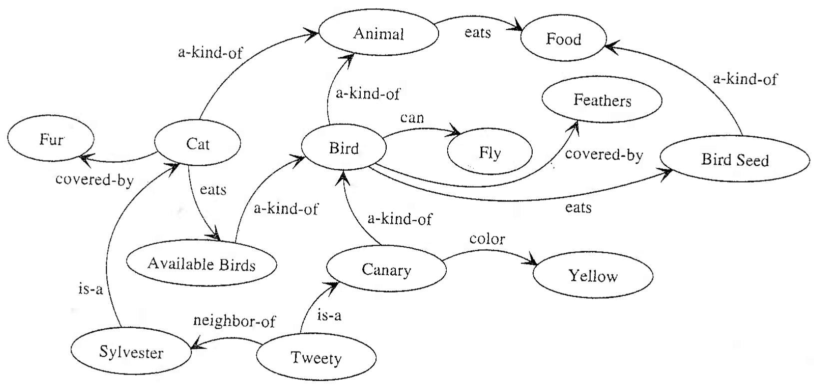

Figure 2.10: One type of semantic network identifies words and the relationships between them. This is also similar to conceptual models which we will discuss later. (redraw)

2.2. Knowledge Organization Systems and Knowledge Representation

Formal systems have been developed many of these approaches to description. Sets of categories can form descriptions of complex areas. Systems of semantic relationships. Specifically, this refers to sets of categories and classes are useful for describing things. Descriptions often reflect representations but they should also facilitate access [37]. They need to be tailored to the needs of the people who will be using them. There are many types of descriptions and we consider them at many places in this book. Some descriptions, those we consider in this section, are simply a few words. Descriptions would also include metadata (2.4.0) and abstracts (2.5.5). Descriptions of entire resources versus the contents with semantic annotation. Different ways of describing things. Epistemology. Frameworks for describing knowledge. Systematic classes. Most often this would be part of specifically selected set of terms. There are several ways these models can be structured. Here we consider three approaches: Taxonomies, Thesauri, and Ontologies; Many nuances are not able to be expressed and there can be drift of meaning across time [29]. Classification systems as boundary objects. Knowledge organizing systems can be applied information resources. In the previous section, we looked at the basic units of information: entities and attributes but useful descriptions require interrelated sets of attributes. These are Knowledge Organization Systems (KOSs).

These techniques are examples of knowledge representation. Linked data is also a type of knowledge representation. Domain models, conceptual models, and user models all applications of knowledge representation. The term knowledge representation is also associated with inference systems (-A.7.0) based on those representations but there can be considerable value to systems of description without considering inference.

2.2.1. Objects, Things, Entities, Instances, and Names

Description is one of the great challenges of information. As we shall see, there are many approaches. We start with the basic units to be described. Data models (3.9.2). FRAD to match and extend FRBR.

Instances have specific values for each attribute. The attribute and its associated value are known as attribute-value pairs. Identity. Attributes (2.1.2). Names identify specific entities. Naming implies a degree of acknowledgment and recognition. The properties of a name depends on how it will be used. Some names, such as "Bob," are informal. This name is useful in some contexts, but it would not be helpful in other contexts (at a convention of people named Bob, for instance). In more formal situations, we want to manage a system of names. To be most useful, a name should be distinctive and persistent (i.e., has it persisted through time). Some physical objects and categories, such as people and places, have proper names. These, however, are often neither distinctive nor permanent. Consider the number of towns in the United States that are named "Springfield". Enough information should be included to make a name a distinct identifier. A related, problem is that many variations of common names may be used. The name of the painter we usually know as Rembrandt appears on paintings with many variations. Concepts (1.1.4, 4.4.1).

The terms applied for common objects given by ordinary users vary widely [9]. These can often be names. Names should be unique, at least in a given context. Social implications of naming.

2.2.2. Knowledge Structures and Knowledgebases

Concepts do not exist in isolation. Rather, than describing separate descriptions, we need sets of related descriptions. Classification policies. Classification model. Description logic. Conceptual frameworks. These are basic models for networks of concepts. It's also worth noting that these descriptive system reflect social efforts and help to define the world for members of the social groups. Sets of classes must be drawn to adequately cover a field. Beyond classes to processes (3.9.3, 8.11.2).

Knowledge structures. Ordered and unordered lists. Schematics. Useful in schematics. Two of the most important knowledge structures are taxonomies and frames. We consider taxonomies below and frames in (4.4.1)(-A.7.1). Knowledge organization systems (2.2.0). Decisions about classification systems for information organizations Indeed, there are more subtle issues in knowledge structures such as inheritance.

Hierarchical Classification and Taxonomies

Grouping relationships can be stacked one on another to form a hierarchical classification. Such hierarchical classification is particularly easy to understand and navigate. An obvious example is library classification system which we discuss in the next chapter (2.5.1). Most classification systems are hierarchical. Indeed, the system of biological classification is so strictly hierarchical that we say it is a taxonomy (Fig. 2.11).

Taxonomies are composite knowledge organizing structures which demonstrate inheritance of attributes. For instance, we know one of the defining characteristics of animals is that they breath so every instance of an animal should have that property. However, inheritance relationships are not always so simple. While it is true that almost all birds can fly, there are exceptions. Penguins and ostriches are birds that cannot fly. A special attribute would be needed to mark such exceptions. such as a subclass of birds that cannot fly, such as penguins and ostriches, be developed? Sometimes, entities may inherit properties from more than one parent (2.5.2). A taxonomy should have a purpose. For instance, it should predict functionalities.

However, it is also worth noting the scientific taxonomies have come to be organized more by evolutionary heritage than by inheritance of visible attributes (9.8.1).

Kingdom: Animal
  Phylum: Chordate
    Class: Mammal
      Order: Carnivsore
        Family: Canide
          Genus: Canus
            Species: familiarus

Figure 2.11: The zoological taxonomy for dogs.

Thesauri

A thesaurus is a descriptive vocabulary about a specific domain. Terms thesaurus terms are developed which describe aspects of the domain and in some cases, there may be loosely specified relationships among the terms. For instance, there many be NTs (Narrower Terms [children]) and BTs (Broader Terms [parents]); define a hierarchical relationship. Typically, a thesaurus also includes RTs (Related Terms). The familiar *Roget's Thesaurus* lists words which are similar to the given word (6.2.1). Also SN, UF. Later, we will implement thesauri with the XML-based SKOS package (2.3.3).

Figure 2.12: Example thesaurus.

Thesauri may also provide a conceptual structure for a domain. Thesauri may facilitate text searches by providing a standard controlled vocabulary (2.5.3) for the concepts in that domain (Fig. 2.13). Not all concepts can be identified. The appropriate concepts can be selected by examining the questions people use. This is another example of identifying orthogonal, hierarchical concepts and then composing them into more complex objects. Thesauri are used in text retrieval for query expansion (10.7.2, -A.6.4). There can be multiple controlled vocabularies.

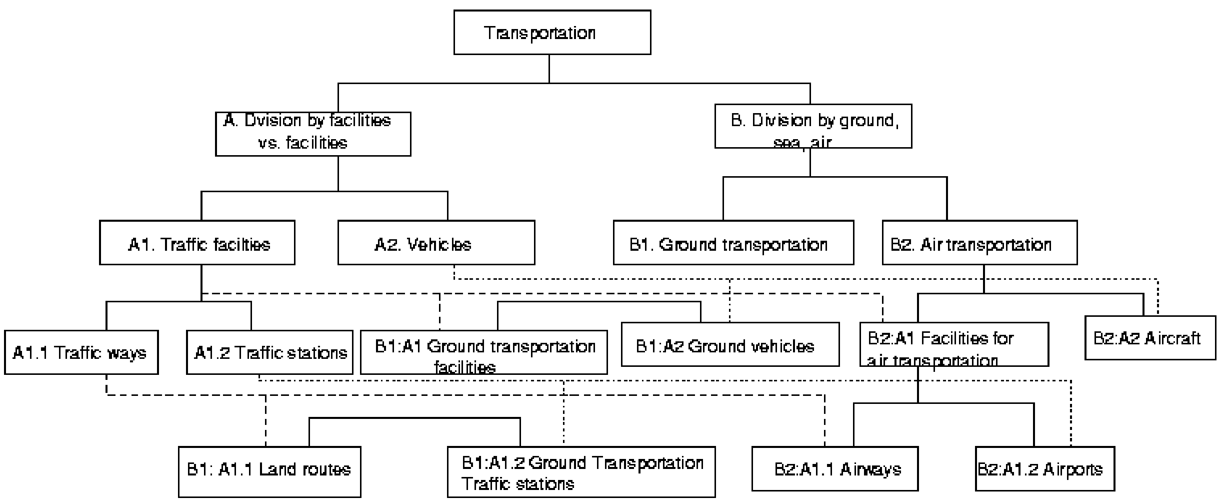

Figure 2.13: A concept hierarchy for aspects of transportation can generate thesaurus terms[26]. Some of the resulting concepts can be composed to form complex concepts. "A1.2 B2 Airports" combines "A1.2 Traffic Stations" and "B2 Air Stations". (check permission)

Formal Ontologies

There are several senses of the term "ontology". While the term ontology is often used loosely to include all types of knowledge organizing systems, the formal definition ontologies extend the semantic network shown in Fig. **??**. Specifically, ontologies provide the content for predicate logic (-A.7.1), which is the deconstruction of natural language to its actionable elements, thus formalizing and codifying its meaning. Linked to other sets of concepts. Ontologies are discussed further when we introduce XML and RDF-related tools(2.3.3). Merging and mapping ontologies.

Predicates and Knowledge Representation Languages

Taxonomies and thesauri have relatively simple relationships among entities but we also need to consider a broader range of relationships among entities. Semantic relationships (2.1.4). Natural Language (6.1.0). Predicates. Statements (Fig 2.14).

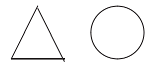

Figure 2.14: more complex structures require a predicate. The triangle is next to the circle. (not finished)

Make statements and inferences about the objects being described. KOS elements can be combined. Languages (6.5.2). Description logic. LOOM classifier logic.

Automated inferences from the knowledge on the web. Such named relationships can be useful for logic; indeed, the KR often results in a "knowledge base" which represents the world by the combination of the facts in it and the inference mechanisms which operate on those facts. Several KR languages have been developed. Some of them may be used with natural language processing systems (6.2.3), the Semantic Web, expert systems and logical inference (2.2.2, -A.7.0).

Inference with Knowledge Representation

Inference has always proven difficult. Symbolic representation and logic. Brittleness.

Inference based on knowledge representation. Ontologies with predicate calculus.

The Semantic Web and Semantic Technologies

The Semantic Web has pushed semantic technologies into new domains. Most importantly, the Semantic Web expect that such descriptions are machine processable. For instance, in supporting interactive systems for interacting with corpora. The annotations provide an indication of similarity. The broader goal of using the Semantic Web for inference is largely unrealized. This is certainly not a formal ontology or even thesaurus in the usual sense because it includes complex concepts. Particularly, used for technical fields with large data sets (9.6.0).

The Semantic Web also addresses many of these issues and it is often used in applications beyond those normally considered by traditional information specialists. Moreover, the Semantic Web emphasizes making the tags machine readable. On the other hand, sometimes the lessons of the traditional approaches are lost in the study of the semantic web. However, the very strengths of controlled vocabularies also suggest limitations. The Semantic Web has brought many advantages of automatic processing and management of terminology. However, that automated processing has allowed great inconsistencies to come in.

Linked data. Beyond linked data to linked processes and events.

Importantly, the semantic web focuses on automatically processed statements. This allows automated evaluations of the vocabulary system. For instance, it can check integrity constraints. It also allows manipulation of basic values such as conversion of units.

Like thesauri, ontologies, are task or domain specific. This is because for a given domain or task, the terms are usually relatively unambiguous. Event ontology. However, coordination across domains can be difficult as are attempts to develop ontologies for general applications, because the terminology can be ambiguous. Furthermore, unlike people for which language is highly fluid, ontologies do not adapt to context or new situations; thus, we say they are brittle. Coordinating disjoint ontologies. This is less of a problem for thesauri since they do not try to be as exact. Indeed, this many also represent the social uses of language and concepts[24]. Furthermore, there may be a combinatoric explosion[2]!

There might be multiple vocabulary systems. Integrated vocabulary modeling[10]. Vocabulary ecosystem. Ontology server. Concept bank. Vocabulary registry and repository. Vocabulary provenance.

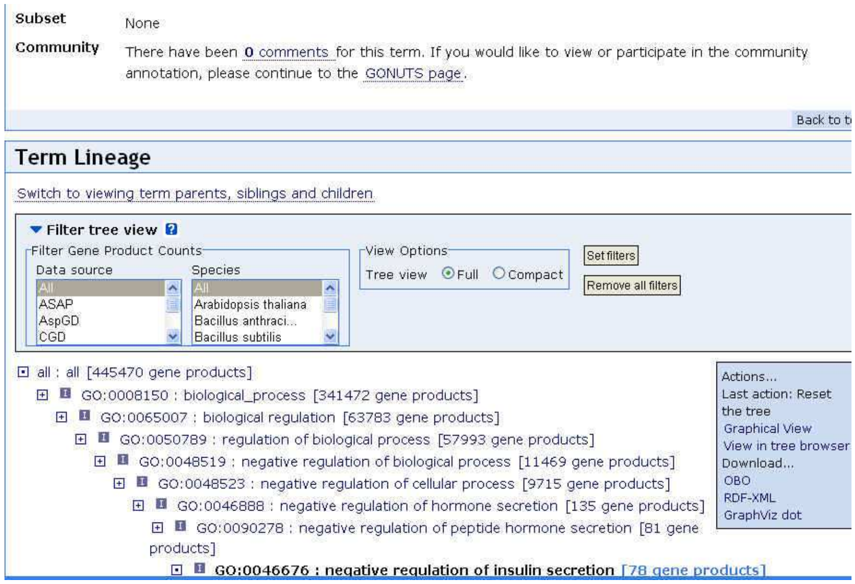

Figure 2.15: GeneWiki[5] uses an "ontology" for describing genes. (crop)

Lexical resources coded with RDF. DBPedia.

2.2.3. Process Models for Description

2.3. Information Resources

2.3.1. Documents

We make complex statements about the world and collect those into documents. Documents are a important construct for in the study of information. We will consider them in two perspectives – as structured information resources and as resources with a social purpose.

There are many ways in which information is captured such as pictures, blocks of text, Web pages, databases, mashups, video, simulations, and software. Some of these such as most pictures or blocks of text are characterized simply as information objects. Such information objects are often combined into more complex objects. In many cases, the composite information objects are documents.

Figure 2.16: A variety of document types: a) A passport has the information necessary for crossing international borders. b) A journal article is structured typically focuses on presenting new information. c)

There are rules, data models, for the ways in which these objects can be combined. Because documents are structured and have distinct components, they can often be tagged with XML and presented electronically. While traditional documents remain static, when presented electronically they can be interactive. Indeed, several pages can be linked together to form hypertexts, which allow richer models of interactivity. Document communities (5.8.2). In a broad sense, documents help to structure society.

At one level, documents are simply structured presentations of information which have permanence. We are issued documents at birth, another at death, and countless ones in the time between. They are very common and highly varied. Examples include passports, books, drivers licenses, newspapers, course listings and technical reports. Documents as a conceptual unit (9.0.0). Genres. Wikis and blogs can be considered as genres for the Web.

When multiple copies of an information resource are made especially when they are made for distribution, it may be helpful to distinguish the original from its copies. By comparison to documents, works are intellectual or artistic creations. There is also a a close connection between works and collections; works are the basic units of a collection is a work.

2.3.2. "Social Life of Documents"

Documents are more typically created to accomplish a certain task or to suit a given function. Increasingly, documents go through many versions and there are intermediate types of content such as coordinated fragments of documents forming mashups. Where a document typically emphasizes the utility of a document for transmitting structured information across organizational boundaries. Thus, we call them boundary objects. When taken out of context, some documents may be difficult to understand; consider emails. Some materials may be designed specifically to be unambiguous and to easily cross boundaries. These "boundary objects" can be understood outside of a narrow context. With its photograph, official-looking seals and concise information, a passport is understood and accepted in many countries. Indeed, such boundary objects allow the transfer of processes across separate systems so that they can become sub-systems of a combined system. Limitations of the effectiveness of boundary objects. However, it is also important to note that documents may end up being used in ways far beyond the intentions of the author[30].

2.3.3. XML: eXtensible Markup Language

Typically, documents are highly structured. That structure can be encoded with XML which is the eXtensible Markup Language has become Here, we approach XML as it is applied to documents. Later, we will see that XML is useful to describing domains can be encoded with XML and it is also useful as a database interchange tool.

Structuring Documents with XML

It helps to think of the content of a document as separate from its layout. A business letter, for instance, has distinct components such as a return address, date, greeting, body, and signature. However, the content of those specific components, whose name, which date, what address, will vary from letter to letter. Useful services can be developed by tagging specific components of the document's structure without considering how or in what order they will be displayed. The presentation can be controlled separately. Tagged content can be useful in developing indexes or a table of contents, or text marked as section headers can be displayed in a style different from the rest of document.

XML separates the components of a document from their layout. Fig. 2.17 shows an example of an XML-tagged document. XML is basically hierarchical: that is, it defines the broadest aspect of an object first, followed by the second-broadest and so on down to the most specific aspect and XML creates document structures like Fig. 2.18. It is a common language (i.e., an interchange standard) for Web-based artifacts. We will discuss several of the applications of XML in later sections.

XML Pattern Documents XML tags provide a type of semantic annotation An XMLSchema provides a simple framework for defining the structure of the document tree. One of the uses for XML schemas is to define the structure of documents (Fig. 2.19) after tagging the components they contain. The notation

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="poem.xsl"?>
<POEM
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi=noNamespaceSchemaLocation="poem.xsd" >
  <TITLE>Sonnet #49</TITLE>
  <AUTHOR> W. Shakespeare </AUTHOR>
  <STANZA>
      <LINE>Against that time, if ever that time come,</LINE>
      <LINE>When I shall see thee frown on my defects,</LINE>
      <LINE>Whenas thy love hath cast his utmost sum,</LINE>
      <LINE>Called to that audit by advised respects;</LINE>
      <LINE>Against that time when thou shall strangely pass</LINE>
      <LINE>And scarcely greet me with that sun thine eye,</LINE>
      <LINE>When love, converted from the thing it was,</LINE>
      <LINE>Shall reasons find of settled gravity:</LINE>
      <LINE>Against that time do I ensconce me here</LINE>
      <LINE>Within the knowledge of mine own desert,</LINE>
      <LINE>And this my hand against myself uprear</LINE>
      <LINE>To guard the lawful reasons on thy part.</LINE>
      <LINE>To leave poor me thou hast the strength of laws,</LINE>
      <LINE>Since why to love I can allege no cause.</LINE>
  </STANZA>
</POEM>
```

Figure 2.17: Poem tagged with XML tags as defined by the XML Schema.

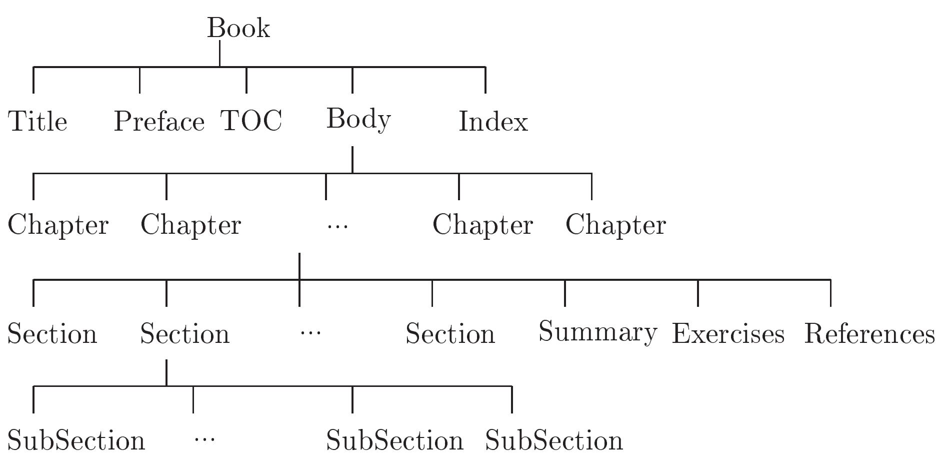

Figure 2.18: A traditional hierarchical document tree applied to the structure of this textbook. While this is an easy structure to understand and browse, it ignores the cross-links between sections such as references to other material

says that a poem has a TITLE, one or more AUTHORS, and one or more STANZAs. STANZAs are made up of one or more LINEs. XML documents need to make sure they conform to the DTD. Developing a standard of elements facilitates the interoperability of documents. DTDs implement hierarchical structures like that in Fig. 2.18. In most cases, individual users do not create their own DTDs but apply pre-established ones. Indeed, many publishers provide standard DTDs for their content to ensure consistency.

```
<?xml version="1.0"?>
<xs:schema
  xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="POEM">
    <xs:complexType>
     <xs:sequence>
        <xs:element ref="TITLE" minOccrs="1" maxOccurs="1"/>
        <xs:element ref="AUTHOR" minOccurs="1" />
        <xs:element ref="STANZA" minOccurs="0" />
     </xs:sequence>
   </xs:complexType>
  </xs:element>

  <xs:element name="STANZA">
    <xs:complexType>
     <xs:sequence>
        <xs:element ref="LINE" type="xs:string" minOccurs="0" />
     </xs:sequence>
   </xs:complexType>
  </xs:element>

  <xs:element name="AUTHOR" type="xs:string"/>
  <xs:element name="LINE" type="xs:string"/>
  <xs:element name="TITLE" type="xs:string"/>
</xs:schema>
```

Figure 2.19: XML Schema which defines the tags used in the POEM document.

Specification of Document Layouts: XSL and XSLT Information should be presented in a way that is most convenient and logical for the recipient. Now that we have defined the components of a document, we can turn to the presentation of a document's content. While the physical layout of a document generally reflects its logical structure, several different physical structures are possible. Fig. 2.20 shows two layouts of a business letter. The two panels reflect two different but equally accepted styles for positioning the return address and signature line. A business letter may have its return address in either the top left or the top right corners.

Because the physical layout should be separate from the logical structure, a special language is needed to describe layouts. The XML Style Language (XSL) was created for this purpose. This language is used to determine the presentation style of an XML document. Sets of XSL specifications are often collected into style sheets. XSLT is the XSL Transformation Language; it allows XML to generate other, multiple formats. An XSLT element can display the title of a document in HTML, and documents can be converted to an electronic-book format or even submitted to a database. Fig. 2.21 illustrates that an XSLT script can generate a variety of formats from an XML file. This is a type of dissemination service. Later we will consider synthesis and publishing of entire publications (8.13.4).

The Resource Description Framework (RDF)

Many packages are built on top of XML. One of the more important of these is RDF, the Resource Description Framework. Fig 2.23. RDF provides a way to associate metadata with digital resources. RDF allows a standard approach to the creation of defining relationships among resources. But this extra capability is not always needed and some services can be implemented in either XML or RDF. XML has many applications beyond documents and information objects. It is particularly helpful for describing semantic relationships. Its applications are shown in the so called "layer cake" diagram in Fig. 2.24.

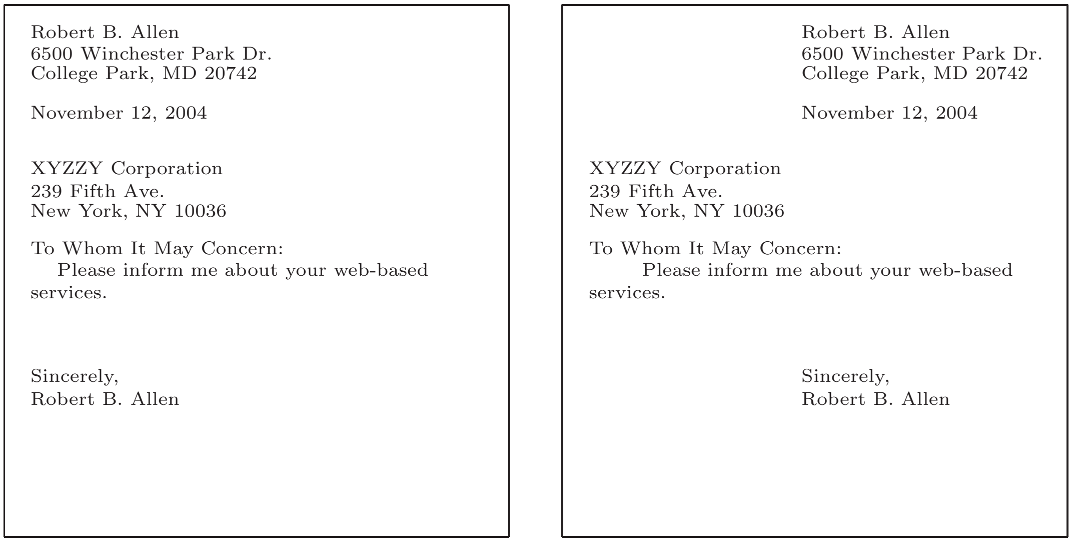

Figure 2.20: Two common layouts for a business letter; the content is identical, but the formatting differs. If the letters are coded with XML, the layouts can be generated with different XSLT scripts.

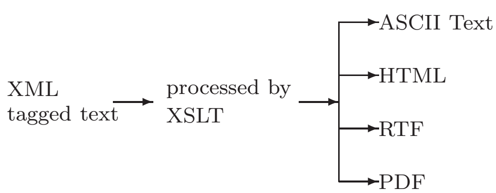

Figure 2.21: XSLT also allows a single tagged XML file to be converted to several different display formats such as ASCII, HTML, RTF, and PDF.

```
<xsl:template match="POEM">
    <HTML>
      <xsl:apply-templates>
    <HTML>
</xsl:template>

<xsl:template match="TITLE">
  <H1> <FONT COLOR="GREEN">
    <xsl:value-of/>
  </FONT> </H1>
</xsl:template>
```

Figure 2.22: Part of an XSLT description for a poem and the title (as used in Fig. 2.17) which generates HTML. The stanzas are composed of additional templates as indicated by “xsl:apply-templates” and the title is a literal string as indicated by “xsl:value-of”.

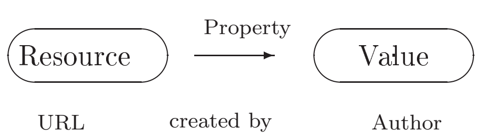

Figure 2.23: RDF associates metadata with a resource. Specifically, it has triples composed of: Resource, Property, Value.

High-Level XML Packages: SKOS and OWL

Several frameworks have been developed for knowledge representation but it is natural to use an approach with is consistent with XML. For instance, for ontologies (2.2.2), Taxonomies and thesauri can be described in RDF with the Simple Knowledge Organization System (SKOS) (Fig. 2.25). OWL, the Web Ontology Language, does that. Specifically, OWL implements a description logic, that is a formal method for creating descriptions. OWL is built on RDF Schema (RDFS) [32] which extends RDF. OWL allows the creation of Classes such as “Mother” or “Father”. Furthermore, OWL allows the specification of types of properties such as functional properties (Fig. 2.26). Using OWL for conceptual descriptions.

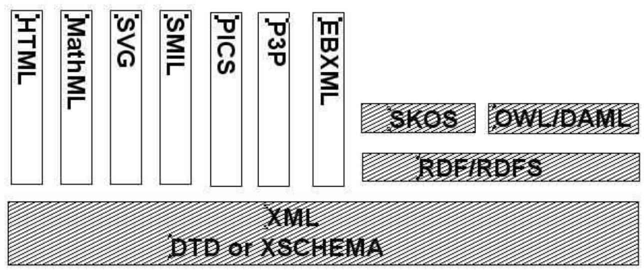

Figure 2.24: This “layer-cake” diagram shows that XML is a unified framework that provides structure and descriptions for many Web-based objects (adapted from[34]). The specific components shown and described in the text.

```
<rdf:RDF
  xmlns:rdf=”http://www.w3.org/1999/02/22-rdf-syntax-ns#”
  xmlns:skos=”http://www.w3.org/2004/02/skos/core#”>

  <skos:Concept rdf:about=”http://www.my.com/#dog”>
    <skos:prefLabel>dog</skos:prefLabel>
    <skos:altLabel>canine</skos:altLabel>
  </skos:Concept>
</rdf:RDF>
```

Figure 2.25: This example uses two XML packages: RDF and SKOS to define a concept (dog) and two labels (“dog” and “canine”) associated with it.

```
<owl:Class rdf:ID=”Operetta”>
  <rdfs:subClassOf rdf:resource=”#MusicalWork”/>
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource=”#hasLibrettist” />
      <owl:minCardinality rdf:datatype=”&xsd;nonNegativeInteger”>
      </owl:minCardinality>
    </owl:Restriction>
  </rdfs:subClassOf>
  <rdfs:subClassOf>
    <owl:Class>
      <owl:complementOf rdf:resource=”#Opera”/>
    </owl:Class>
  </rdfs:subClassOf>
</owl:Class>
```

Figure 2.26: An example of an OWL statement. This defines an Operetta as a Musical Work which much have Librettist and which is a complement of an Opera[33]. (check permission).

2.4. Data Schemas and Metadata

Data schemas are structured descriptions of objects and metadata are structured descriptions of information resources. The author of a book is an attribute of that book, and can therefore be a piece of metadata. We do not need to be too strict about the distinction between data and metadata; the important point is that metadata describe and supports the primary information contained in a system or collection. In some cases, the distinction between data and metadata is blurred. For instance, descriptions about people or about locations.

2.4.1. Data Schemas

A schema is a template for an entity with a selected set of attributes. Schema.org

Micro-data. Frames (4.4.1).

Broad range of items to classify. Metadata for non-traditional objects. Comic books. T-shirts.

Criteria for a good classification system. Metadata for data repositories.

Inheritance hierarchy (2.1.4). For example:

Thing > Person,
FOAF,

Thing > Creative Work > Book

Descriptions of scientific results. Description of geography. Descriptions of museum objects (7.6.1).

2.4.2. Metadata

When information resources are being described, we describe the attributes as metadata. These systems have been particularly weel worked out. Reasons for metadata: find, identify, select, obtain, explore. There are several types, levels, and applications of metadata. Describing content and then repurposing it for different platforms such as mobile, smart TV. Semantic publishing (**??**).

Library metadata, archival metadata (7.5.4)design and process metadata ((sec:designmetadata))..

Figure 2.27: The meaning of a picture is different from the elements that appear in the picture. This picture illustrates the metaphor that the "broom" of woman's suffrage will "sweep clean" prostitution, gambling, and drunkenness[18]. This illustrates the difference in describing the "ofness" and the "aboutness".

More generally, different types of metadata have value at different stages of the lifecycle of the information resource. Some description systems are based on the content of the information the system contains, while others describe attributes of the resource itself, such as the creator or the date. Metadata description is a representation. It is a description of information resources. Thus it is a secondary representation. Semantic annotation. Descriptions of scientific data sets. Tagging versus annotation.

Information resources and metadata associated with that. Constrained sets of attributes have been developed to guide the content of any given description. We will first focus on descriptive systems for information resources and then turn to more general description frameworks. We have emphasized the importance of representations. Let us consider document representations; they should be discriminative, descriptive, complete, and correct. Metadata are attribute values used to describe information resources[14]. Metadata can be described as data about data. The set of metadata used to describe an entity is an information model.

Metadata supports services and user needs. Physical objects can also be described by metadata; museum artifacts, for example, need descriptors (7.5.4). Metadata is clustered into groups (Fig. 2.28). When we want to describe a collection of documents so we need a flexible set of terms. Knowledge organizing systems (2.2.0). Developing metadata descriptions in the context of a complex collection of objects is more difficult than describing individual objects. Simple metadata that is consistent across users and collections facilitates access for a variety of users. Any system of metadata should cover the scope of a field and should be coordinated across domains. Furthermore, descriptive systems need to serve a community.

2.4.3. Library-Oriented Bibliographic Metadata

Information resources have attributes in common which typically fit well together. Here, we focus on library resources which are often books with attributes such the publisher and the date of publication.

Standards for provide consistency across environments. However, the standards have become increasingly varied and complex. The MARC (Machine Readable Cataloging) record is a library standard for organizing bibliographic records. Metadata composites for complex objects (7.8.0).

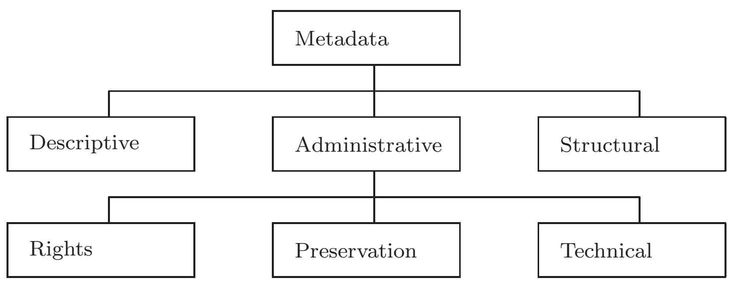

Figure 2.28: One way of characterizing types of bibliographic metadata[17].

Bibliographic records are standard descriptions while presenting pertinent information about collections of information resources. Bibliographic theory.

Bibliographic Works and Records

One of the distinctive features of published materials is that there are many closely related copies of closely related material. When we describe such material, at some points we want to describe the original work which is being reproduced and at other times we may want to describe individual copies.

Traditional publications produce multiple nearly identical copies. Metadata may be organized by a data model (Fig. 2.29) (3.9.1). Functional requirements (7.9.1). As indicated on the right side of the figure, different types of metadata are associated with each level of the hierarchy. FRBR: item level, collection level[6]. The original version of a creative work (2.4.3) is distinct from all subsequent instances of that work For traditional texts, such as books and documents, the concept of a "work" is generally clear. On the Web, however, it is not always so clear. Sometimes, the individual page might be considered a work, and at other times, the entire Web site might be considered a "work". As we will see, defining the original work is an important part of organizing the metadata that pertains to it. A "derivative work" is not entirely original, but involves adding intellectual effort to an original work. A translation is a derivative of the work being translated. A superwork includes many related versions of work. Ability to include a broader range of materials in a catalog. Describe relationships among entities. Works also generally have social significance [**?**].

Beyond book, other collections of information resources have related lateyed structures.

Entities as the basis for the functional requirements (7.9.1). Bibliographic relationships help to create an entity-relationship model (3.9.1). Relationships among information resource include [**?**]: Equivalence, Derivative, Descriptive, Whole-part, Accompanying, Sequential. Derivative relationships can be subdivided into ...

Work

Expression

Manifestation

Item

Figure 2.29: When many copies of an information object are made and especially when there are many versions of that information object, metadata can keep that straight. Some attributes belong to individual copies and others apply to the entire work. That is, some of the metadata values are inherited from the higher levels. Typical metadata attributes for formally published materials are shown in parentheses at each of the level.

Bibliographic Control and Authority Files

Consistency across the records in a catalog. An example of semantic tools. Bibliographic control ensure quality and consistency. Cataloging rules provide standard definitions and encourage consistency in catalog records[7]. One example is the "Rule of 3," which specifies that any author list that contains three or more names should be simplified by stating the first author's name followed by "et al.". If a database has a fields for first, middle, and last names, consider the difficulty of entering the following names: Madonna, George Herbert Walker Bush, Sitting Bull. For formal indexing, explicit policies should be created. Principles not just rules. Work languages, Document languages, Subject languages. Cross-cultural conceptions of authorship and classification [**?**].

Authority files provide standardized forms of entities. Specifically, name authority files provide standard spelling for a name (Fig. 2.30).

Catalogs

Nowadays these may be in digital repository (7.8.0). Typically, access points for collections are grouped along dimensions such as title, author, or subject. This are attributes which reflect common information access behavior of users. user needs or use cases. Applying successive levels of restrictions can be a way to specify a search (Fig. 2.31). Cooperative cataloging. Use cases (3.10.2) for content development.

Catalogs for collections present standardized metadata for the objects in that collection. ICP: Convenience of the user, Common usage, Representation, Accuracy, Sufficiency and necessity, Significance, Economy, Consistency and standardization, Integration. The metadata used in a catalog should be constructed to help users to find items in that collection. More discussion about metadata when we consider complex digital objects (**??**). Union catalog.

2.4.4. Dublin Core Metadata System and Schema.org/Book

Dublin Core was designed as a light-weight metadata system for describing Web pages and not necessarily for full works. However, it is so common that we will include it here. For the Web, the known in the Dublin Core. There are 15 elements of Dublin Core (Fig. 2.32), the metadata system that is often used for Web objects. As its name suggests, these 15 elements are intended as a core and that core can be extended to cover a wide range content types including visual resources and educational materials (5.11.6). Dublin Core attributes can also be "qualified" by sub-attributes. "dc.creator" can be qualified

Paul Rembran	Rembrandt Harmenszoon van Rijn	Rembrant Van Rin
Paul Rembrandt	Rembrandt Harmensz Van Rijn	Rembrardt
Rambrandt	Rembrandt Harmensz van Rijn	Rembrat
Rebranch	Rembrandt Harmensz. van Rijn or Rhijn	Rembrdandt
Reimbrant	Rembrandt Hermanszoon van Rijn	Remdrandt
Rem.	Rembrandt Hermansz van Rijn	Reymbram olandes
Rembrach'	Rembrandt Olandese	Rijmbrand
Rembradt	Rembrandt Van Rhyn	Rijn, Rembrandt Harmensz. van
Rembrand	Rembrandt van Rijn	Rijn, Rembrandt van
Rembrande	Rembrandt van Ryn	School of Rembrandt
Rembrands	Rembrant	Van Rhyn Rhembrandt
Rembrandt	Rembrants	Van Ryn, Paul Rembrandt
	Rembrant van Rhijn Rembrant van Rijn	

Figure 2.30: The painter Rembrandt and variations in the spelling of his name[15]. (check permission)

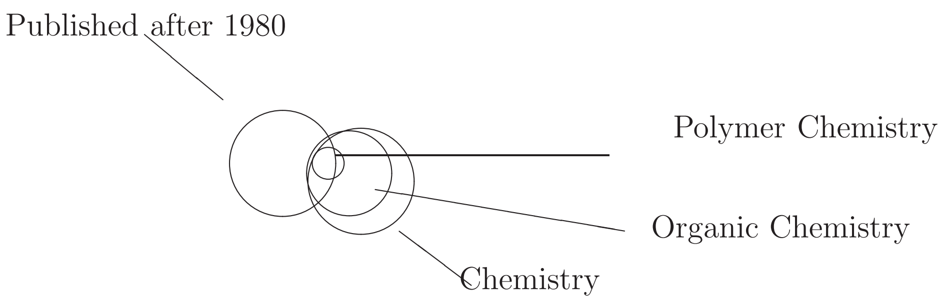

Figure 2.31: Levels of hierarchical metadata can be useful for controlling scope during retrieval. We could first search on topics relating to organic chemistry published after 1980 before moving on to the narrower search for research on polymer chemistry.

as "dc.creator.illustrator".

When tags from different metadata systems are included in a given document, it is necessary to be clear about what system they come from. This is defined by the "namespace" (xmlns) and the namespace package identifier is included with the tag. dq:creator is the creator tag as defined by the Dublin Core metadata system.

Linking Works with Metadata Attributes

RDF. Semantic graph.

Resource Description and Access (RDA) proposes rules for developing systematic metadata. Low-level attributes at the item level.

FRBR describes Entities. Creating catalogs.

Machine processable. Dublin Core abstract model. As the name suggests, RDF used to apply resource descriptions such as Dublin Core to documents. This is accomplished using an "about" clause that governs the relationship between the resources and attributes.

Element	**Description**	**Example**
Title	A name given to the resource.	Information: A Fundamental Construct
Creator	An entity primarily responsible for making the content of the resource.	Robert B. Allen
Subject	The topic of the content of the resource.	Information science and systems
Description	An account of the content of the resource.	A textbook.
Publisher	An entity responsible for making the resource available.	Robert B. Allen
Contributor	An entity responsible for making contributions to the content of the resource.	Robert B. Allen
Date	A date associated with an event in the life cycle of the resource.	1/1/07
Type	The nature or genre of the content of the resource.	textbook
Identifier	An unambiguous reference to the resource within a given context.	ISBN
Format	The physical or digital manifestation of the resource.	LaTeX
Source	A reference to a resource from which the present resource is derived.	Authored
Language	The language of the intellectual content of the resource.	English
Relation	A reference to a related resource.	PPTs
Coverage	The extent or scope of the content of the resource.	”Information Science, Information Systems, Web Science”
Rights	Information about rights held in and over the resource.	Robert B. Allen

Figure 2.32: The base set of Dublin Core metadata attributes[4]. Here, an example is filled in. Not every element is included in many semi-formal collections. (check permission)

<META NAME=“DC.creator”>
<META NAME=“DC.creator.illustrator”>
<META NAME=“DC.subject” CONTENT=“lcsh-heading” SCHEME= “LCSH”>
<META NAME=“DC.subject” CONTENT=“mesh-heading” SCHEME= “MESH”>

Figure 2.33: The base set of DC attributes can be qualified with subdivisions as creator.illustrator. Further attributes can be extended. For the subject tag CONTENT and SCHEME which describe the system used for the content description (LCSH and MESH are systems of subject descriptors).

Extended DC

Figure 2.34: Extended DC.

Going forward, such efforts will facilitate making resources more available from Web based search and, thus, will be able to satisfy more information needs and this has been a significant concern for academic librarians.

Metadata Application Profile

A metadata application profile specifies the range or applications to which a set of metadata is typically applied. It is related to the community interests which the collection is expected to serve. Dublin Core application profiles.
Singapore application profile framework. The MPEG standards body has defined MPEG-A as a framework for new MPEG applications. Functional requirements
Domain model
Description Set Profile

```
<?xml version='1.0'?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
      xmlns:dc = "http://purl.org/dc/elements/1.0/"
      xmlns:dcq = "http://purl.org/dc/qualifiers/1.0/">
   <rdf:Description rdf:about = "http://doc">
     <dc:creator>
       <rdf:Description>
         <rdf:value> Pat Jones </rdf:value>
         <dcq:creatorType> Photographer </dcq:creatorType>
       </rdf:Description>
     </dc:creator>
   </rdf:Description>
</rdf:RDF>
```

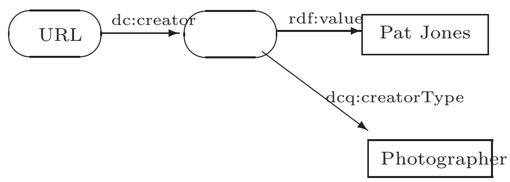

Figure 2.35: RDF can be applied with qualified and extended Dublin Core. The dc:creator attribute is qualified dcq:CreatorType with the value of "Photographer".

Usage guidelines
Encoding syntax guidelines

2.4.5. Documentary Languages

2.5. Subject Languages: Descriptions Based on Document Content

The metadata examined thus far has not focused on the content of the information resources but about attributes such as the year of publication and author's name. Tools which use such description include indexes, abstracts, and classification.

Applying knowledge organizing systems (2.2.0). We have already considered thesauri (2.2.2). SKOS (2.3.3). In additional to information resources, cultural objects such found in museums (7.6.1) and architecture.

Language help to define communities.

The "Semantic Web" is often associated with ontologies, but it frequently goes beyond these to cover all types of descriptions [21]. Beyond indexing to semantic annotations (7.8.4). This identify semantic units within the text. Alphabetic languages versus topic-oriented languages.

Description of other resources Data sets (9.6.0).

Sensory, perceptual, emotional dimensions. MPEG-7.

There are a variety of semantic technologies ranging from classification systems to controlled vocabularies to ontologies. Each of these has strengths and may usefully be applied in different situations.

2.5.1. Hierarchical Subject (Topic) Classification

Classification is used for many kinds of objects and information, such as videos in a video store, food in a grocery store, topics in a newsgroup, or items in online auctions. Classification systems are frequently used to organize books and other materials in libraries; you are probably familiar with the subject classification system used for books in your local library. Formal classification systems, such as those used in libraries, are often hierarchical (2.2.2). Classification systems: broad, close, design.

Library Classification Systems

Libraries (7.2.1) have been particularly active in developing large-scale classification systems. The largest and most widely used classification systems are simple hierarchies. It is likely that your library uses one of the two most common systems: the Dewey Decimal System or the Library of Congress Classification Systems (LCC). The Dewey Decimal Classification (DDC) system is used in most public libraries in the U.S. As the word "decimal" suggests, the DDC has no more than 10 items per level. The top-level categories for DDC are shown on the left side of Fig. 2.36. Books and other documents with numbers between 000 and 099 fall into the category called "Generalities". Although library classification systems are primarily hierarchical, faceting (2.5.3) is sometimes added to them. This crosses the main classification dimension with other dimensions. Mining might be subdivided by a category such as geographic region (e.g., mining in Asia, mining in North America, etc.). Classification systems may describe the same concept in rather different ways; we need a guide for how terms from the two systems are related. Such guides are called crosswalks.

Number	Description
000	Generalities
100	Philosophy and Related Subjects
200	Religion
300	Social Sciences
400	Language
500	Mathematics
600	Technology
700	The Arts
800	Literature and Rhetoric
900	General Geography and History

Figure 2.36: Top-level of Dewey Decimal Classification.

Primary Labels	Secondary Labels
Arts & Humanities	Literature, Photography...
Business & Economy	Companies, Finance, Jobs...
Computers & Internet	Internet, WWW, Software, Games...
Education	Universities, K-12, College Entrance...
Entertainment	Cool Links, Movies, Humor, Music...
Government	Military, Politics, Law, Taxes...
Health & Medicine	Diseases, Drugs, Fitness...
News¡ & Media	Full Coverage, Newspapers, TV...
Recreation & Sports	Sports, Travel, Autos, Outdoors...
Reference	Libraries, Dictionaries, Quotations...
Regional	Countries, Regions, US States...
Science	Biology, Astronomy, Engineering...
Social Science	Archaeology, Economics, Languages...
Society & Culture	People, Environment, Religion...

Figure 2.37: Top-level of Yahoo.com classification (as of January, 1999).

In addition to the DDC and LC, there are several other comprehensive library classification systems such as the UDC and Colon Classification.

Structure and Evolution of Subject Classification Systems

Decisions about library classification structures are often based on the notion of warrant. Semantic warrant, literary warrant.

A classification schedule from the 1950s would not have much about space travel; one from 1980 wouldn't mention HIV. While being dynamic enough to change as needed, a subject classification system should be static enough to be predictable for users. Although the top-level subject classification systems are static, the Dewey Decimal Classification is revised frequently as new areas of knowledge emerge. A recent expansion included Eastern Religions, which had not been covered fully in the earlier editions. Fig. 2.38 shows the changes in a section of the classification system used in the rapidly changing the field of computer science from 1964 to 1998. Evolution of terminology is even more rapid in descriptions of popular music.

1964	1998
3.7 Information Retrieval	H.3 INFORMATION STORAGE AND RETRIEVAL
3.70 General	H.3.0 General
3.71 Content Analysis	H.3.1 Content Analysis and Indexing
3.72 Evaluation of Systems	H.3.2 Information Storage
3.73 File Maintenance	H.3.3 Information Search and Retrieval
3.74 Searching	H.3.4 Systems and Software
3.75 Vocabulary	H.3.5 Online Information Services
3.79 Miscellaneous	H.3.6 Library Automation
	H.3.7 Digital Libraries
	H.3.m Miscellaneous

Figure 2.38: Here is a classification developed for the rapidly developing field of Computer Science. Fragment of the ACM Classification in 1964 (left) and the corresponding section in 1998 (right). Note how much the classifications changed in the space of 34 years. Topics such as "online information services" did not appear at all in the earlier classification[1].

2.5.2. Poly-hierarchies, Multiple Inheritance, and Facets

One of the strengths of simple single hierarchies such as those used in traditional library classification systems is that the items are located in one and only one position. However, it may be difficult to find a single specific location in a hierarchy because an item seems to belong to several categories. Pneumonia is both an infectious disease and a lung disease. Sharing properties from several parent categories is known as "multiple inheritance," and the structures formed from multiple inheritance are called "polyhierarchies" (Fig. 2.39). Some classification systems attempt to avoid multiple inheritance because of the complications in overlapping attributes.

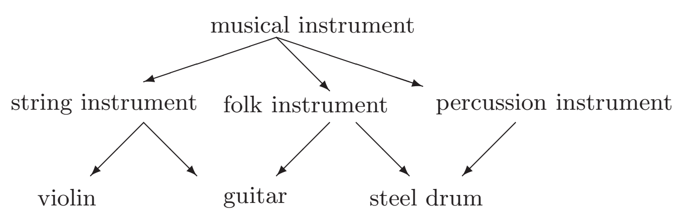

Figure 2.39: A guitar can be part of a polyhierarchy under string instrument and folk instrument.

Facets and Facet Classification

About facets. EBay.

Facets can be systematically developed with semantic factoring can create a faceted, controlled vocabulary by identifying orthogonal underlying terms. Many works and collections are better characterized by independent facets. These faceted systems have orthogonal dimensions. That is, they categorize their concepts with a series of seemingly unrelated concepts. With such a system, minerals for instance, could be considered according to the regions in which they are found. Ideally, each dimension would be independent of the others as shown in the example of a faceted thesaurus (Fig. 2.40).

Wikipedia topic structure as a DAG.

2.5.3. Index Terms and Indexing Languages

The term "index" is used in several ways. An index can be a data structure used by a document retrieval system, a pointer to topics in one document, or a catalog for access to information resources such and those in a document or collection. an index provides an organization of the literature of an

Facet Name / Associated Hierarchies	
Associated Concepts	
	Associated Concepts
Physical Attributes	
	Attributes and Properties
	Conditions and Effects
	Design Elements
	Color
Styles and Periods	
	Styles and Periods
Agents	
	People
	Organizations
Activities	
	Disciplines
	Functions
	Events
	Physical Activities
	Processes and Techniques

Facet Name / Associated Hierarchies	
Materials	
	Materials
Objects	
	Object groupings and systems
	Object genres
	Settlements and landscapes
	Built complexes and districts
	Single built works
	Open spaces and site elements
	Furnishings
	Costume
	Tools and equipment
	Weapons and ammunition
	Measuring devices
	Containers
	Sound devices
	Recreational artifacts
	Transportation vehicles
	Visual works
	Exchange media
	Information forms

Figure 2.40: Top-level facets from the *Art and Architecture Thesaurus*[22]. Note that the facets are designed to be independent from each other.

entire field. An index may be measured by "exhaustivity," or the extent to which it covers all of the concepts included in a work and by its "specificity," that is, the level of detail, the depth, or ichness of the indexing. Indexing functionality.

Subject Categories and Controlled Vocabularies

Topic descriptions versus other attributes. Which attributes to select and include in a set of metadata. Systems of metadata (2.4.3). It is useful to have a standard set of descriptive terms as a controlled vocabulary. Although there are differences among concepts, in a controlled vocabulary, these distinctions may be helpful. This process of selecting optimal terms is similar to the process of defining entities. We need to extract terms for a set of documents that are pre-defined as referring to that set. Fig. 2.42 shows the stages for such a systematic development of a thesaurus. Another basis for a developing a controlled vocabulary is by examining the words people use to ask questions. Coordinating with lingustic tools such as FrameNet (6.2.3).

abode, address, apartment, asylum, bungalow, cabin, castle, cave, commorancy, condo, condominium, cottage, crash pad, diggings, digs, domicile, dormitory, dump, dwelling, farm, fireside, flat, habitation, hangout, haunt, hearth, hideout, home plate, homestead, hospital, house, hut, igloo, illahie, joint, living quarters, manor, mansion, nest, orphanage, pad, palace, parking place, place, residence, resort, roof, rooming house, roost, shanty, shelter, trailer, turf, villa.

Figure 2.41: Terms that may be used to describe a "home" (adapted from Roget). While the variants have slightly different senses, for indexing it is usually clearer to use just one standard term.

Many concepts are combinations of other concepts. The concept of "doctor" or "nurse" combines the concepts of "person" and "medical treatment". Each concept is independent, i.e., orthogonal, from the others. This process of identifying the underlying dimensions is known as "semantic factoring". Recall

	Examples	
	Original Terms	**Final Term**
1. Combine related terms	Aesthetics and Esthetics	Aesthetics
2. Combine related concepts	Aesthetics and Production Values	Production Values

Figure 2.42: Steps in vocabulary reduction for creating controlled vocabulary word lists.

that semantics is the study of meaning in language. The concept of "hospital" could be decomposed into "building" and "medical treatment".

Tools for managing large-scale collections of vocabularies.

Subject descriptors are standard terms that cover the major topics in a collection. They are usually not hierarchical and are properly an example of "enumeration" rather than classification. The Library of Congress Subject Headings (LCSH) are the most widely used set of subject descriptors Several subject descriptors may be combined for a specific document, several subject headings may be used (Fig. 2.43). An index may include concepts which do not actually appear in the document.

France–History–Revolution, 1789-1799–Songs and music
Motion pictures–Law and legislation–Japan

Figure 2.43: Library of Congress Subject Headings may be combined into composite descriptions. The second example above would be for a document about laws concerning motion pictures in Japan. The order of the terms identifies which concepts are most important with respect to the object which is being indexed. (new example)

Subject Analysis and Facet Analysis

In order to classify it, we need to determine what a book or document is about. Indeed, classification systems such as the Dewey Decimal System identify single positions in the hierarchies. A subject classification system requires identifying what a work is about. "Subject analysis" determines the subject of a work and assigns it to a subject classification system. It would be nice to assume that a work has only a single subject, but resources are often complex and contain many attributes, making it difficult to assign only one subject category. There may simply not be a single topic, and viewpoint classification may be ambiguous from the user's viewpoint. Finding the book on a given topic via text processing. What would people want to use this book for? Epistemological potential [**?**]. [13]. In some approaches, facets may be combined to create complex statements about the topic of a book.

2.5.4. Creating Metadata and Metadata Systems

Developing a consistent large-scale metadata system is very difficult. Authority implies care and attention to details.

Communities of practice define metadata systems appropriate to their needs.

Good metadata supports interoperability. Metadata comes from many sources. in other cases, it is the result of systematic effort by professionals. Indeed, there are formal organizations for considering metadata standards. In other cases, metadata is loosely defined. The amount of effort invested in creating metadata depends on the importance of the collection and the needs of the users. Some metadata are harder to define than others.

It is surprisingly difficult to generate accurate metadata. There are three problems in doing this: the feature may not be known, there may be true ambiguity about the feature, or the metadata may be assigned carelessly. "Content guidelines" facilitate consistency of the metadata but care may be needed to assign even with such guidelines (Fig. 2.44). Using controlled vocabularies Validation lists for checking the actual terms entered.

Costs of systematic metadata development. There is a chance of systematic attacks of organization of information. Automatic capture of metadata at creation.

> If in doubt about what constitutes the title, repeat the Title element and include the variants in second and subsequent Title iterations. If the item is in HTML, view the source document and make sure that the title identified in the title header is also included as a meta title (unless the DC metadata element is to be embedded in the document itself).

Figure 2.44: Content guidelines for the Title Element in the Dublin Core[35].

Cooperative cataloging for sharing metadata records which are used in library catalogs. Cost-benefit for developing metadata.

Open metadata.

Socially Constructed Metadata

Traditionally, the metadata for formal collections hase been carefully constructed by professionals. Another approach, is to let the users create the metadata. Social indexing. The sets of metadata generated in this way is known as folksonomies. This is certainly much cheaper and more flexible, but it has other implications. These may be reflect cultural biases or of intentionality, persuasion and bias.

Need for consistency in metadata. Groundswell of popular trends and emergent metadata. Limitations of folksonomies[20].

The Web is a highly dynamic environment. Separate taxonomies could be developed quickly for separate interest groups. Ad hoc taxonomies. This can be helpful when systematic descriptions are not possible. The Open Directory Project (DMOZ)[3]. Social tagging and finding objects: del.icio.us. Comparison of social tagging to policies for traditional classification[23]. The danger is that social tags may reflect a popularity context rather than systematic classification. Another approach for generating metadata is "Games with a purpose"[31] (Fig. 2.45). Games (11.7.0). Semantic relationships (6.2.3). Game-oriented crowdsourcing.

Figure 2.45: "Games with a Purpose" generate descriptors in which web-mediated participants try to match descriptive terms. (check permission)

Workflow models.

Coordinating Across Systems of Metadata

Linked data.

2.5.5. Making Resources and Collections Usable

Content Coordination

Techniques for supporting interaction with content. Interface tools for interacting with information resource content. This internal structure can be captured with Coordination Widgets. Across re-usable content objects [?] Information architecture (1.1.3) and semantic publishing. Books (8.13.6). Annotations of several sorts. Reader annotations.

Tables of contents support access to it the components of a work such as its chapters. Structure often cannot be separated from meaningful presentations. Table of figures. Table of (legal) cases TOC for video.

Knowledge organization widgets in encyclopedias.

Back-of-the-Book Indexes

As suggested earlier, the term index is used in several ways. In general use, an index is most often a back-of-the-book index. Subject indexes do not simply select keywords from the text. Problem of indexing mentions. The phrase: "But John Major was no Winston Churchill..." should not be indexed under 'Churchill'.

Indexes across collections of books. Metadex.

User-centered indexing. Adaptive hypertexts for personalized indexes. Task-oriented abstracts.

Meta-dex.

Catalogs

Snippets and Surrogates A document surrogate stands in place of a document. It might be a thumbnail image of a document but it is most often a bundle of metadata which follows the information model for that type of documents. When documents are arranged in collections, surrogates may be organized into a catalog.

Web page summaries often include snippets.

Abstracts

Descriptions beyond metadata. Abstracts can help users maintain "current awareness" of work in a field as new documents are written. Like other information resources, abstracts should serve information needs. Abstracts may be characterized by the type of description they provide (Fig. **??**) [**?**]. This is especially important for scholarly literature (9.1.1). An "informative abstract" attempts to convey as much of the information of the larger document as possible. An "indicative abstract" simply indicates the topics which are covered. It is most often used for material which is difficult to summarize such as the contents of a database. An evaluative abstract critiques the ideas and gives an indication of what is contained in the article without necessarily describing the contents. Abstracts should cover the major points in the work they refer. Some abstracts are structured; that is, they may discuss specific issues based on the structure of the original document. An abstract of a scientific publication might require descriptions of the hypotheses, procedures, results, and conclusion sections.

Some abstracts are structured so readers can focus on the essential aspects of the research[12]. This has become especially common for medical applications. One example of a structured abstract style sheet requires that the following categories be included: Background, Purpose, Research Design, Setting, Study Sample, Intervention, Control or Comparison Condition, Data Collection and Analysis, Findings, Conclusions, Citation.

2.6. Hypertext and The Web

Linking supports browsing. Stand-alone documents are effective for many applications, but a wider range of user needs can be supported with linking those documents to others. Hypertexts are sets of information objects that are linked together. Many types of services can be developed to support interaction in these hypertexts. Links in hypertext serve multiple functions. They provide a navigational path but they also provide signals of association between concepts. In a real sense, knowledge is stored in the network of links. Links are similar to semantic relationships (6.2.3). Hypertext structures provide a types of information organization which support browsing. Hypertext as a literary genre (6.3.7).

2.6.1. Links and Anchors

The simplest links connect two documents. We have briefly seen Xlinks. A more complex type of link, embedded or contextual links, connect regions within documents. Fig. 2.46 shows familiar HTML HREF links and anchors which as embedded links. The end points of a link are known as "anchors". Anchors can be single points within a document, sections of a document, or temporal locations for scenes in a video or other multimedia objects. For HTML documents, the location of anchors may mean linking to a whole document or only to a section within a document.

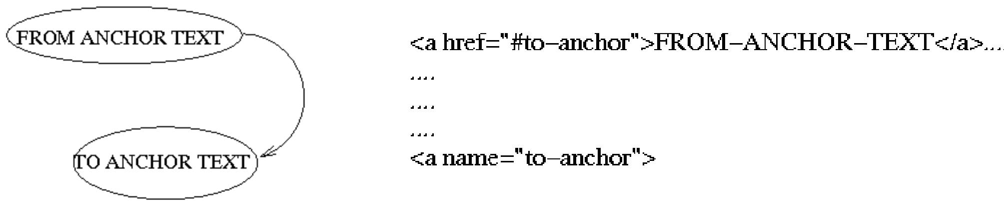

Figure 2.46: Anchors are end points of embedded links. This is illustrated with HREFs in HTML. (redraw)(check permission)

The collection of all the links in a hypertext forms the structure of that hypertext. “Referential integrity” checks whether the links are complete; that is, whether or not each link (reference) contained in a hypertext is composed of an object that it is linking from, as well as an object that it is linking to.

Links in a hypertext can have attributes. An electronic book might have a special type of link for providing definitions of words. When hypertext systems have typed-links, the link types are often drawn from a predefined set. XLink, the link framework for XML (Fig. 2.47) shows the specification for an XLink. The links can be defined to have attributes; that is, they can take on “roles” or functions, such as the simple “dictionary-definition” function that links a word to its definition in a dictionary program. Beyond simple HREF’s there are many variations of linking. The links may be multidimensional (a single link may connect to several other sites) (10.4.3) or links may be adaptive (they may be displayed for only some users or situations). Link roles may be compared to semantic relationships (2.1.4). Multi-headed links and OHS.

```
<!ELEMENT student ANY>
<!ATTLIST student
  xmlns:xlink CDATA #FIXED “http://www.w3.org/1999/xlink/namespace/”
  xlink:type CDATA #FIXED “simple”
  xlink:href CDATA #REQUIRED
  xlink:role CDATA #IMPLIED
  xlink:title CDATA #IMPLIED
  xlink:show () “replace”
  xlink:actuate () “onRequest” >

<students xlink:href=“studentList.xml”>
  The list of students.
</students>
```

Figure 2.47: An XLink definition and an example of its use. The “student” tag has an argument which is the HREF of a file called “studentList.xml”.

2.6.2. Composite Hypertext Structures

HTML implements a simple model for linking notes in a hypertext. Other types of hypertexts can introduce additional structure. Several of these are summarized in Fig. 2.48. Formally, hypertexts may even be specified with data models (3.9.0). Basic hypertext is easily modeled as a graph (-A.3.0). Composites [11] are higher-level objects, such as indexes and tables of content. Composites can also introduce their own navigational structures. Instead of a link simply navigating the user to a new document a link in a composite might bring up a schematic on a split-screen to allow comparison with the content of the composite. These hypertext composites help users to contextualize knowledge. Visual information, especially as seen in visualization has similarities to hypertext (11.2.5).

Implicit structure versus full visualization of the structure. The “language of selection” [19]. Formal

Type	Description (Section)
Table of contents	Structure of links (2.5.5)
Guided tours	A predetermined chain of related pages. (2.6.2)
Templates	Links mapped to regions in a graphical structure. (2.6.2)
Spatial hypertexts	Implicit links based on proximity. (9.10.0)
Hypertext maps	Overview of link structure. (2.6.2)
Argumentation systems	Typed links that describe the components of an "argument". (6.3.5)

Figure 2.48: Composite hypertext and related structures.

Hypertext Models Open hypertext models. Mappings between different hypertext models.

Menus allow the selection of options from a set of brief descriptions. Menus can be used to explore documents that are organized hierarchically (2.1.2). One common example of a menu is a table of contents. A menu with more breadth contains more choices per page, but fewer pages. (Fig. 2.49). A menu with more depth contains fewer choices per page, but more pages. Users are generally able to find items in menus with high breadth faster than in menus with high depth, as it requires fewer clicks to reach a given point. In addition, user satisfaction often decreases as the number of required clicks increases. However, a menu with a greater depth often allows for a more logical, sequential progression of choices, decreasing the possibility of user confusion. There is a tradeoff between depth and breadth in the efficacy of menu organization, and it may be found that certain menu styles are more suited to particular tasks than others.

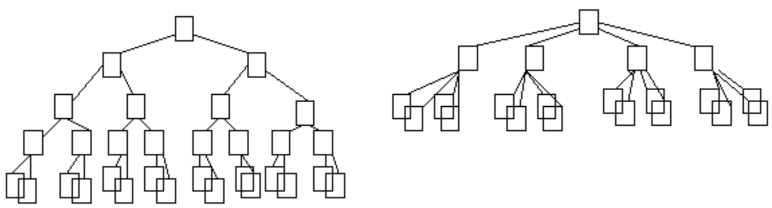

Figure 2.49: Two structures of menus that allow the user to reach 16 nodes. The one with high depth (left) has more layers but fewer choices at each layer. The other, with high breadth (right), has fewer layers but more options at each layer.

Several of these structures are the basis for coordination widgets (2.5.5).

A guided tour follows a predetermined path through a collection of information resources; it can be considered a type of composite hypertext. The simplest guided tour has a single path, which is presented straight through from beginning to end. Other guided tours allow you to "choose your own adventure," and are more branched and complicated. Examples of guided tour composites include lectures, novels, broadcast television news programs, and movies.

Hypertext Maps, Templates, and Spatial Hypertexts

Interfaces for interacting with arguments. Graphical views of arguments.

Argumentation vs inference. The structure of arguments is captured in argumentation systems. As their name implies, argumentation systems are often used for describing group discussions. Fig. 2.50 shows a tagged fragment of the discussion about rebuilding the Reichstag in Berlin. Fig. 2.51 shows an argumentation system that helps students to develop scientific explanations collaboratively by illustrating the connections between seemingly disparate facts. Group argumentation systems are used for education (2.6.2).

Hypertext maps provide an overview of several nodes. Some hypertexts are composed of templates that reflect specific knowledge structures related to the tasks. These may be schematics. Fig. 2.52 shows a workspace filled with templates representing information about individual countries. Spatial

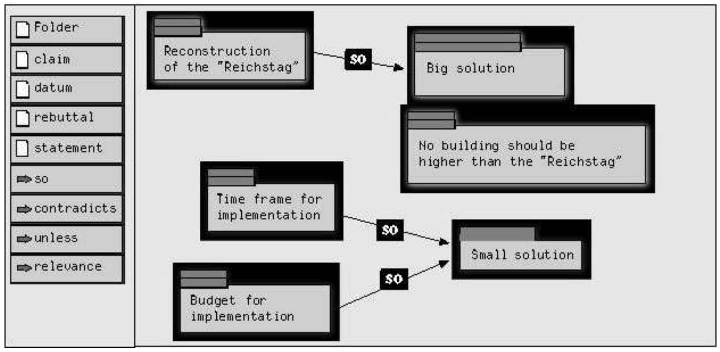

Figure 2.50: An argumentation system is a hypertext map (adapted from[27]) which lays out aspects of an argument. Note the objects types (folder, claim, datum, rebuttal, statement) and the link types (so, contradicts, unless, reference). (redraw) (check permission)

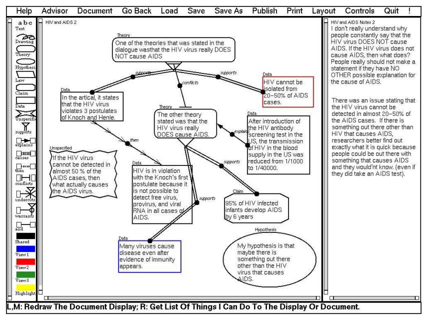

Figure 2.51: An argumentation system can support student learning about scientific reasoning[28]. (check permission)

layout organizes the templates; thus, these sets of templates form a spatial hypertext in which the user is guided by the structure rather than by explicit links.

Structure and interactivity are introduced to hypertext maps these become interactive schematics and visualization systems (11.2.5).

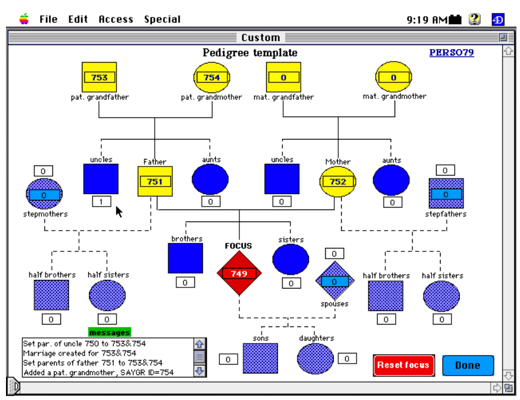

Figure 2.52: A schematic can provide a visual structure for facilitating page-based browsing[25].

Adaptive Hypertexts

Adaptive hypertexts support reconfiguration of the nodes and links based on user characteristics and history. Prioritizing links on a page based on user preferences. Effectively, this becomes a model of the user's knowledge. Personalization (4.10.2). These can be useful in teaching and are related to adaptive tutoring systems (5.11.3).

2.6.3. The Web as a Common-Use Hypertext

The Web is more than a simple collection of documents in a hypertext or library. It provides many kinds of information ranging from recipes to reservations to digital libraries. Thus, the Web is known as a common-use hypertext. The Web does not have a simple unified architecture, but XML is being expanded to provide a unified framework.

Web-Page and Web-Site Design

Information design and information architecture. Visual languages (11.2.4). Information architecture (1.1.3). The goal of layout is to allow the user to identify and easily access the content of a Web site. Web sites have many applications, some focused on specific users and some broadly based for the public. To build an effective Web site, we need to decide how, and by whom, it will be used. We then need to provide access points for meeting the information needs of the user group. The interface in Fig. 2.53 allows users to search for movies by title, by actors, and by locations. The content of the Web site should be highlighted in the interface and clues or instructions given to users about navigation.

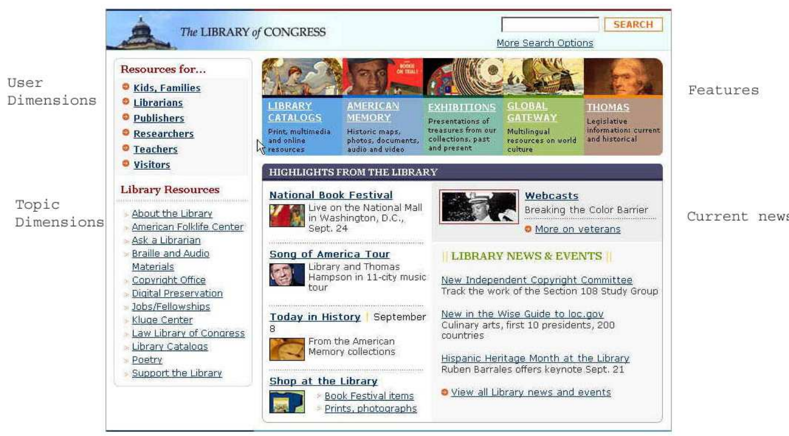

Figure 2.53: Access dimensions for a browser display should reflect the underlying content.

Just as library catalogs have different dimensions for access, web pages should be designed with consideration of the types of material users will want to access. This is similar to the specification of use cases in software applications (3.10.2). Whatever the design chosen, it should remain consistent across the entire site, and there should also be no dead-end links. A well designed site will highlight its core information, while at the same time providing diversions and subordinate information in easily accessible links. Interaction design (4.8.1). General principles for design of applications beyond the Web will be considered later (4.8.0).

Layout for disjoint information objects. The layout of a newspaper — how the stories or sections are organized on a single page or throughout the issue — contributes to a reader's ability to both find articles of interest and to understand the relationship of various news items. Layout, in the news or other media, is often used (or manipulated) to aid reading or to make associations for viewers; an effective layout is one that highlights a recurring theme. The theme of newspapers is generally one of importance: information that is deemed to be important is given a special place — the front page — while news that is considered less important is moved toward the back. Visuals are used in a way that contributes to the advancement of the overall theme and creates a synergy between text and images. The photographs of a newspaper typically support the information that the news articles contain; in other media, such as comic strips or satires, the text may contradict the image to create irony. A layout need not be simply visual, but may include audio or even tactile presentations, the latter existing mostly in the world of art. The dynamic elements of interactivity make layout and design decisions more complex: interactive electronic documents are now designed for a specific user's preferences and actions, rather than to an entire group. Interactivity leads us from documents to hypertexts, which we shall consider in the next section. Interaction design (4.8.1).

Design and patterns.

Discourse relationships can help structure layout (6.3.2) to support comprehension (10.2.3) . Document analysis (10.1.5).

Link Semantics Creating a link adds meaning. It suggests that there is a significant relationship between two documents. Links can be an indication of similarity (10.10.2). In some hypertext models different types of links perform different actions. Some links, such as a "Submit" button, commit the user to action. Other links, such as a back button or a chapter heading, simply navigate to a new location. However, all links, as the operable elements of a hypertext, share a common purpose: to support information access and task completion by users, and not just provide a formal model. Following a link has two effects on a user: it shifts the attention to a new topic while at the same time retaining the context of the previous page.

A link should be easily distinguishable from the text in which it occurs. This is often accomplished with different-colored font or underlining. In addition, because interactive documents and hypertexts allow users to jump to information that is of particular interest to them, a link should provide clues to the user about where it leads. Fig. 2.54 shows an example of "link visualization". This is one of many general user interface principles (4.8.0).

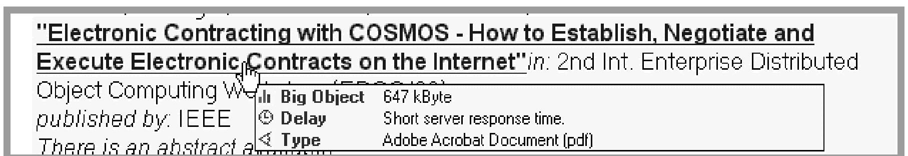

Figure 2.54: Link visualization can provide information about the object to be accessed[36]. (check permission).

Hypertext provides an alternative to traditional linear documents. It allows a great deal of flexibility in allowing users to browse through a set of inter-related concepts. Thus, there is a usability tradeoff in the flexibility provided by hypertext rather than the simple linear order of traditional documents.

Emergent Structure of Information Networks

The Web is the result of many people and organizations independently designing sites and posting material of interest to those sites. The Web is an information network. Nonetheless, it is not entirely chaotic; patterns emerge. We can count Web objects such as pages, servers, and links; we can count how frequently these objects change; and we can record user interaction with the Web. The resulting patterns allow us to identify different elements of the World Wide Web. It is helpful to characterize the Web as a graph (-A.3.0). Specifically, the web is a small-world graph. Social networks (5.1.0). Characterizing aggregate structure of the Web (Fig. 2.55). Because the Web is so large, we can look at the number of in-links and out links across a large number of nodes.

It provides links between information resources. The Web is the most obvious example but there are many others. For instance, in traditional scientific research articles the citations form links. Two notable types of sites are "authorities" and "hubs" (Fig. 2.56). "Authorities" are linked to by many other pages; that is, they have a lot of inward links. Moreover, the greater the number of different pages linking to an "authority" is an indication of that page's quality. "Hubs" are the opposite of authorities. They link to many other pages. The quality of a hub may be measured by the quality of the authorities to which it points. This insight is the basis for the PageRank algorithm, which is used to rank documents following a Web search (10.10.2, -A.3.5).

Exercises

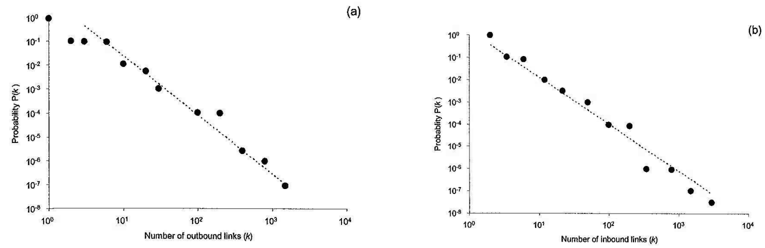

Figure 2.55: Graph of frequency versus number of in-links and out-links for Web pages. These are log-log plots so the data shows a power law. (check permission)

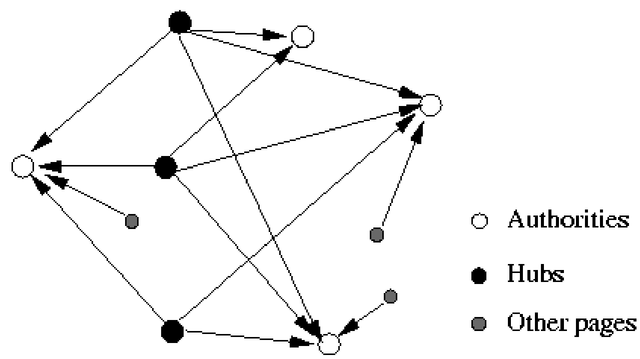

Figure 2.56: We can treat the web as a large complex system. Schematic of the structure of the Web. Authorities (open circles) have many other pages pointing to them. Hubs (black circles) point to many other pages. (redraw)

Short Definitions:

Abstract (document)
Abstraction
Access point (collection)
Aggregation (document)
Attributes
Attribute-value pair
Authority file
Data model
Cataloging
Classification
Collection
Common-use hypertext
Content guideline
Controlled vocabulary
Data dictionary
Database
Derivative work
Document
Document Type Definition(DTD)
Dublin Core
Entity (databases)
Epistemology
Folksonomy
Facet (classification)
Guided tour
Inheritance (KR)
Information Model
Knowledgebase
Menu
Metadata
Multiple inheritance
Namespace
Ontology
Procedural knowledge
Prototypes
Query language
Representational bias
Resource Description Framework (RDF)
Schema (data)
Semantic factoring
Surrogate
Symbolic representation
Taxonomy
Thesaurus
Typed-link
XLINK
XML
XSLT
XMLSchema
Work (metadata)

Review Questions:

1. List some defining and characteristic attributes for an automobile. (2.1.2)
2. Describe the relative advantages of "classification" and "key word" systems. (2.1.2)
3. Give additional examples of the grouping relationships we described. (2.1.4)

4. What are some of the difficulties in a single, simple hierarchical topic classification system. (2.1.2)
5. Identify the elements of this chapter that should be included in a DTD. (2.3.3)
6. Compare DTDs and XMLSchemas for describing the structure of documents. (2.3.3)
7. Explain the difference between logical structure and presentation structure for documents. (2.3.3)
8. What are some different ways a person could be a "creator" of an information object. (2.4.4)
9. Compare the process of identifying entities for a database and selecting a controlled vocabulary. (2.5.3)
10. Compare the structure of the a folksonomy subject classification system with the structure of formal library classification systems such as the LC or Dewey Decimal Systems. (2.5.1)
11. What are some of the advantages and disadvantages of a controlled vocabulary for a given topic? (2.5.3)
12. What are the relative advantages of informative and indicative abstracts? (2.5.5)
13. Explain what is meant by a "composite hypertext". Give an example. (2.6.2)
14. List several elements of effective Web site design. (2.6.3)
15. Give some examples of Web sites that are "hubs" and other sites that are "authorities". (2.6.3)

Short-Essays and Hand-Worked Problems:

1. What are some of the advantages and difficulties in the standard ("Aristotelian") approach to categorization. (2.1.1)
2. Explain how you would identify the category of "airport". Is an aircraft carrier an airport? (2.1.1)
3. Can you identify any truly unambiguous categories? (2.1.1)
4. What are some examples of prototypes as a model of categorization? (2.1.3)
5. Describe the pros and cons of classification into a single hierarchy versus facets. (2.1.2, 2.5.3)
6. Consider the objects around you as you read this. Briefly describe those objects and propose a classification system for them. (2.1.2)
7. Consider the books you own. Make a subject classification system for organizing them. What are the difficulties? (2.1.2)
8. Critique the effectiveness of the library subject classification system used in your university library or in your town's public library. Pick a work from the shelf and explain how it might have classified in a different location. (2.1.2)
9. Give an example of a classification system you have used that is confusing or ambiguous. How could that be improved? (2.1.2)
10. What are the advantages and disadvantages of using subject classification systems as a primary information access technique? (2.1.2)
11. Ask two friends to develop subject classification systems for the same topic independently from each other. For instance, they might make a classification system for games. Compare the results. (2.1.2)
12. Hierarchies are widely used as a navigation structure for hypertext. Describe why it is useful and what are some of the difficulties in using it. (2.1.4)
13. Pick a section of the Dewey Decimal System and attempt to explain why classification may have been selected. (2.1.2)
14. What makes an effective classification system? (2.1.2)
15. Will search engines replace the need for metadata? (2.1.2, 10.7.4)
16. Develop a system for categorizing the food stored in your kitchen (or your parent's kitchen). (2.2.0)
17. Explain the distinction between "types" and "tokens". (2.2.1)
18. Should subjective metadata reflect the creator's view of the material or the user's likely view of that information?(2.2.0)
19. Select a small domain about which you are very familiar and build an ontology of the concepts for it. (2.2.2)
20. Explain how you might create a thesaurus of (a) your personal photographs and (b) Web objects. (2.2.2)
21. Choose a topic and build a thesaurus for it. The terms should show complete coverage of the area without being redundant. Hint: Use a systematic strategy such as that illustrated in Fig. 2.42. (2.2.2)
22. How is a thesaurus different from an ontology? (2.2.2)
23. Some knowledge representation projects have attempted to map all knowledge. What are some of the difficulties of doing this? (2.2.2)
24. What is a "fact"? (2.2.2)
25. Why are people inconsistent about assigning names? (2.2.1, 2.2.2, 6.2.3)
26. Contrast the definition of documents. (2.3.1)
27. Create a DTD for this chapter of the text. Entities should include: chapter, sections, subsections, exercises, notes, readings, and references. (2.3.3)
28. Explain the difference between DTD and XSLT files. (2.3.3)
29. Create Dublin Core metadata for your course home page. (2.4.0)
30. What is the appropriate metadata for an electronic thesis or dissertation? (2.4.0)

31. What is the relationship between "North by Northwest" and "Der unsichtbare Dritte". (2.4.0)
32. What techniques could you use to ensure the consistency of metadata? (2.4.0)
33. Describe a system of metadata for describing a collection of cartoons. (2.4.3)
34. What is the main advantage of RDF over basic XML? (2.3.3, 2.4.4)
35. What are some of the possible ways the "Date" attribute in Dublin Core could be used? (2.4.4)
36. Develop a Dublin Core description for your home page, a book, or a document. Develop one for a DVD (2.4.4)
37. Explain the differences between simple, qualified, and extended Dublin Core. What are the strengths and weaknesses of each approach? (2.4.4)
38. Using the approach in Fig. 2.42, develop your own controlled vocabulary for either a sport of your choice or for an educational resource used at your university. (2.5.3)
39. Pick a site which you believe supports browsing of different sorts of users. Discuss what categories of users it is aimed for and how it supports each of those groups. (2.6.3)
40. Identify the types of users who are likely to go to a computer company Web site and their information needs. (2.6.3)
41. Describe some of the clues that can be provided to users to support navigation in hypertexts. (2.6.3)
42. How is navigation with a map related to navigation of a hypertext? How might navigation of a hypertext be improved using ideas from a map of physical space? If documents are to be created only for audio presentation, how would they be different from text and image documents? (2.6.3, 9.10.5)

Practicum:

1. **Objectives and Skills:**
2. Do classification. Create metadata.
3. XML for documents.
4. Build a thesaurus. (2.2.2)
5. Layout.
6. Simple XML, (2.3.3)

Going Beyond:

1. Do you agree with statement that "A record of any type of human thought is a document?" Explain. (2.3.1)
2. Describe some of the difficulties in transforming a complex object such as a table from one format into another second format. (2.3.3)
3. (a) Describe a program that would validate whether a document has XML tags which are consistent with a DTD. (b) Build it. (2.3.3, 10.4.2)
4. How would you develop metadata for a movie which is based on a book? (2.4.0)
5. The proliferation of XML standards may lead to a "tower of babble" in the use of different metadata schemes. How could that possibility be minimized? (2.3.3, 2.4.3)
6. Metadata is sometimes described as "data about data". Is that a good description? (2.4.3)
7. If you were developing a system of metadata what terms would you include? (2.4.3)
8. The Dublin Core "Type" attribute is often criticized as being vague. Explain whether or not you agree. (2.4.4)
9. Generate an example of Dublin Core using RDF. (2.4.4)
10. Should classification systems and tools that support them such as data description languages, support multiple inheritance? (2.5.2)
11. Describe and contrast how topics in mythology are cataloged by the Dewey and LCC classification systems. (2.5.1)
12. Develop a subject classification system for Web pages and build a tool to classify them. (2.5.1)
13. Some people argue that the non-linearity of hypertext frees readers from the limitations of linear thinking imposed by traditional documents. Do you agree with this criticism? (2.6.0, 10.2.0)
14. Build an application in frames and Javascript to present guided tours of Web pages. (2.6.2)
15. Pick two Web pages at random and find a path of links that goes between them. Is that the shortest path? (2.6.3)
16. Sample about 20 Web random pages and count how many links they have and report then in a bar chart. (2.6.3)

Teaching Notes

Objectives and Skills: The student should develop an understanding of document structure and learn the basics of XML and RDF, Making effective descriptions using metadata. Developing classification systems.
Instructor Strategies: The threads of XML and collaboration could be emphasized. Advanced practice with XML. Many of the themes of hypertext will be revisited later in other contexts and could be previewed here.

Related Books

- Bowker, G., and Starr, S. *Sorting Things Out: Classification and its Consequences*. MIT Press, Cambridge MA, 1999
- Brachman, R., and Levesque, H. *Knowledge Representation*. Morgan-Kaufmann, San Francisco, 2004.
- Jonassen, D.H., Beisser, K., and Yacci, M. *Structural Knowledge: Techniques for Representing. Conveying, and Acquiring Structural Knowledge*. Erlbaum Associates, Hillsdale NJ, 1993.
- Kent, W. *Data and Reality*. 1stBooks, 2000.
- Lakoff, G. *Women, Fire, and Dangerous Things: What Categories Reveal About the Mind*. University of Chicago Press, Chicago, 1990.
- Levy, D. *Scrolling Forward: Making Sense of Documents in the Digital Age*. Arcade Publishing, New York, 2001.
- Lynch, P.J., and Horton, S. *Web Style Guide: Basic Design Principles for Creating Web Sites*. Yale University Press, New Haven CT, 1999.
- O'Connor, B.C. *Explanations in Indexing and Abstracting: Pointing, Virtue, and Power*. Libraries Unlimited, Westport CT, 1996.
- Rosenfeld, L. and Morville, P. *Information Architecture*. 2^{nd} ed. O'Reilly, Sebastopol CA, 2002.
- Sowa, J. *Knowledge Representation: Logical, Philosophical. and Computational Foundations*. Brooks/Cole, Pacific Grove CA, 2000.
- Svenonius, E. *The Intellectual Foundation of Information Organization* MIT Press, Cambridge MA, 2000.
- Taylor, A.G. *The Organization of Information*. Libraries Unlimited, Westport CT, 1999.

Chapter 3. Tasks and Entertainments

In the previous chapter, we considered the structure of information resources. Here, we consider how it is used and the impact it has. Broad activities.

3.1. Information Behavior

People often find information just by looking around at the world or by by browsing hypertext systems. But, at other times people have to systematically search for information. Because information can be so useful, people have developed systems for managing and retrieving it. Because information reduces uncertainty and helps people make good decisions, people will work to find information. This is true whether they are engaged in everyday activities, or in developing new scholarly theories, or in the analysis of complex situations. While the various tasks and activities have distinctive features, here, we introduce the very simple model, look-decide-do, to illustrate the basic elements of accessing and retrieving information. Specific tasks versus sense-making. Information behavior is an interaction of complex components [**?**].

3.1.1. Everyday Information

Some activities include problem solving, planning, and design. Many goals in finding information: Exploration, sense-making, and task-directed information finding. We may assemble information to systematically make a decision and then to complete a task. We will discuss that approach later in the chapter but we start by considering less directed information seeking (e.g., sense-making).

We are all surrounded by information and use it to answer many explicit or implicit questions: Where to go for products, What your friends like, Doctor's appointments, Knowing recipes and fixing things around the house. When a store closes. Common sense. Temperature. Some of that we encounter and use without thinking about it. We have simple strategies for accessing other types of other everyday information. Remembering telephone numbers.

Figure 3.1: One common type of information exchange. (check permission)

Everyday tasks. Errands and coordination with family members.

Information interactions in families and small worlds. Information poverty.

Although our definition of tasks (see below) is very general, not every activity is most naturally described as a task. Tasks are often not one-time activities. Indeed, people often have long-term roles. Being a knowledgeable person. Integrative activities versus specific tasks. Continually interacting with sense-making. Learning about food.

Sense-making

Many information activities are long term. Fan base. Ongoing awareness of news. Routines.

Combine both cognitive and affective systems. Information avoidance.

3.1.2. Tasks and Work

While everyday information seeking can be considered part of a task, tasks are generally more structured. Tasks also provide structure to the user. Tasks may be characterized in several dimensions (Fig. 3.2). Structured tasks involve a known and well-documented process for accomplishing them, while unstructured tasks require that a process be created. Completing text edits with a text editor could be an example of a simple "unit task," in which one proceeds in a step-wise manner until all of the edits are complete. Making a movie, on the other hand, is a complex task; this sort of task is often ongoing, and may require repetition and consultation with other people.

Task Dimension	Description
Goal directed	Is the task aimed at completing a specific goal? What is the motivation for completing the task?
Routinized	Is there a predictable pattern in the steps required to complete the task?
Locus of control	Are decisions about the task made by the person doing it?
Sequentially	Is there a simple ordering to the task?
Time limited	How much time is available for completing the task?
Complexity	Is the task able to be completed directly in one step or does it require several steps?

Figure 3.2: Dimensions of tasks (extended from[29]).

Tasks, work, and action.

Representing tasks. Representational bias for tasks. Tasks and activities are highly varied. After we have examined the basic processes, we will, later, consider the role of information in more complex tasks in which involve workflows and critical thinking. Workflow (3.10.2) is a representation of how the activity should be accomplished.

Science tasks. Medical tasks.

We start with *Look→Decide→Do*, the simplest of the schematics of information use as we described earlier. However, it is important to remember that tasks, and the processes that are used to accomplish them, are often much more complex than this simple equation implies. When observed in detail, task completion methodologies are exciting and complex systems involving theories and practices of processes, information, strategies, and decisions. While observable in everyday life, tasks and their methods of completion are also particularly important to the design of information systems. Tasks are not always stable; the environment in which they occur may change. Developing effective knowledge representations depends on know the task for which they are used. Reading the news as a type of browsing.

Information and activity management such as alerts.

Management of simple information checklists.

Workflows for Information Seeking

Put another way, tasks provide the context. Tasks may be decomposed into phases. A simple task, for instance, can be described by the *Look→Decide→Do* process. Information collection (the *Look* phase) is an essential part of all tasks. This schematic is not a full description for a complex activities such as critical thinking, design, or science (9.2.0).

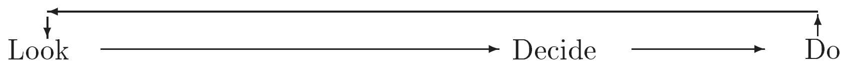

Figure 3.3: A very simple model for using information to complete tasks: *Look→Decide→Do*.

The interdependence of process, information, and decisions is especially clear in goal-directed activities such as design, problem solving, and decision-making. The process may include returning to earlier stages, for instance to collect more information before reaching a decision. Furthermore, the process may be repeated if the action did not have the desired effect or if the task is only one part of a more complex activity. The incentive structure is also important to the outcome. There are several types of search including searching with a metadata indexing system and search with a with full-text. Moreover, exploratory search may be contrasted with routinized tasks.

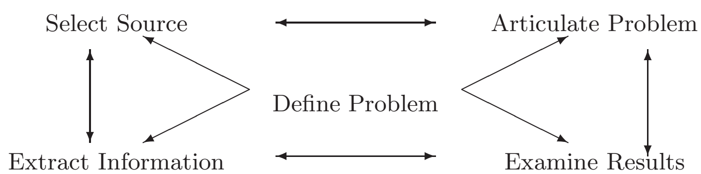

Figure 3.4: A task may also be viewed as problem analysis and information may be gathered and used as needed for the analyses[39].

Task specification. There is a chain of actions and workflow languages. Furthermore, the structure of the task often provides a convenient structure for organizing information related to that task. Procedures for getting something done. Object-oriented methods. Algorithms. In some cases, a sequence of tasks needs to be repeated. Human issues need to be considered. This includes how people think about the tools they use for completing them can impact the efficiency of task completion[24]. For repeated tasks, extra time spent readying the tools required to complete a task the first time may pay off when it is necessary to repeat the task. These may include tasks of individuals, tasks for organizations and workflows. Tasks in organizations are generally associated with roles. Indeed, a role may be defined by the tasks it includes. At the end of this chapter we will consider some formalisms for specifying tasks and workflows. That is, these representations go beyond the simple data models we examined earlier. Structure and phases of tasks with activity theory[21] (3.5.1).

Situational Awareness and Environmental Scanning

Another type of information activity is getting a big picture and having a sense of how different components are reacting to a complex situation.

Figure 3.5: Situational awareness involves knowing what's coming at you. (check permission)

3.2. Look – Information Seeking Behavior

Information gathering is an integral part of tasks. Tasks may be complex, and they often have information needs that go well beyond a simple search. Thus, Information Seeking Behavior is a particularly important type of Information Behavior. Indeed, the process of information seeking itself helps an individual develop a strategic framework for accomplishing a given task[32]; after information has been gathered, a plan can be formulated. The *Look* process can be decomposed as a type of task (Fig. 3.6). There are so many different types of information and scenarios for the use of information we can only make some generalities.

Information seeking can be directly affected by information organization which we discussed in the previous chapter.

3.2.1. Why People Seek Information: Information Needs

One answer to the question of why people seek information is because they have information needs. In some cases, people don't know what information they need. This may be because they don't understand the source of their own questions or that they don't understand how to decompose the problem facing them in a way that is compatible with the available literature. Current awareness. Information needs vs needs for a service. We may use information resources to find out about a new topic. Information needs may be predicted from task-roles such as those of professionals and scholars. Information needs are often associated with roles. We want to know about information needs because the affect the types of services we develop.

While we often think of information needs as task-focused, but in many cases, the task is not clear[18]. Information needs depend on context or the culture.

Shifting information needs in a shifting landscape of information providers.

Imagine that you want to plan a ski trip. You realize that you should check the snow conditions at your destination, arrange for your travel, and find some accommodations near your destination. To go skiing, you need a lot of information. You may need a Web site that lists ski areas. You need directions and need to find a hotel.

We begin by asking what triggers people to start looking for information. Specifically, at what point does one realize the need to start seeking information, and once aware of the "information need," what strategies are adopted? The desire to seek information can be caused by many factors such as: an affective (uncertainty) desire to learn more about a given subject, domain, or situation; situational (task) concerns, in which an individual needs information to accomplish an agenda; or cognitive dimensions (knowledge), in which knowledge or information is obtained for its own sake.

Tasks and Information Needs

Information needs often reflect a task in which a user is engaged. Information needs for supporting roles and activities in which users engage. Some tasks require high-recall searches; that is, they must retrieve complete information. Legal and medical searches need to be complete for a professional to give the possible service and avoid malpractice (3.3.3). Other tasks may not need a large amount of information, but only a limited amount of very accurate information from trusted, highly authoritative sources. Authoritative information versus credibility of information. Science-related information tasks [**?**].

People may even plan to satisfy "anticipated information needs". A person may subscribe to a newspaper in this expectation that it will help meet information needs in the future.

Awareness of Information Needs

When skiers decide to go on their trip, there are several things they should determine before beginning. They have information needs: How to get there. What equipment is necessary. How much the tickets cost, and so on. People develop a more focused awareness of an information need (Fig. **??**). We call these pre-conscious needs visceral needs. As they begin to formulate their plans, the group becomes aware of some of their needs by, for instance, making a list — now they have conscious needs. As information needs are shared and further developed, they become “formalized”; finally, depending on what kind of information they have gathered, they may have to find ways to compromise in terms of their needs. Implications for question answering (3.3.2). Awareness of one’s information needs is a type of meta-cognition (5.11.4). It may develop gradually as a person develops a better understanding of the issues involved.

Browsing. Non-task oriented “divergent” information behavior. Personalization and personal relevance.

3.2.2. Types of Information Seeking: Find, Identify, Select, and Obtain

When a person faces an information need, that person faces many choices which may be summarized as: find, identify, select, and obtain[2]. Information services and systems should be designed to support the users in these different stages.

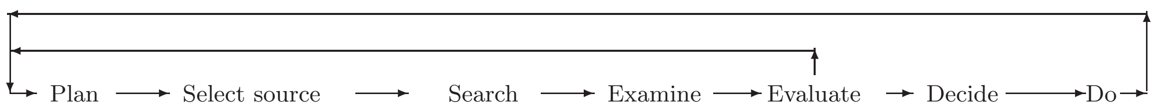

Figure 3.6: In this idealized schematic, the process of collecting information, that is the *Look* part of Look→Decide→Do, is itself a cycle (use IFLA: find, identify, select, obtain).

When a person is aware of their information need, that individual may seek information to fill in a perceived “gap” between what they currently understand and what they believe they need to understand. As in the example of planning a skiing trip the person may elect a strategy for attempting to access that information. The first step is source selection. Choosing from a variety of search engines. For example, the sources must be credible and cost effective.

The information seeker must describe the information they are seeking into a language that the system can understand. This is the difference between formalized and compromised statements of information needs. When considering how to express an information need, either to another person or to a system’s search engine, users may attempt to manage their information load, or to develop a cognitive framework with which to interpret their need. People may be trying to find facts, but in a larger context. They are often trying to make sense of a situation[19].

Information seeking may follow from information needs. People tend to approach the act of finding information differently, depending on the individual. Everyone has a personal knowledge strategy, in which an order of operations, past experience, and trusted sources all figure. Given an information-seeking task, a person will think about the question(s), consult their experience, select a strategy, select a source(s), and begin.

Users may engage in “information triage”; they may determine the broad scope of the information sought; what type of information is needed and what queries should be used to seek it.

Individuals often consider cost, quality, effectiveness, and convenience when determining a search strategy. All of these criteria contribute to an information resource’s perceived utility, which largely determines its appeal to users (3.3.3). Different user interface genres have been developed to highlight the utility of an information system. Users will often have a favorite information source, based upon their perception of its utility and interface design, that they regularly use first when seeking information. Effect of information systems on information seeking[4].

Information seeking may fail Possibly because the user’s question was simply unanswerable, because the information is not included in the information system, or simply because the user can?t figure out how to access the information from the system. The latter case is known as retrieval failure.

Conversations with colleagues
Personal ties
Conversations with consultants, subcontractors
Conversations with clients
Conversations with vendors
Internal technical reports
Reference librarian
Product literature
Textbooks, handbooks
Codes, standards
Industry newsletters
Consultations with academic researchers

Figure 3.7: A search may shift across social, accessibility, and quality levels as it is refined[49]. Everyday interaction with information is often limited to conversations.

3.2.3. Access Genres

There are many ways of interacting with information resources. Combine conceptual models with interactive with real collections. Browsing, searching, and filtering are general forms of information searching, and form the access genres that we will consider here. Relates to information behavior and tasks. Some support information access that is task-oriented. Others support "serendipity," or people's chance encounters with information that is useful to them even when they are not looking for it.

Filtering and Alerting

Some types of information, such as news, are streamed and that can be filtering. A filter has criteria by which incoming material will be judged; material that fits the set of criteria will be allowed through, but material that does not will be filtered out (Fig. **??**). Anticipated information needs are served by setting up a filter.

Filters can employ a range of techniques. Some may be based on attributes of the messages such as the source, a priority rating, or Some have the user specify specific terms to enter. Suppose you wanted all of the news stories about California as they appeared on the news wire. You could set up a filter that channeled only stories containing the word "California" in the text to your account. Filtering and RSS feeds. Others may attempt to infer the terms by observing the users choices. Sometimes, filters are known as "alerting services" since they notify you of the material and events in which you have expressed an interest. Rule-based filtering. Most filtering systems require users to enter terms that are matched to terms in the filtered documents. Filtering systems that are adaptive, or learn a user's preferences and apply filters automatically, are being developed. These user models, also called "implicit" models (as compared to "explicit" models in which the user selects the filters) are designed to reduce user work and more precisely apply filtering terms. Filtering spam (10.3.2). Filtering web content for children. eRules for processing email campaigns. Media aggregators and social curation.

Browsing

Browsing generally proceeds without a formal goal. That is, the material is interest but is part of an active task. Many serendipitous encounters with information will occur as a result of accessing information in this manner. Browsing is well-supported with hypertext (2.6.0) because it allows a user to easily follow a train of thought, or a series of related ideas. Hypertexts. Supporting browsing with information visualization. Browsing hierarchies. Linearity/non-linearity (hypertextuality)[34].

Searching

Search is often problem-driven. When the user has a specific information need, the user may be more likely to conduct a search. Searching is distinguished from other means information searching by the user actively generating a query. If a searcher is trying to obtain a copy of an item or document that they know to be in a collection, they are conducting a "known-item search". Calling a video store to ask if they have any copies of a movie is also a type of known-item search. By contrast to known-item search, exploratory search is aimed at getting a high-level overview. Exploratory search many combine browsing and searching.

We have already considered searching structured data sets (3.9.0). Searching metadata versus full-text queries with search engines (10.7.4). We will consider the details of search engines later (10.7.4). Because people do not know the details of the search algorithms that a search engine employs, they cannot truly optimize their searches. Rather, they may rely on mental models (4.4.4) of how the search engines work and even what terms a given author may have used to express an idea.

Searching may employ of questions or queries. Questions are natural language expressions. They are most commonly employed when dealing with a human search intermediary. This could be an actual person or a conversational agent (11.10.4). Queries and questions can be categorized by (a) topic and (b) the kind of answer required. Queries are related to questions but are generally not true natural language statements. Generally, they attempt to describe attributes of the objects being sought as closely as possible. Questions and question-answering systems will be considered in more depth in (10.12.0).

3.3. Complex Questions and Searches

Questions and queries can range from searching for answers about simple facts (factoids) to exceedingly subtle or even unanswerable points. Consider the following complex questions:

> What is the second most deadly viral disease in Africa?
> Are there any foods that are prohibited from being brought to Canada by tourists who have been visiting Belgium?

What's mores, searches may also confused or implausible, such as: Who is the current king of France? Similarly, what is the atomic number of coal? Moreover, many questions have no definite answer. [35].

It is helpful to know what kind of answer is expected when setting out to answer a question. Some questions do not actually seek to elicit information, but instead state an opinion or make a point. Could we make a taxonomy of question types? So, question taxonomies which categorize questions by the types of answers which are expected have been developed. Categorizing question types can get more complex when people are ironic. Categories of types of questions which get asked (Fig 3.8). There are a variety of roles for information specialists beyond reference services to collaborative information retrieval.

3.3.1. Strategies for Answering Questions with Information Systems

Some queries are so complex that they cannot be answered directly. One way to handle them is the brake them into pieces. Many strategies have been proposed for combining those results. One way to break down a complex search is to analyze the sequence of steps required. Is it better to search that goes from general information to specific information? Or, would it be better to start with very specific information and work backward, acquiring ever more general knowledge?

Search Strategies

Many of these complex search strategies and are based on Boolean techniques (3.9.2) are more productive than other search procedures such as a ranked-retrieval search (10.9.2). Doing this allows for sequential searches. It also suggests that a sequence of searches that lead toward an answer of the original question.

Several systematic strategies have been proposed. Some of these are based on just analysis of the queries other strategies are based on analysis of the documents retrieved in initial queries (Fig. 3.10). A complex task may require searching a large number of information sources and the ultimate answer may involve the integration of many separate pieces of information. Information from one source can be used to double-check the information from another source. This is particularly useful for checking the validity of informal sources. A neighbor's advice on a good restaurant (informal channel) may provide

Types of Answers Expected	Examples
Assertion	
	Would you spell your name?
Request/Directive	
	Would you open the window?
Short Answer	
Verification	Is it raining?
Disjunctive	Are you happy or sad?
Concept completion	Who did this?
Feature specification	What color is the dress?
Quantification	How many people were at the last class?
Long Answer	
Definition	What is an “oxymoron”?
Example	Can you give me an example of electron bonding?
Comparison	What’s the difference between a beagle and a terrier?
Interpretation	What does this mean?
Causal antecedent	What were the causes of the Civil War?
Causal consequence	What happened when you got elected?
Goal orientation	What were you trying to accomplish?
Instrumental/procedural	What are the items for the agenda?
Establishment	Where were you on the night of October 17?
Expectational	What did you think would happen?
Judgmental	What was the importance of what she did?

Figure 3.8: A classification of questions based on the type of response expected (adapted from[33] with examples added). Determining the question type helps in answering it.

```
(((master settlement agreement OR msa) AND NOT
(medical savings account OR metropolitan standard area))
OR s. 1415 OR (ets AND NOT educational testing service)
OR (liggett AND NOT sharon a. liggett)
OR atco OR lorillard OR ...
```

Figure 3.9: Fragment of a complex Boolean query. Specifically, this is a part of a search for a health items for court documents from the tobacco settlement.

valuable information that is unavailable by any other means, but consulting the phone book (formal channel) to determine if there is indeed any such restaurant is a useful way to determine whether or not the advice may be valuable.

Technique	Description
Building Blocks	The searcher identifies key parts of the problem, usually the most specific facets, and searches for them first. Other facets are then added.
Successive Fractions	A general query yields a large collection of documents. The searcher then successively applies restrictions that narrow down the collection until only very specific documents remain[26].
Pearl Growing	Finding quality material often leads to other quality material. The user starts with a small set of relevant documents and uses them to build outward.

Figure 3.10: Strategies for complex searching based on question analysis and on query reformulation following inspection of documents returned by an initial search.

For complex Web searches, a systematic approach is needed. For a complex search task, a searcher should not expect a single search to be comprehensive, but should count on performing several searches to accumulate partial answers (Fig. 3.11).

> I do a fair amount [of preparation]. I always make a list of keywords, synonyms and alternate words, and think about which words should be truncated. I think about what databases to search and make a note of them. Then, as I do the search, I refine it and check off what I've searched. Depending on how complex the search is and how many alternate terms it includes, my search plan is more like a diagram, with several columns of alternate terms separated by the appropriate connectors.

Figure 3.11: A searcher's description of strategies in preparing for searching[25].

The Dynamics of Information Seeking

When people look for information, they need to make certain decisions whether explicitly or implicitly. Looking for information takes effort. When trying to make a decision, how should we determine when the optimal amount of information has been found. The issues are when that transition occurs and when to stop. Fig. 3.12 tracks the choices made by an individual during a search[15]; that it is somewhat hierarchical, with the initial, broad task occupying the most directive position, with all the supporting tasks arrayed below it, and in a sense working for it. We can also note from this figure that completing a task is not a one-step process. Several stages must be negotiated before a result is achieved. This is partly do to the complex nature of some tasks, but also due to the fact that there is an interaction between the user and the environment. Some tasks cannot be done at just any time.

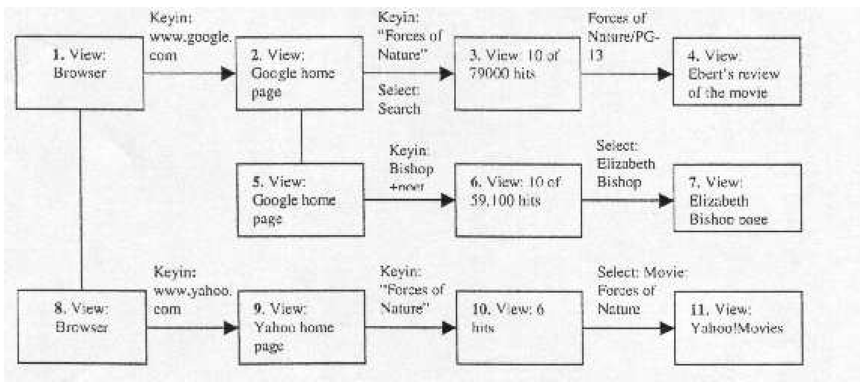

Figure 3.12: This problem-behavior graph trace of search behavior[15]. Actual searches are often non-linear. (redraw) (check permission)

Most web-based information combines both searching and browsing. Shared search trails. Behavior graph.

Determining the expected value of information. What is the value of a weather forecast? How much effort are you willing to put into collecting information. These can be calculated as the expected value of information[5] (8.13.2).

Estimates of how much information has obtained from each source and when that runs out, we stop seeking for information. Clues for estimating the value of information resources. Surrogates. Richness of information resources. Foraging theory[41] (Fig. 3.13).

Foraging and the introduction of information systems. Amount of information versus The accuracy of decision and confidence judgments. The value of some information is understood only after seeing other information. Information scent is also related to relevance judgment factors (3.3.3). This is a type of task specification.

Affect in information seeking.

Even More Complex Questions

Some questions are so complex that the can be decomposed and answered in pieces. For instance "How

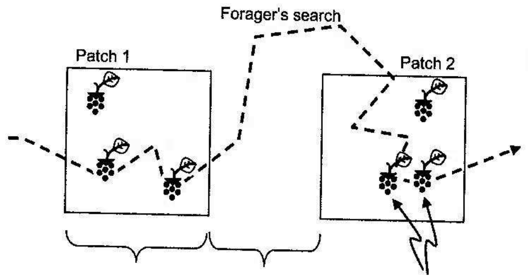

Figure 3.13: Information seeking can be thought of a type of foraging[41]. Thus foraging theory descri how information consumers will move from one information source to other information sources. (redraw)

should we reform schools to provide the education for students?" Only fragmented clues about them can be gathered and some evidence supporting one position or another can be synthesized. A searcher may trade off the effort required with the formality or detail of answer required (Fig. 3.7). Beyond the capability of individual researchers, organizational teams, and scholarly communities (9.0.0) can provide more detailed analysis of complex issues. The first reaction is to ask people who you know. Developing a social network of reliable information resources. Small worlds of knowledge. They know who knows what on which they rely when needing an answer.

3.3.2. Reference Services

Individuals might need assistance in answering questions. They may not be familiar with the area they are researching. In such cases, a human intermediary may help users to find information resources. These may include questions about how to use reference materials as well as helping the person to answer questions directly. Customer service (8.12.5). There are two levels of reference: First, finding authoritative answers to a question. Indeed, there is a strong preference for providing answers based on information resources rather than providing personal opinions. Second, teaching users how to answer their own questions. This may go beyond simply answering the question. Indeed, the answer may not be given directly; rather, the reference service may give pointers for the searcher to find the answer for him or herself. Provide instruction about the resources.

A searcher may be unfamiliar with a field or its information resources, so that an intermediary may be of assistance. Intermediaries are specialists who help individuals meet an information need. An intermediary often knows the types of sources available as well as general search strategies; they employ these strategies to help the user frame a query more effectively. An intermediary might conduct a "reference interview". The user does not necessarily have a clear picture of the issues they use when they describe what they are looking for. In some cases, users may be confused about the domain they are studying or the nature of the information resources they are trying to explore. A person might want to search about treatments for sniffles, but they may really have a more serious health problem which, in turn, has been brought on by not paying their heating bills. Thus the question may become how to get those bills paid. Question answering as tutoring (5.11.3) and may require instructional design (5.11.3).

Fig ??.

Figure 3.14: Information kiosks will answer questions but usually only within a limited domain.

Question Answering Services

Question answering from online communities (5.8.2).

Figure 3.15: Yahoo Answers supports cooperative question answering. Some quality control is provided by rating of "the Answer".

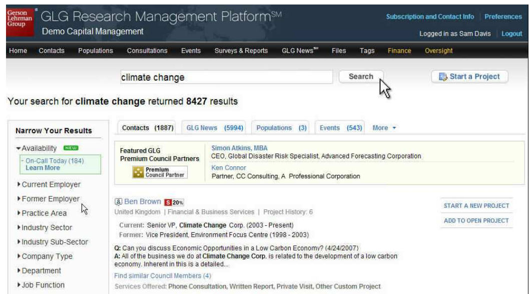

Figure 3.16: Service for contacting an information specialist. This web site provides listings an index of consultants and in this case a consultant is located who specializes in financial implications of climate change policy by consideration of descriptive terms. (check permission)

Frequently Asked Questions (FAQs) compile questions which are asked so often by a given population that it is easier to post an answer once so they can be browsed. Social question answering. Minimizing the effect of spam with "the best answer". Social search (10.11.1) may used friend's profiles as context to support searching.

Search Intermediaries and Reference Interviews

An effective reference interview may start with a clarification dialog. A first step in working with an individual might be to find about what they are trying to accomplish and why. In short, this is determining a person's information needs (3.2.1). The intermediary may work with the patron to determine what information will be of most use as well as exploring other parameters of the search such as time and cost constraints. Because this involves the patron, this is also sometimes called query negotiation. The intermediary may attempt to develop a model of the user's state of knowledge about the problem the user is investigating. In neutral questioning [20] the intermediary comes to understand the user's questions from the user's viewpoint may be termed question negotiation. Leading questions can be avoided by using simple sentences with a minimal number of assumptions. Many of an information intermediary's activities are similar to tutoring; they may assess the client's information needs in much the same way a tutor assesses the current state of a student's understanding (5.11.3).

Virtual Reference Services and Social Media Supported Search

Reference services can be delivered remotely. by telephone, email, or chat. We can call these virtual reference services. The quality of the interaction (e.g., social presence) is affected by the richness of the medium [3]. This can also be a step toward automated question answering (5.6.5) since text processing techniques can be applied. Virtual reference desk interaction via email. When reference interaction virtual and synchronous, the questioners can get information where and when they need it. Social question answering (3.3.2). To the extent the interaction is computer-mediated, at least some of the responses might be automated. Moving toward question answering systems (10.12.0) but interaction on reference may require many different types of expertise. Social search in the sense of social media facilitating search (10.11.1). Beyond question answering, a question referral system, as distinct from a question answering system passes questions to experts. Workflow for reference answering system. Or, the question answering may be crowdsourced. Wiki-answers. Mobility and information where and when its needed.

Reliable Sources and Reference Works

Identifying good information. Not only should the information be authoritative but It should be at an appropriate level. For example, book recommendations for children should usually be at a simpler reading level than for adults.

Effective reference services should use quality information for searches and refer the user to reliable sources (5.12.2). There are some rules of thumb for that. Pages with citations are likely to be more authoritative than those without. Indeed, the reference service should include showing the patron how to answer similar questions for themselves.

These are standard compilations which are accepted to be autoritative. Dictionaries and definitions (6.2.3). Atlas, Encyclopedia. Phamacopia. Standard reference works. Authoritative works, websites, and databases. Reference collection (7.1.3). Also, in science reference data sets (9.6.0). Reference works are based on the notion of authoritative resources. Who decides what is authoritative. What kinds of authorities do we accept? (Fig. 3.17). Traditionally, well-regarded scholars were asked to prepare encyclopedia articles. This approach has been challenged by Wikipedia in which articles are authored and edited by community consensus. While Wikipedia has developed procedures to promote integrity (10.3.2) they might be susceptible to a concerted attack.

From: http://physics.nist.gov/constants

Fundamental Physical Constants — Electromagnetic constants

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
elementary charge	e	$1.602\,176\,565(35) \times 10^{-19}$	C	2.2×10^{-8}
	e/h	$2.417\,989\,348(53) \times 10^{14}$	A J^{-1}	2.2×10^{-8}
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,758(46) \times 10^{-15}$	Wb	2.2×10^{-8}
conductance quantum $2e^2/h$	G_0	$7.748\,091\,7346(25) \times 10^{-5}$	S	3.2×10^{-10}
inverse of conductance quantum	G_0^{-1}	$12\,906.403\,7217(42)$	Ω	3.2×10^{-10}
Josephson constant[1] $2e/h$	K_J	$483\,597.870(11) \times 10^9$	Hz V^{-1}	2.2×10^{-8}
von Klitzing constant[2] $h/e^2 = \mu_0 c/2\alpha$	R_K	$25\,812.807\,4434(84)$	Ω	3.2×10^{-10}

Figure 3.17: Reference works, such as dictionaries and tables of scientific constants, provide standard and authoritative definitions. Typically, they are consulted about very specific questions.

3.3.3. Evaluating the Effectiveness of Retrieval

How do we measure the effectiveness of different search and question answering techniques? It seems obvious that an information system should provide users with information that is relevant for tasks they are trying to complete. The information or information system must be both relevant to the user's needs and readily accessible (5.11.3). While measuring relevance is most often associated with Search engines, it can also apply to many types of information access such as following hypertext links. Although, the success at answering complex questions is is harder to measure. System evaluation (7.10.2). Linking as an indication of relevance.

Relevance

Even for basic techniques, the first problem is defining relevance itself. A classic definition of relevance is that a document satisfies a person's information needs. However, that tends to confuse the subject of the document with whether it is actually useful for the reader. Here, we will focus on relevance as topical relevance. In the simplest view, relevance is logically all-or-none. Either it completely satisfies the user's needs, or it is termed irrelevant. While this position is arguable, it is often adopted in text retrieval research because it is necessary to make the calculations tractable (it is difficult to calculate using degrees of relevance). Sometimes, this property is termed "pertinence"[45]; that is, the document content might be pertinent to an information need (3.2.1) but not relevant to a particular searcher who, for instance, may already be familiar with the claims discussed.

Relevance can be user-specific depending on the individual, or even on the task in which that individual is engaged. There can be different levels of relevance, ranging from base-rate information to personalized user and task relevance. While measures of relevance are often highly subjective, behavioral indicators of relevance can be observed by an outsider. The amount of time spent viewing a document can be a sign of relevance; this may be useful in personalizing relevance. Relevance from the user's viewpoint in terms of cognitive comprehension. Personalized and momentary relevance. Leading the individual to understand the important dimensions to consider. Counter to the echo chamber. Multiple editors to provide a variety of opinions. Filter bubble. Serendipity. Hypertexts. User engagement.

Precision and Recall for Relevance

When we retrieve documents from a collection, we would like to retrieve all relevant documents and as few non-relevant ones as possible. The procedure used can then be evaluated based on how well the return list matches an independent rating of relevant documents. The most common metrics for measuring the quality of retrieval algorithms are "precision" and "recall". As described by the formulas below, precision tells us how relevant documents are in a list returned to a search query. While precision refers to the number of relevant documents retrieved from one query out of the total number of relevant documents in the collection.

$$Precision = \frac{number\ of\ relevant\ documents\ retrieved}{number\ of\ documents\ retrieved} \tag{3.1}$$

$$Recall = \frac{number\ of\ relevant\ documents\ retrieved}{number\ of\ relevant\ documents\ in\ the\ collection} \tag{3.2}$$

		Retrieval		
		Retrieved	**Non-Retrieved**	**Total**
Relevant	**Relevant**	10	10	20
	Not-Relevant	20	60	80
	Total	30	70	100

Relevance Judgment Factors, Perceived Credibility, and Perceived Relevance

When a person views a document or a document surrogate after a search, that person needs make a decision about whether a document is relevant or not. After a search, a list of surrogates for potentially relevant documents may be presented (10.7.3). Based on these, the user often makes a quick judgment on whether to examine the given set of documents further. "Relevance judgment factors" are aspects of a surrogate that the user employs to decide whether to select a resource. These may include the quality of the author, and the length and apparent complexity of a document. Perceived credibility[43].

Because there are a variety of information sources that a person may select from, the searcher may consider whether a given source is optimal or whether they should be switching to another source; they may judge the effectiveness of an information source. It is difficult for users to know about the relevance of documents; rather, they judge the service on impressions. Furthermore, it is difficult to evaluate interactive retrieval because the results often depend heavily on the searcher and the task.

Utility of Information Resources

Topical relevance is only one factor that affects a user's decision to access a document. A document may match a topic in which the user is interested but still not meet a user's information need. It may be written in a foreign language or it may be very similar to a document that the user has already examined. In these cases, we may say that it is relevant but not "useful". Novelty, credibility, time all affect utility. to retrieve, language, and cost. Measuring the value of information (8.13.3).

$$Utility = \frac{Relevance * Validity}{Work} \tag{3.3}$$

Evaluating Interactive Retrieval

Because complex searches are generally conducted as part of a larger activity, it is important that the search tools be helpful in completing that task. We should allow the user to interactively explore the relevance judgment factors of the surrogate documents (3.3.3). Precision and recall simply measure the performance of the search algorithm; for useful retrieval, we are interested in how effectively the algorithm fits the task, and, ultimately, in the quality of work produced from the interface. Search engine interfaces (10.7.3). These issues are also similar to the usability issue for other information systems (7.10.2). Relevance judgment factors.

3.4. Decide

After information is collected it is often used for making decisions and those decisions are often acted upon. Evidence-based decision making – using data to make decisions. There is a range of complexity and difficulty in the complexity of decisions. Simple decisions versus complex decisions when the outcomes are not known [47]. Sometimes, accurate decisions can be made quickly by a person with a great deal of experience. An expert is able to get rid of distracting information, experts become less prone to act on a hunch when a slightly more sophisticated decision model would do better [1]. However, human decisions are not always accurate, as we discussed earlier, there are many biases in human information processing. Here, we focus on decision formalisms, but later we'll consider other approaches such as cognitive distortions in human decision making and group decision making.

Decision strategies vary widely. Human inference and decision making (4.1.1). In some cases decision are made after extensive analysis (3.4.2)and in some cases they are made very informally. Managers are sometimes told simply to make decisions based on their "gut". This can be a challenge since the may show biases in availability (4.3.4). It is also possible that formal models are being mis-applied.

3.4.1. Decision Strategies and Formalisms

While we make lots of decisions without thinking much about them, there are other decisions that we evaluate systematically. Here, we consider some of the principles for decision making. Some decisions can be made by rule following and exact measurements while others are just based on judgments of plausibility. Multi-criterion decision making. Sensitivity analysis. We consider additional formalisms for decision making. Sometimes, we don't know what the critical features are. Feature analysis and classifiers. These procedures need to be balanced by recognition of the costs and benefits. Direct and indirect costs. Opportunity costs. Goals. Objectives, objective hierarchy, multiple objectives.

Decision Rules and Decision Trees

When a complex decision needs to be made rapidly, it may help to have a pre-calculated tree of choices to guide a decision maker. Indeed, this minimizes the need to obtain and weigh complex information. How should a busy doctor treat a patient for the possibility of a heart attack (Fig. 3.18). The simplest decision trees have a Boolean OR of options; that is, every choice has one or the other alternative. Furthermore, they are binary trees with exactly two (yes/no) choices at each level. Techniques for clarifying possible decisions and laying out open possibilities, this method involves some of the downfalls of categorization, as one is effectively trying to categorize decisions as "yes" or "no," when they may be neither or both. Later we will consider generalization of decision trees (-A.7.1). However, these are not flexible when conditions change.

Danger of applying decision tree too routinely. Part of medical decision making ((sec:medicaldecision)).

Decisions Based on Comparing Preferences for Attributes

There are many ways that a decision can be decomposed. Integrating many dimensions. There are many decisions that require us to weigh the attributes of several different choices. That is, making a decision in which different options have different variables, pros and cons, associated with them. There are many strategies for these types of decisions. One way of looking at them is through paired comparisons — this method of decision analysis is a good way of measuring the relative importance of different options (Fig. 3.19). In it, comparisons are made between options one at a time, to see which

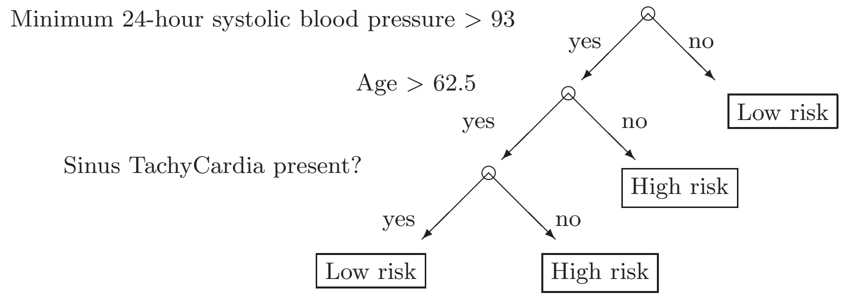

Figure 3.18: A decision tree for a hospital to use for determining a patient's the chance of a heart attack[16].

one is most important. The most important out of all of them would be the option that "won" more of these head-to-head battles. Another approach would give weights to each attribute and a numeric score could be determined from that. (-A.9.4).

	Type			
Dimension	Sedan	Compact	Sports Car	Pickup Truck
Price	Hi	Low	Hi	Mid
Fun	Low	Low	Hi	Low
Durability	Hi	Mid	Mid	Hi
Safety	Hi	Low	Low	Mid
Seating	Hi	Low	Low	Mid
Other uses	Mid	Low	Low	Hi

Figure 3.19: Suppose you were deciding which type of vehicle to purchase; and have been rated on several dimensions. What strategies might you adopt to narrow down the choices?

Formal choice theory and determining utility. Many of these factors depend on determining subjective values and not easy to pin down, but there should be constraints among them. For instance, transitivity should hold.

Decision Making with Pressure, Uncertainty, and Risk

Many decisions are made when there is little time pressure. Typically, this increases cognitive load (4.3.3) and options are not able to be explored fully. Uncertainty and risk also affect decision making. We can never have complete confidence that we have all the necessary information to make a decision. Decision-making occurs in classification and recognition processes. Sometimes, decisions must be made in a state of uncertainty. This may be due to confusing or inconsistent information (noise), or there may be data that applies to more than one decision or possibility (overlap). Fig. 3.20 shows a decision threshold applied to data that is not easily separated between true information (i.e., which is explained by a model) and noise (-A.9.2). Indeed, there is in fact no way to separate them perfectly, so there will always be some errors. "False alarms" come from saying there was a hit when, in fact, there wasn't. "Misses" come from saying there was no information when there actually was (Fig. 3.21).

Risk

Many decisions involve risk. Risk models.

Decisions with Strategy: Game Theory

Game theory is an approach to understanding and predicting the choices made by people when interacting with other people for a given set of payoffs. Game theory is an idealization but it does highlight some types of decision making. Simple economic decisions (8.7.0) reflect not only the individual's preferences but also preferences of others. That is, when two people interact, their actions affect each other, and the strategy producing the greatest benefit to one individual over time may not be beneficial to the other individual(s). Hence, an individual's optimal strategy may be either competitive or cooperative. In a cooperative strategy, some form of negotiation is usually required (3.4.4).

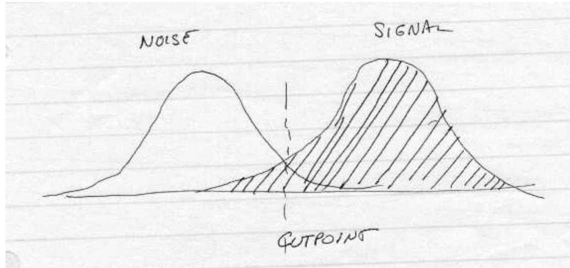

Figure 3.20: A decision may involve finding a signal in a noisy environment. Whether a noise you hear is really your doorbell. A decision cut-point is shown between the two distributions. In the middle, the two distributions overlap and it is not possible to tell the distributions apart. (to be rendered)

		Actual Signal	
		Present	**Absent**
Observer's Judgment	**Yes**	Hit	False Alarm (False Positive)
	No	Miss (False Negative)	Correct Rejection

Figure 3.21: 2x2 table for decision making. An effective decision policy would minimize the hits and correct rejections. The observations might not be accurate since they might be due to noise, as suggested by Fig. 3.20. (check permission)

Game theory be useful for determining information security strategies. Game theory provides a model for comparing payoffs of interactions between players. In this approach, "games" are modeled as interactions in which each player has several options. The choices made in such games will often tend toward an equilibrium. With a fixed number of players and game rules, these games tend to simplify the factors inherent in decision analysis. In a zero-sum game, the net payoff is fixed. What one person wins, the other person loses (Fig. 3.22). However, some other games can be "win-win" — both sides come out better because of the deal (Fig. 3.23).

		Player A	
		A1	A2
Player B	B1	1,-1	1,-1
	B2	3, -3	5, -5

Figure 3.22: In this game, whatever on player wins is exactly balanced what the other player loses. The payoffs to the two players always have a net of zero. This is "zero-sum" game. (merge with next figure on to same line)

		Player A	
		A1	A2
Player B	B1	-1,-1	-1,1
	B2	1,-1	5, 5

Figure 3.23: In a win-win game, players can do better by coordinating with each other. In the example, Actions A2 and B2 give both players a better payoff than the other options.

Additional examples in game theory (-A.9.3).

QUOTE Collaborative multidisciplinary decision making using game theory and design capability indices ENDQUOTE

3.4.2. Decision Interfaces and Analysis: Decision Support Systems (DSS)

Supporting reasoned decision making.

While we have been considering the simple *Look*– >*Decide*– >*Do* model, for some tasks, there is a tight loop interaction with a model which helps in evaluating the implications of various options prior to making a complex decision. Tools for exploration and analysis prior to making a decision. Decision aids.

Collecting information may still be an important aspect. Information analysis. Competitive intelligence. Differing types of evidence for various judgments. Visualization tools (11.2.5).

Decision support systems (DSS) are complex task environments and tools that provide information and analysis tools to support decision making. Ideally, the will reduce cognitive load and provide the opportunity critical thinking. A manager could use a DSS to predict the prices to charge for widgets her company is making. Such tools are called Management Information Systems (MIS) (7.3.2). Similar workspaces are used for other applications such as scientific research (9.2.0). Intelligence analysis (7.11.1). Visual analytics (9.6.5). A spreadsheet is a simple decision support tool.

Storing and interacting with partial work products.

Decision support systems allow users to collect and analyze information. Ideally, they world facilitate effective decision models. The system might help to do this by analyzing the cost of similar products, the cost of production and marketing, and the profit margin and growth the company hopes to achieve. DSS systems may also provide a task environment (3.5.4). These environments provide tools (data sorting, searching, representation, etc.) specifically designed for a particular task that allow a user to make better decisions. Analyst's interfaces. Supporting explanations (6.3.4) with a type of discourse structure. Increasingly, such systems incorporate task-oriented digital libraries including text resources such as news reports and qualitative data.

Task-specific desktops. Tool ecologies (4.11.2). DSS applications may also include geographic and resource constraints. Similar projects for agriculture, water use, and biological diversity. This could also includes GIS and even sensors (Fig. 3.24).

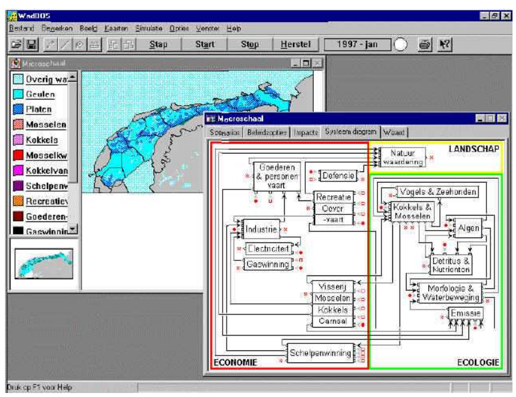

Figure 3.24: A decision support system which models the ecological dynamics of the Wadden Sea[7]. (check permission)

These systems allow users to move beyond simple decision making to planning for complex activities. Thus, they use strategic knowledge (7.3.6). Understanding significant concepts affecting the decision can be based on concept analysis, or grouping objects (or ideas) by way of common properties. This, concept analysis can be used to construct a decision support system from existing information. In a complex organization such as a large business, for example, important data are often spread across many databases.

DSSs are often used models to make forecasts. Statistical analysis applies probabilistic outcomes to predict an outcome (and therefore recommend a decision) and logical analysis determines what outcomes flow directly from the available information. DSSs often employ mathematical models such as regression and statistics (-A.10.1). Many of these problems can be avoided by basing forecasting on high-quality data. A DSS is built around a model or simulation. Simulation and multi-scale simulation (9.5.0). Basing inferences on functional relationships. Sensitivity analysis (9.5.4). Provenance of evidence and decision support systems. Issue tracking.

There are problems in relying too much on the validity of such models (9.5.2).

Complex Decision Support (CDS)

Complex decision support (CDS) beyond basic DSS. For instance, a business might be concerned with broad issues of competitive intelligence. Supporting critical thinking (5.12.0). Wicked problems. Some complex decisions are really decisions about policy or long-term strategies. These systems may use planning models (3.7.2).

3.4.3. Group Decision Support Systems (GDSS)

Group-generated solutions can sometimes be better than individual solutions; they utilize many minds and a collective repository of experience instead of relying on the judgment of one person. Here we discuss the techniques for refining the ideas a group generates. Argument and debate help to illuminate issues. Argumentation systems (6.3.5). Group dynamics (5.6.0). Groupwork systems and CSCW. We should distinguish between participatory systems and group systems. Later, these will be extended to the consideration of social decision marking (8.4.3). Distributed cognition (5.6.1).

Supporting Collaborative Brainstorming

Stages of problem solving. Given a specific project or decision, many groups start by generating ideas – brainstorming. The typical brain-storming activity begins with a free expression of lots of ideas. The main objective is quantity, not quality. While crucial at later stages, criticism is a distinct disadvantage when applied too early in the idea generation process. Indeed, anonymity can often be an advantage in allowing people to express their opinions freely. These ideas can then be clustered into categories for further discussion with an affinity diagram.

Collaborative workspaces. Awareness of common goals. Collaborative discussion, analysis, and argumentation systems. Wikis (10.3.2) for discussions in a community of practice. Ad hoc roles for members of discussions in collaborative teams. Task groups.

Group Analysis of Complex Problems

One aspect of collaborative work. Many groups are organized with individuals representing different constituencies or expertise. Another strategy for collecting information relevant a topic is to systematically collect opinions from a variety of experts and stakeholders. Levels of expertise. Experts in a variety of areas should be included. This might include, for instance, specialists on content, on task requirements, and system development.

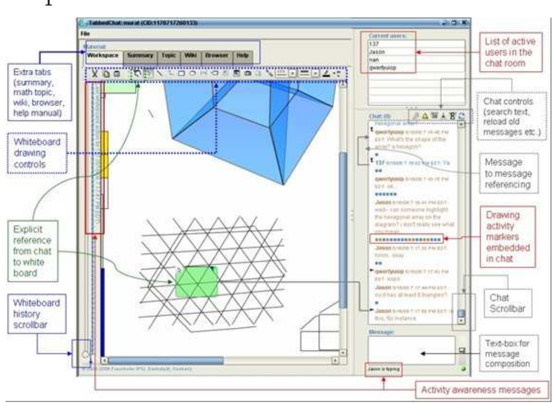

Figure 3.25: A whiteboard interface that allows users to share comments about displayed objects. In this case, it is used by virtual math teams[6].

The selection of the group members can be randomized, or determined based on domain knowledge. This is a highly structured method of group decision generation. In this format, it is necessary to structure the questions and responses in a way that provides a usable set of data. The primary method of accomplishing this is by providing a systematic analysis of the practical or possible alternatives to a given situation, thereby forcing the assembled group of experts to vote for only one of a predetermined list of answers. One example is the Joint Application Development (JAD) procedure which is a group design and decision-making technique for systems analysis and creation which we will discuss later (7.9.1).

One example is the Delphi method for generating predictions about complex issues (Fig. 3.26). The Delphi method attempts to avoid the major drawback and structure the group interaction by creating a continuous feedback loop of questions, or series of surveys. This method posits that the appropriate list of questions or alternatives will eventually be negotiated and a consensus reached through the feedback cycle. Delphi has many applications, including public policy. The entire process is also considerably enhanced by the power of computers to facilitate the technique The main difficulty is selecting an appropriate (or accurate) list of alternatives. [?, ?]. The multiple experts not only bring multiple perspectives but they also bring a range of professional values. However, Delphi works best for highly focused tasks. Indeed, it remains unclear that even so-called experts can effectively disentangle complex situations.

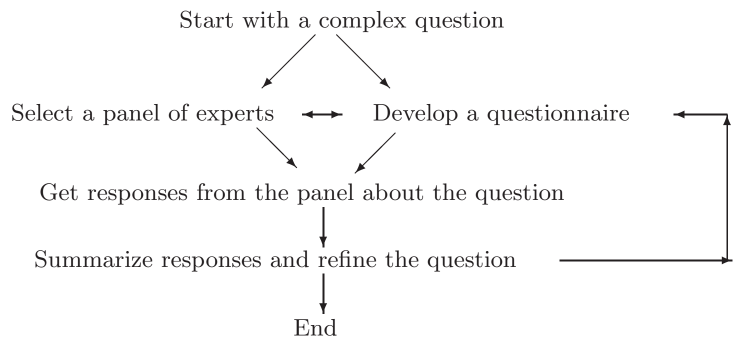

Figure 3.26: Schematic of the Delphi method for analyzing alternative paths in complex problems.

3.4.4. Negotiation and Mediation

A negotiation is a dialog which tries to achieve a compromise across several dimensions which may be viewed as the best alternative for each of the parties. In many cases, the value of attributes is different for the two sides so the compromise means finding combinations of attributes that work for both. Fig. 3.27 shows the path of a hypothetical negotiation to find an equilibrium that is acceptable to both sides.

Game theory (3.4.1) usually assumes no interaction between the parties, but of course, some conflicts between people can be resolved by the sides working together to find a compromise which best fits the needs of each side. Negotiation involves many factors. Negotiation analysis to support negotiation. Compromise is needed to satisfy constraints from many sides of an issue.

Negotiation is a process of reaching decisions between two people or groups. Making decisions is an important part of a negotiation. Earlier negotiation was described as a social process (3.4.4). Here we consider the individual decisions that have to be made during formal negotiations. Because the process of formal negotiation is complex, a "negotiation support system" could be developed[42]. A system such as this would help negotiators understand the full implications of their own positions and what they have to bargain with, as well as the same factors on the other side of the table.

It's generally useful for a negotiator to have a strategy. Reservation price is the lowest price for which a negotiator can part with a product or service. With regard to products, the reservation price may

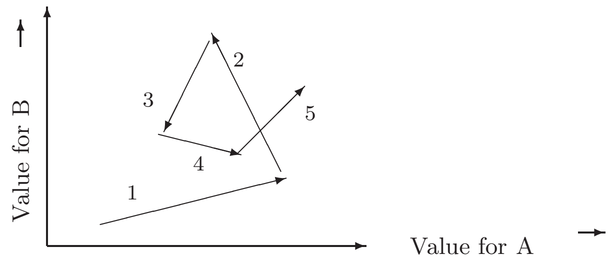

Figure 3.27: Negotiation can be thought of as finding the compromise between the two sides (A and B). In this example, five sets of tradeoffs between those factors are examined. Through negotiation two equalize values of the outcomes The lines indicate reservation values — minimum acceptable values for negotiation. A reasonable solution for both parties falls on the diagonal, as far out as possible.

be tied directly to production costs, for example. Another is to adopt an Alternative to a Negotiated Agreement (BATNA), it is the course of action a negotiator would take if negotiation were to fail. These elements form the bedrock of deal making; they are the limits past which no concessions will be granted by the parties in question. In a negotiation with a car salesman, the buyer's BATNA might be the price that the car dealership across the street is offering for the same car — all things being equal, it does not make sense for the buyer to agree to pay a price that is higher than that which they can get elsewhere. If the car salesman knows this then they should be willing to go below the other dealership's price (only to the point of their own reservation price, however) to make the sale. However, all things are not always equal. Deadlocks between negotiating positions can sometimes be broken by adding new dimensions to the negotiation. In the example above, it might be wise for the buyer to accept a higher sticker price if the salesman was able to offer a lower financing percentage.

These strategies are elements of "distributive bargaining", that is a negotiation in which the participants are attempting to secure for themselves as much of a limited commodity as is possible. This form of bargaining can be contrasted with "integrative bargaining," in which participants work to reach agreements that prove to be mutually beneficial. Often this means actively seeking potential areas of collaboration outside of the initially conceived domain of negotiation. Integrative bargaining can provide a common resource for all sides of a negotiation.

There may not be an orderly framework for a negotiation. Conflict resolution combines finding an acceptable equilibrium for each side and a process for reaching it. Saving face. Build down. There is a continuum – from conflict to conciliation. Mediation and collaborative mediation can facilitate reaching a decision. Practical steps in getting people to view and accept the alternatives in a different way. Handling conflict in distributed teams and with different communication modalities.

3.5. Do: Tasks

The "Do" part of the look-decide-do look applies more generally to all tasks.

Simple action. Commitment or complex actions. Coordination and management. Information is embedded in procedures which may not be able to be articulated. Commitment to action.

Activities, tasks, scheduling, coordination. Project management. Coordinating related types of activities.

3.5.1. Procedures and Processes

Linearize formal specification of workflow (3.10.2). Moreover, recipes need to be comprehensible. Recipes (Fig. 1.5). Fig. 6.50 emphasizes the context of actions.

Work as practical action. Related to bricolage and planning. Work is composed of activities. Work practice. How tasks and information are passed between people. Articulation. Practical action versus office procedures. Situatedness of work.

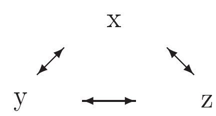

Figure 3.28: Activity theory.

3.5.2. Allocating Organizational Resources

Once a decision is reached, whether by an individual or an organization, it needs to be implemented. Job specification and switching Management (8.11.0). Gap analysis between what is needed and what is doable. As we shall see later, approaches to planning can be formally specified for some tasks (3.7.2). The key in deciding when more work is needed and when to stop. Then, once a decision is reached, it needs to be implemented. Some tasks are complex and are not well modeled by a hierarchy. A decision about a type of medical treatment may involve many details and may have many implications in following through.

Employees. Job analysis. Division of labor. Job description and what's needed to satisfactorily complete a job: Knowledge, Skills, Attributes. Mytical man-month.

Changing skill requirements.

We have used the *Look→Decide→Do* model to describe the process by which we accomplish an action. As we described earlier, this is an approximate strategy. Each phase of the overall model may include several repetitions of the entire cycle. Particularly within the *Look* phase, the *Look→Decide→Do* model may need to be applied to a sub-task. In this sense, the *Look* phase is not as much a content-directed plan as it is a strategy for finding answers. The step-wise model often works well for simple tasks, but information seeking can be significantly more tangled when performed for complex tasks (Fig. 3.29). Furthermore, the tasks have to be mapped to the abilities and available time for individual workers. Work breakdown structures. Coordination (3.5.3). Articulation work (5.6.2).

$Task_1$	$Task_1$
$Look_1$	$Look_1$
$Plan_1$	$Plan_1$
Do_1	Do_1
$SubTask_1.1$	$SubTask_1.1$
$Look1.1$	$SubTask_1.2$
$Decide1.1$	$Look1.1$
$Do1.1$	$Look1.2$
$SubTask_1.2$	$Do1.1$
$Look1.2$	$Decide1.1$
$Decide1.2$	$Decide1.2$
$Do1.2$	$Do1.2$

Figure 3.29: For the $Look > Decide > Do$ sequences, like other tasks, the collection and use of information many be formalized as a hierarchy (left). However when executed (right), information tasks will probably not follow a simple hierarchical structure.

The implementation of decisions, especially those requiring coordination among several components, requires management (8.11.3). The overall process is intricately tied to each individual phase, and any changes to an individual part will create a ripple-effect of changes to the subsequent parts.

Within an organization, management and the way that decisions are implemented can affect this type of unformed, changing process. A system that encourages improvisation as well as imposing constraints —

scheduling activities to minimize context switching, for example — lends itself to this type of situation. A philosophy of "get started and then see where we are" may adapt to changing needs and goals better than one that advocates plowing through a detailed plan only to find that the plan doesn't connect all exceptions. A final step is the assignment of individuals to complete specific jobs. Individuals may have skills which have to considered in the job assignments.

3.5.3. Coordinating People (or Autonomous Agents)

When people or other agents work together, they need to coordinate. Formal description and social aspects. The social aspects may range from politeness to leadership. Two approaches: formal models and social coordination. Coordination and dependencies. Coordination as part of goal-seeking. Agents completing tasks in multiagent systyems. Agent communication (6.5.3).

Formal Description of Coordination

Top-Down Coordination. For complex activities there are dependencies among resources and other agents and coordination is needed to make them flow smoothly. Coordination is a function of common goals, shared knowledge and individual interaction. For instance, when two or more people interact they must coordinate the mechanics of the interaction; yielding the floor to let other people participate in a discussion (6.4.2) is one example. Workflow (3.10.2).

Articulation.

Systems, formal and informal, exist for the mediation of interaction. Some of these interaction conventions may be task-dependent dynamics, such as those having to do with assigned roles and consensus-building, while others are more general and are often tacit social systems. While group coordination is often facilitated by social bonding and emotional content, it is interesting that the coordination of computerized agents or services may also follow principles similar to those seen in the coordination of individuals in groups. In so doing, the agents and services are attempting to simulate an organic processing model that more closely mirrors the natural world. Coordination (Fig. 3.30). Dependencies. Flow: pre-requisite, "accessibility, and usability. Sub-types of flow dependency: prerequisite, accessibility, usability. Synchronization. Application in business process engineering (8.11.2).

Effects of changing coordination and success in accomplishing processes in a complex system.

Synchronization. Parallel routing example. Deadlock.

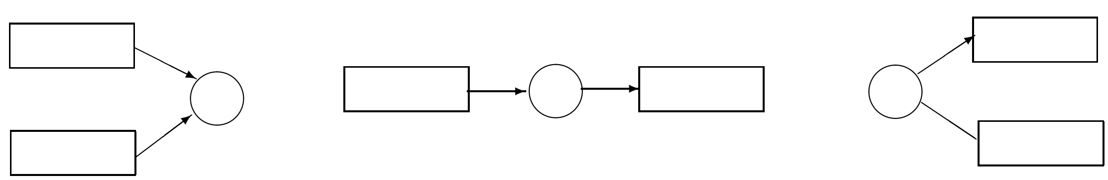

Figure 3.30: Three basic coordination structures (Fit, Flow, and Share) between activities (rectangles) and resources (circles) (adapted from[38]).

A group, whether a group of human beings or a group of computer agents, can be seen as cooperating agents. Coordination can managed by controlling flows between the agents.

Coordination in Groups and Teams

Coordination and collaboration. Dependencies. Managing shared resources, managing produce consumer constraints, managing simultaneity, managing the task-subtask relationship[38]. Coordination in team games (5.8.2).

Coordination is a necessary element of any effective group interaction. Coordination involving people can be much more subtle. Coordination in social interaction via norms. Workflow as coordination. Task assignment. Parallel computing.

Coordination of people also requires shared goals.

Parallel processing. Management (8.11.0).

The amount of work that gets done is reduced by the amount of effort required to coordinate among the participants. These tradeoffs also apply to the coordination of several computers working to solve a problem. Some tasks, such as multiplication, are easily modularized and can be distributed across different processors. Other tasks, such as generating statistical models, need to be focused on one processor. The degree of coordination between processors often depends on how the problem is divided between them. Maximizing the computing power of the available resources requires careful design considerations — these will include the task to be accomplished, the computing that the task requires, and how the work requirements are distributed throughout the system. With no coordination cost, additional processors have a linear effect on the amount of computing (Fig. **??**) that is able to be accomplished. When there are substantial coordination costs between processors, less work is able to be done. The dynamics of coordination costs and processing power in computer systems are remarkably similar to the model for the same factors within human groups. When a group of people work together on a project, progress on any one task may be slowed to enable interaction the members. In more complex settings, coordination may also involve compromise, contracts, trust (5.2.3), and negotiation (3.4.4), which further slows the progress. Coordination mechanisms are needed. Agent coordination language (6.5.3).

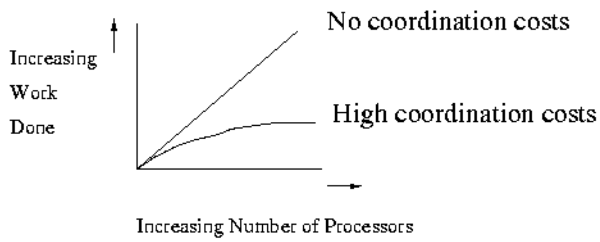

Figure 3.31: Coordination costs affect the amount of work that gets done by a group of processing units – whether people or computers.

3.5.4. Task Environments

Work is conflation of person, task, and tools. The simple Look-Decide-Do model is too simple for many tasks. There is a co-evolution of the information possessed and the understanding of the task to be completed. Ecologies are often related to task environments. Much of this is interface design (4.8.0) but it goes beyond a narrow view of the interface and considers broader task framework and organizational needs.

Information Behaviors for Specific Tasks, Situations, and Professions

Would like to match information services provided to the users of secondary information resources such as catalogs (2.4.3) and assistance such as references services (3.3.2). Information interaction in the family.

Just as we focused on information behavior as an important aspect case of information we can focus on usability characteristcs for information search behavior. For instance, in a crisis, people show distinct patters of information seeking (8.6.4).

Intentionally shielding information from others. Information poverty[18]

Communities of practice (**??**). Hobbyist information. Health information (9.9.0) such as the use of electronic health records. Information behavior of scientists (9.2.0).

How people interact with email items and collections. personal information management (4.11.0).

Information Environments, Learning Environments, and Work Environments

An information workspace is an area whose purpose is primarily the acquisition of information. A library, may also be considered an information workspace. which offers a range of information resources are determined by the collection selection policy. Bring the information to where people need it when they need it. Moreover, as with libraries, the content needs to be updated and managed (7.2.2). They may include libraries, archives of email, and collaborative work environments and they can be thought of as ecologies of information resources. The quality of information can be evaluated with an information audit. The role of libraries in information environments is changing. Learning environments (5.11.7). Information genres filling the niches. Information poverty.

Universities (8.13.2).

Work Environments Workspaces should be designed to support the user's tasks. In some cases, this means just the tools that are needed to do a specific task. In other cases, a flexible and wide-ranging set of tools is needed. Typically, these are highly interactive services which are not easily decomposed.

Figure 3.32: The transactional model of information and review is typical of complex tasks such as problem solving, planning, and design.

The task analysis can help in selecting and coordinating tools. Considering tasks in a broader context such as the overall goals of an organization. A particularly clear example of the way which the *look* > *decide* > *do* model is simplistic is that it does not describe the procedures for critical thinking (5.12.0). We consider the challenges in developing a scholar's workstation[23].

Desktops and Beyond There are several familiar genres of information workspaces and they are suitable for different tasks. The desktop has many files and documents. Portals are the entry points to Web-based resources. Metaphor based design potentially enhances learnability.

Many other models. Beyond the desktop[30] Types of tasks. Immersive environments. CVEs. Mobile environments. Loose sense of place for information as suggested by the desktop metaphor.

A work environment provides sets of resources readily available for the task at hand. The "desktop" is the dominant work environment for personal computing. It is a type of hypermedia application (11.1.5); it has sets of flexible tools and resources available in an environment. Desktops are also sometimes described as control panels and dashboards. Directories and folders are often used to organize personal information and software resources are often kept in folders. Who does the design and what is their understanding of the task.

The tools may include document management systems or more broadly, general information ecologies which are sets of inter-related information resources. The social and organizational structures such inter-related information resources can support. The workspace includes other technologies and other people.

Figure 3.33: Controls for the workspace on a PDA.

Increasingly, multiple environmental devices for interaction. Ideally, seamless interaction.

Time-critical task environments Some tasks are time critical and have high demands on attention. These include aircraft cockpits and medical emergency rooms. These environments need to support decision making when cognition is resource limited. That is when there's just not enough human computational resources to reach a valid answer in the time available. Design includes layout for displays. Delivering the right information just when it is needed. Limited task awareness. Monitoring work activities. Even more effective would be an interface which was responsive to attention. Multi-tasking and cognitive resource allocation.

Tools, Tools Design, and Tool Ecologies

Some routine tasks can be completed with only one tool but most non-routine and complex tasks require a set of tools. Any set of tools need to coordinate effectively. An alternative approach is to redesign the tasks. (3.8.3, 8.11.2). Creating tools that facilitate interactions. Completeness and ease of use.

Tradeoff of the what the tools can accomplish and what the user will do. Sets of tools should interoperate and these should be continuity/consistency of the interaction (3.8.3). Balance between tools and tasks are flexible and tools that are well coordinated to complete specific tasks. Some environments require users to define subsets of tools. Other task environments apply some algorithms for determining the optimal subset of tools.

Relationship to HCI ((sec:HCI)). One effective technique drops the tools from the active toolbar but still allows the user to get to them. Some toolsets may be tailored to very specific tasks while others may be tailored for very specific tasks. Flexible environments versus tailored environments. An example of this is a biological-story-telling environment (9.2.3). Everyday users often work on several tasks at one time, so a desktop may require maintaining several threads at the same time. Visions of future computing environments[14]. Contrast with the notion of disruptive technologies.

Coordinating Complex Information Activities and Streams Prioritizing information access for users.

3.6. Entertainment, Engagement, and Experience

Entertainment shares many aspects of information including being stored by information systems. Given our broad definition of information, we argue that some information simply instills emotion. While entertainment often emphasizes emotional reactions, quite a bit of entertainment is also informative. We can learn about how people act under pressure from movies and novels. Some information seeking, such as reading the newspaper, can be entertainment and playing some games can be educational. On one hand, it seems like some entertainment is about mood optimization. A horror movie seems to provide an emotional jag rather than reducing uncertainty about the future. In any event, the technologies for managing entertainment and for information overlap so much that we consider them together here. On the other hand, it is useful to separate affect from information. Narrative. Entertainment behavior. Emotional content needs to be reconciled with information. Emotional may changes the representation but often in a transient way. Entertainment is also often a social process. Engagement. Casual games.

3.6.1. Trans-media

Cross-platform. Common backstory.

3.6.2. Affective Needs

Affective needs. Affective relevance.

How and when people seek entertainment (4.6.2).

Leisure information behavior. Entertainment does not attempt to develop abstractions. Finding all the information available on a topic. Information behavior affected by mobile devices. Information behavior is affected by the users' emotional state.

Interactive Mood Control

Mood management (4.6.2). Not just affect control but allowing mood control from external agents

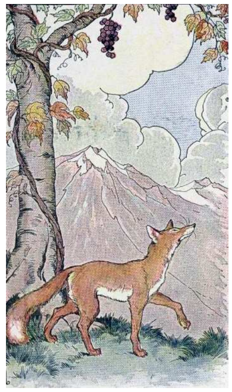


Figure 3.34: Left: The Fox and the Grapes from Aesop's Fables[8]. Right: the Hip-Hop artist Public Enemy. Entertainment can also provide information. (check permission)

Figure 3.35: Cyber-drama.

(11.11.1).

3.6.3. Social dimensions of entertainment

Social exchange. Sociability.

Using Technology for Social Activity Management

Waiting for a table to be called at a restaurant. Scheduling leisure time activities as in an amusement park.

3.7. Problem Solving and Planning

Problem solving, planning, and design are related to decision making. They all involve working toward a goal. All complex tasks involve complex analysis and decision making. The issues are interwoven but have different emphases. As we noted above, several models for interaction of information and decision making. We often find several kinds of information resources being used for this type of task. Complex tasks are those which involve the completion of many sub-tasks. They are often described as requiring problem solving, planning, or design. These task types differ primarily by their relationship to predetermined goals; that is, what activities are necessary to complete the goals.

3.7.1. Problem Solving

Basic problem solving finds a way to getting around an obstacle to reaching a goal. Problem solving can be considered a task that often consists of a series of tasks. Problem solving with minimal information collection. It requires a task environment to determine the history, constraints, and intricacies of the problem. Problem solving can include analysis of complex tasks and simple tasks, negotiation, and even group interaction with group decision support systems. The abilities of people engaged in everyday problem solving such as automobile mechanics. Diagnosis (4.4.5).

Problem Analysis

People encounter many obstacles to completing tasks and they need to develop strategies for getting around them. Sometimes, a systematic procedure for dealing with an obstacle can be applied to reach a solution. People who engage in these activities must *represent* the problem, its intricacies, and the range of task solutions to that problem. Often there are constraints such as deadlines or lack of information which complicate these strategies and eliminate possible solutions to the problem as options. The recording of such solutions can lead to a more efficient overall operation if the obstacles are likely to be encountered again. Other times, there is no easy solution and tradeoffs between the real and the ideal solution may be required.

Ignoring irrelevant details. Framing the problem. The range of options to explore, or the total number of possible actions given the desired end-state. Some problems are able to be decomposed into finer steps. Each of those steps can be solved. The original constraints on the processes is known as the problem space and the result is the solution space. (Fig. 3.36). Identifying and naming the major components are the first step. Problem solving as search in a problem space In this view, the fundamental task is conceptualizing and reconceptualizing the problem space.

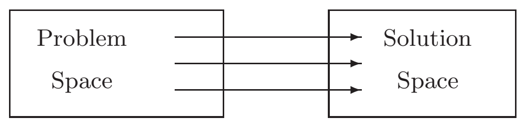

Figure 3.36: Problem solving tries to find a path from the definition of the problem, the problem space, to the range of possible answers, the solution space.

Collection of information to assist in problem solving (3.2.0). Tool kits for completing the problem solving. Objects, XML, and Java. Eifel.

Algorithms: Procedures for Solving Problems

Some problems can be solved directly by applying a known procedure. To give a simple example, there is a well-known procedure for subtracting a smaller multiple-digit number form a larger one. Given a problem of that nature, one simply applies the procedure to the specifics of the situation and calculates an answer Fig. 3.37 shows an activity diagram for subtraction. In such cases, problem solving consists of simply finding an appropriate set of rules. Algorithms are abstract procedures which act on data held in data structures.

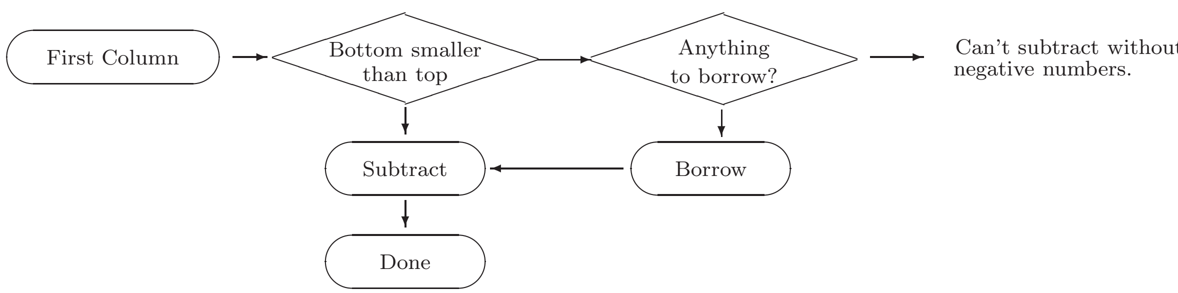

Figure 3.37: An activity diagram illustrating borrowing which is a simple algorithm to do subtraction.

Some slightly more complex problems are composed of several parts but each of those parts can be solved by the application of an algorithm. problems can be solved simply by decomposing them into simpler problems for which a known Algorithmic thinking and computer programming can be helpful for structuring some types of problem solving. In this view, structuring the problem is the main challenge.

Not all problems can be directly solved by algorithms but some of them can be decomposed and then algorithms applied to pieces. The easiest way to decompose a problem is into a hierarchy. For more complex problems, other strategies can be applied. Some simple strategies include: identifying key elements of the problem; utilizing available expert advice and technology; considering a problem's similarity to other, already solved problems (applying a known procedure); this can be done by solving one element of a problem at a time; and, perhaps, by re-conceptualizing the problem.

Problem Solving and Learning. Pattern recognition - matching to outcomes. SOAR. Chunking. Learning by applying algorithms. Tutoring systems (5.11.3) are relatively effective in support of these types of activities.

Tractability and Efficiency of Computations

Algorithms are often specified using programming languages (-A.5.0). Information-limited versus computational-resource limited problems. Algorithms (3.7.1, -A.5.0) versus brute force solutions. The efficiency of an algorithm can make the difference between a problem being tractable or not. Getting the answer fast. programming languages. Some important problem are essentially not solvable without the application of specific algorithms. (Fig -A.47). Computational efficiency (3.7.1). Algorithmic complexity measures (-A.5.3).

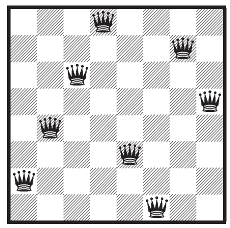

Figure 3.38: The 8-queens problem demonstrates the value of algorithms to solve problems that are very difficult to solver by trial-and-error. The queens need to be lined up so that no two are on the same vertical, horizontal or diagonal row.

Strategies for Increasingly Complex Problems

Strategies for search complex problem spaces to find an answer (Fig. 3.39). Pick solutions which reduce the hypotehsis space. This is typical of diagnosis ((sec:disgnosis)). The most effective strategy depends on the situation; likely, every problem and strategy will face real world issues and constraints. The problem solver must explore the options within a problem space and determine the possible strategy.

Example of means-end analysis. Find the difference between the current state and the target state. Pick and implement a method which reduces the difference.

Strategy	**Description**
Means-ends analysis (Goal-seek analysis)	Work backward from goals.
Generate-and-test	Propose solutions, try them, and then evaluate the outcomes.
Analysis-by-synthesis	Assemble the solution from an understanding of the components required to complete a task.

Figure 3.39: Some approaches for complex problem solving.

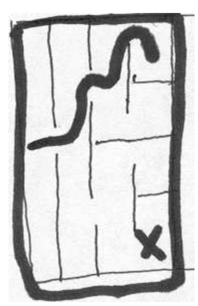

Figure 3.40: A person starting at S and trying to find a target (F) in a maze with a simple tree-like structure might apply a simple rule of always taking the left branch until reaching a dead-end. The person would then "backtrack" to the nearest choice point and try following that with a left-hand rule.

Blackboard systems. Selectively filtering the most promising alternatives.

Group problem solving. Problem Structuring Methods (PSM).

Given all of the emphasis on tasks, we can ask about creativity. But, that it is a very different type of "task".

Reasoning by analogy (4.3.4).

Especially Complex and Wicked Problems

Some problems are so difficult, there's not clear model for solving them and they can't be easily decomposed into simpler units. The solutions are often characterized as the lesser of two evils. These are called "wicked" problems [44]. They generally require understanding complex interactions among several interlocking problems. The issues surrounding global warming or ending terrorism are so tangled that there is no ideal solution. In any event, analysis of these tasks requires critical thinking (5.12.0). They may benefit from systematic analysis such as from issue-based analysis (6.3.5). These are often the result of complex systems. "Systems thinking" looks at the relationship among aspects of the problem. System dynamics (-A.10.2).

Scenario visualization.

Expertise

What is an expert? Expertise is highly situational. Expert systems (-A.7.3). Can affect features selection in problem analysis. Finding expertise. Expertise in chess. Experts tend to spend more time in problem analysis and develop a richer problem representation.

3.7.2. Planning

Planning develop strategies for the future action. It includes long-range planning such as for retirement or planning very immediate tasks such as baking cookies. Planning and language generation. Planning is often used for project management (8.11.3). Developing procedures for unstructured tasks. Difficulty of strategic planning [40]. Representations of plans. Some plans are fixed or deterministic while others are semi-structured or even just a rough sketch. Enterprise resource planning. Planning and language. Constituent planning.

Planning system applications. Conversational agents. Coordinated activity and shared plans. Planning a complex system such as a complex engineering project. This feeds logistics (8.12.1) and project management.

Simple Plans

Once again, hierarchies are helpful. In simple planning, actions are decomposed into a hierarchy of goals and sub-goals (3.5.2). These hierarchies can be useful for analyzing problems and constructing an organized method for dealing with them. That may be implemented by a goal hierarchy (Fig. 3.41).

- Goal 1
  - Subgoal 1.1
    - sub-Subgoal 1.1.1
      - sub-sub-Subgoal 1.1.1.1
    - sub-Subgoal 1.1.2
      - sub-sub-Subgoal 1.1.2.2
  - Subgoal 1.2
    - sub-Subgoal 1.2.1
    - sub-Subgoal 1.2.2

Figure 3.41: A goal hierarchy.

Complex, and Dynamic Plans

Planning is more complex when the activities can be easily organized into a hierarchy, when there is uncertainty in some element, or when there are differential costs. One strategy for dealing with uncertainty is to analyze its source. By concentrating first on areas of uncertainty, a planner can attempt to either eliminate the uncertainty, or to devise a plan in which the uncertainty does not factor. Another strategy for planning around uncertainty is to allow for a range of outcomes plan for each accordingly. To make plans, an agent needs some estimate of the costs and benefits of the options. Scenario development is often the first step in planning.

Dynamic planning schematic (Fig. 3.42).

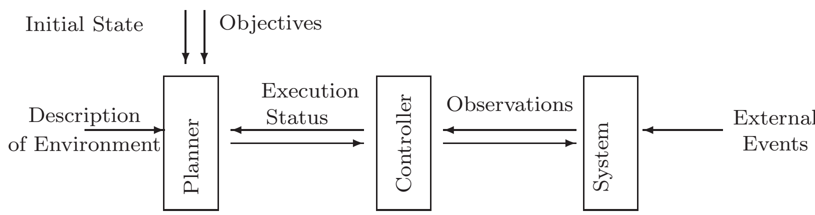

Figure 3.42: Schematic of a dynamic planning system. (check permission)

Trajectories through space and social situations.

Situated planning.

Task scheduling is planning the sequence in which tasks are completed. This is a part of project management (8.11.3) and supply-chain management. The outcome of planning may be uncertain, so the results must be monitored with the possibility in mind of revising the process. In these cases, planning involves estimating probabilities. Plans may have to evolve to meet unexpected conditions, so flexibility must be built into the planning process. In still other cases, "contingency plans" may have to be adopted when the original plan falters. In general, formal (AI) planning models do not take context into effect.

Process support systems.

Planning a searching as a state space. Plan graphs. Schedules are often optimized with constraint satisfaction (3.7.2). Examples of hard and soft constraints. Constraint processing. Constraint satisfaction. From constraints to optimization. Cost optimization. Over-constrained problems.

Contingency planning.

Heuristics and constraint processing. Heuristics for knowledge discovery (9.2.2).

Planning complex coordinated situations.

Partial order planning.

Generative Planning

Planning and agents (7.7.8). Planning of natural language. Planning and design. Planning and drama management.

Adversarial situations (7.11.0). Game theory (3.4.1). Mission modeling in adversarial situations (Fig. 3.43).

Plan Recognition

When watch another person, we try to understand their goals and how they are trying to accomplish those goals. When driving and we see somebody ide the side of the road, we may anticipate from their location and their manner that they are planning to cross the street, and we may slow down accordingly. This is related to attribution (5.5.2) which is the social psychological approach to determine how people

Figure 3.43: Adversarial planning is essential in chess. (check permission). (VAST).

assign responsibility. Other techniques include probabilities[17] and Bayesian models (-A.8.2) for plans in uncertainty environments. Difficulty of detecting reception. BDI (6.5.3).

While plan recognition attempts to categorize activities as indicators on plans, when there is sufficient data available it is possible to use brute force statistics without inferring a plan.

Repairing Broken Plans

Some plans will fail. Apollo 13 was going to the moon. Every detail of the trip had been planned. But, half way to the moon, an oxygen tank blew up and the crew had to improvise simply to survive[37]. This is an example of the need for adaptive plans, plans for unstructured tasks, and repairing broken plans. Exception handling. This requires improvisation, use of the tools at hand, or "bricolage"[22]. Replanning.

Despite detailed planning, events may not follow the plan; that is, the plan may be "broken". The weather may be uncooperative and slow construction, a critical piece of equipment may not be received, or a key employee may be indisposed. There should be a fall-back position. Procedures need to be adapted to specific situations.

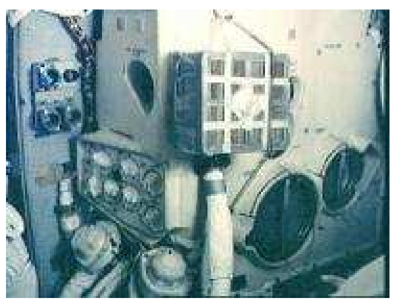

Figure 3.44: "Houston, We've Had a Problem". After the Apollo 13 accident, the oxygen supply for the crew was endangered. A canister was improvised to filter the air.

3.8. Design

3.8.1. What is Design?

Designing creates a new object or process in a way that satisfies goals. A design is a created form that is imposed on something. Ideally, a design provides an elegant solution to a difficult problems. Design can apply to simple objects such as teapots or to complex systems. We may design a bridge, a circuit, or a curriculum. Handling complexity. From design to implementation. We may design an object (e.g., a bridge or a Web page), an information system, or a process (e.g., a curriculum).

Design as a process or design as an outcome. Object design, process design, interaction design, socio-technical design. Designing can be recursive in nature. Creating a complex product may require both the design of the product as well as the design of the process by which the product will be designed. Further, the plan for the design of the process by which the product will be designed can itself be said to be designed. An individual creates, or authors, the manner in which viewers/readers/learners will perceive and interact with the content. This is not true of all design, however. Other design tasks involve multiple people who may be part of a complex organization or even several organizations. Trans-disciplinary design. Moreover, design of social systems or other type of adaptive system is co-evolutionary. Design space. Searching the design space to find an optimal solution. Critic to the design process. Design activities may include: Designing objects, designing systems, and designing environments. Complexity of designing information systems will be described later (7.9.0). Information architecture (1.1.3) as design. Design of complex systems with requirements (7.9.1). Systematic design versus the reflective practitioner. Design by a cyclic process of refinement, composition, abstraction, factorization.

Figure 3.45: Ideally, a design would be both functional and aesthetically pleasing as in this teapot. Design also needs to consider costs and cultural factors. (check permission)

Emotional design. Design of affective objects. Design of game characters who show emotion.

There are specific design domains and the techniques and strategies particular to them, as well as the science of design in general. Architecture, ships, software, organizations. In particular we will consider the design of information systems in (7.9.0). The implementation of the design requires planning and project management. It can be difficult to apply system analysis. in human systems because human activities are highly flexible. Indeed, it can be counter-productive to over-constrain human activities.

Consistent processes and workflows can improve efficiency and sometimes even safety for complex organizational activities. In a factory work can be scheduled and coordinated through process engineering so the output of a factory is maximized. Moreover, consider the standardized of processes for air travel which allows safe travel for millions of passengers.

Design is a shaping of the world as we would like it to become.

3.8.2. Architectures

Information architecture. Computer system architectures. Building architectures.

3.8.3. Design Strategies

Design often involves complex tradeoffs involving many subsystems. Design is similar to problem solving but is more focused on developing elegant and efficient processes. Several strategies have been proposed for design. We might attempt to decompose a design process into parts. The "design space" is the range of options available to a designer. It is analogous to the concept of "problem space" (3.7.1). Any design in the design space is a feasible solution, although probably some are easier and cheaper than others. Later, we will discuss requirements (7.9.1) which provide constraints that specify the design space. In some cases a template is applied repeatedly in situations which vary only slightly from case to case. In other cases, a design may not be explicit but rather can be a set of rules or policies.

Generating alternatives. Evaluating them

Handling System Complexity

Information systems need to perform a wide range of functions so they are very complex. handling that complexity is a major consideration. There are several ways to handle this complexity. Several techniques have been identified, including layering, modularity, and indirection (Fig. 3.46). Information systems and services are built on many layers.

Hierarchy and decomposition. Modular systems are easier to develop and maintain because functions are clearly separated; they are fault-tolerant because copies can be replicated across machines. Indeed, relatively stable information processing can be built from faulty components. As an analogy, although human neurons are not precise conceptual units, when working together, they can produce complex information processing.

Technique	**Description**
Abstraction	Removing all context from a concept so that only the essence is retained.
Indirection	There should be only one version of a program and applications should point it rather than developing their own version.
Layering	Separate the functions so that they are updated separately from each other.
Modularity	Modular services can be based on separate computers in different locations.

Figure 3.46: Some techniques for handling complexity in natural systems and computer systems.

Design Tradeoffs

The process of explicit design often requires tradeoffs and coordination of several activities. These may be spread out over several groups or teams, to the gathering of information or technical statistics. Managing communication among design teams. Software teams (7.9.3).

Design of especially complex systems and devices often involves formal requirements specification (7.9.1). Use-cases and scenarios serve to give examples of actual and possible uses of a design-object. This involves knowing about that characteristic activities of users. The process of design can include many sub-activities and strategies such as successive refinement.

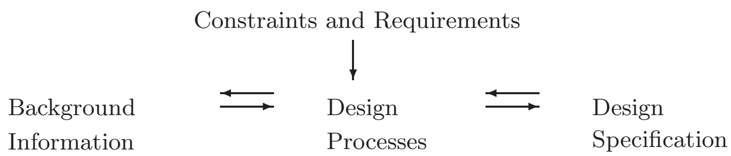

Figure 3.47: There is a tight interaction between the information use and the task activities.

Pattern Languages

This is illustrated in Fig. 3.49 which shows how rules can result in the varied but consistent layout of English villages and in Chinese Feng Shui. Design patterns.

Some consumer devices show high design and implementation standards. These techniques are often effective for the design of novel devices such as the IPhone (Fig. 3.48).

Figure 3.48: Products such as the IPhone introduce new dimensions to the design space. (check permission)

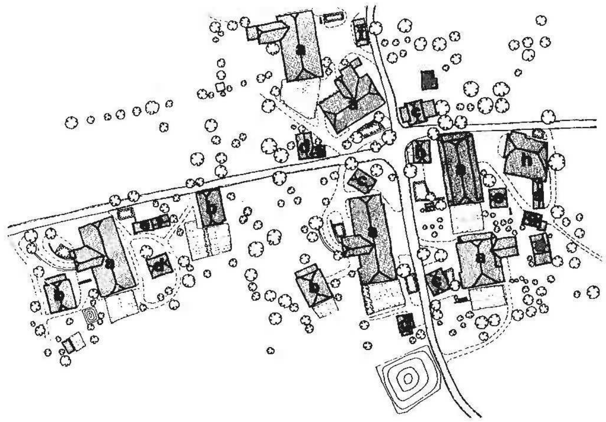

Figure 3.49: Patterns as generative grammars. Here, conventions describing the way traditions for designing homes result in an organic layout in a small village[10]. Organic growth versus over-controlled growth.

Design and Decision Making Given the complexity of the design process, it is helpful if a record of an object's important design decisions and the rationale behind them be kept (3.8.7). These decisions mark milestones in a complex design process; having the ability to retrospectively review and analyze those decisions is a great benefit. Organizational structure has a large impact on design. In a traditional, highly structured organization, design processes often move in a waterfall fashion — in a stepwise manner from origin, or conception, to testing and distribution. This means, however, that user tests cannot influence the design of a product. Indeed, all too often with this type of organizational structure, the product is delayed at some earlier stage and user testing is abbreviated, resulting in a product that does not produce customer satisfaction. A process in which early feedback is solicited so that designs can be refined is often far more effective. Including feedback in the design process is known as "formative evaluation". Using formative evaluation techniques can lead to truly innovative, user-centered design approaches. These innovations can be used, in turn, to create design templates, which streamline future projects. While formative design avoids the difficulty of exactly specifying the requirements, it has the danger of being too flexible and unsystematic.

Decisions are intertwined with design. Choices are made during design - for instance about choices among alternatives – and these may reflect choice biases. Thus, decision strategies such as game theory (3.4.1) can be applied[11]. Design methodologies. Design automation. Decisions about what should be designed are fundamental.

Design for Experience. Ambient design. Product attachment theory. Architecture.

3.8.4. Design Libraries and Archives

Design libraries. Designs for 3-D printers.

Design Metadata for Complex Objects

Because design deals with especially complex objects these have can have object assembly-leve metadata. Structure, function, behavior. The form would include shape, materials, inputs, and outputs. Applications for manufacturing ((sec:factoryfloor)). We might specify the behavior with object-oriented methods. The function is specified by the procedure;. there is a similar split for MathML (9.7.2).

Assembly-level descriptions.

Fig. 3.51.

Form	Shape and materials.
Function	What the engine is used for.
Behavior	How the engine works.

Figure 3.50: Form, function, and behavior descriptions for an engine (adapted from[46]).

Figure 3.51: Architecture is a type of design. Modern architecture is often implemented with CAD systems. Though, of course, the overall design also needs consider costs and building codes. (check permission)

3.8.5. Design Tools

CAD. The design of physical objects is often visual, and can be supported with tools such as CAD (8.12.3)and sketching interfaces[48].

These tools also guide the designer, providing a visual illustration of the constraints and properties of the object and its intended environment. From design to simulation for testing (9.5.0).

Some tasks benefit from rapid prototyping.

Formal methods for evaluating design. Multi-objective optimization.

3.8.6. Collaborative and Participatory Design

The traditional approach of sequential design and production can be inflexible, inefficient, and ineffective. Some organizations are now introducing elements of integrated product design and formative evaluation. Joint Application Development Teams (JADs) (7.9.1) streamline their design practices. Teams composed of people from various departments and specialties can collaborate on product design and develop innovative ideas continuously, products can be quickly re-formatted at every stage to better accommodate customer testing results, and rapid communication across various departments and groups creates informed decisions at every level. Designers may employ models.

Participatory design uses input from the users to generate design suggestions. When designing an information system for a hospital it would be reasonable to involve the hospital staff. On the other hand, there is a danger that users may over-influence the designers, or may not have a realistic a view of technical constraints.

Collaboration and negotiation around design artifact. Negotiation over design details (3.4.4). Two kinds of interaction. Content space and relational space[13].

3.8.7. Design Informatics: Documentation, Notation, Histories, Rationale, and Advice

Design is information intensive. Suppose that you were handed a complex piece of machinery and asked to rebuild it. Surely it would be helpful to know why it was constructed the way it was. Design is a complex activity often includes a long sequence of decisions. It is often helpful to have a record of that process to streamline future designs and to anticipate any missteps. However, it is also helpful to capture the rationale behind those formal decisions — why were they made, and does that reasoning apply to a current situation. To do this it is necessary to consider how the system will be used to determine what decisions should be recorded, and how they should be represented, stored, and retrieved. Beyond representing the design itself, it should also identify what should be highlighted, note the critical decisions, and the provenance from the design rationale. Preservation of the design rationale along with other project documentation. Neutral records versus interpretation. Capture of discussions and even decisions can be tricky because of jargon, irony, humor, or even non-verbal interaction. Compare design decisions to requirements (7.9.1). and even for training. Formal and informal design artifacts from sketches to blueprints and CAD. A document trail reflecting formal decisions is an example. The design specifications are artifacts (1.1.2). Critics to evaluate design and support the design process.

Design ontology. Continuum from design specification tied into requirements. Indexing and re-use of design information. Design representation. From design to manufacturing (8.12.1). CAD. Specifying system components (1.3.1). Designers often benefit from the work of those who have gone before them. A solution to the design problem faced in one task is often applicable to the problems faced in another task.

Hypertext maps may be useful to presenting a graphical view of design decisions. What kinds of information needs do people have for design archives. Effective decision rationale requires a model of the system being designed. Design specification are artifacts.

Discussing design alternatives. Presenting plans[27]. Design knowledge (Fig. 3.52). Requirements (7.9.1). Design ontologies.

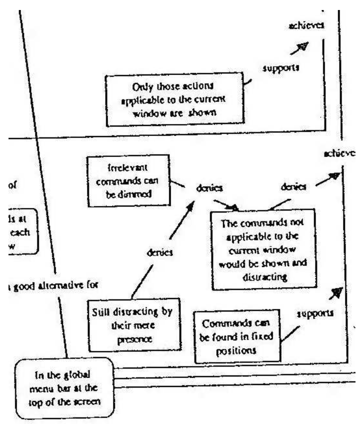

Figure 3.52: Detail of design rationale graphic[12]. (check permission) (redraw)

Structured design interaction.

Design rationale (3.8.7) can be integrated with DSSs to identify the logic of a decision module in a decision support system. It is helpful to employ effective descriptions of a design or decision process so it can be recovered later. These are called design notation and design histories. The difficulty is that much of the design is in people's heads. Design intent.

Typically, the goals, concepts or constraints of a project that determine its design. Having a record is helpful if the design decisions must be revisited, when several groups of designers are collaborating and they need to understand the design history, and can be useful for training new employees.

Creating design rationales. It could be done with archives of design meetings (5.6.4) and argumentation systems (6.3.5), for example, and may include functional and structural descriptions. Much of the understanding of the design decisions are in people's heads. The design rationale should describe how the design satisfies the initial requirements. Why were tradeoffs considered and adopted? This can be incorporated with the description of the object itself (8.12.3).

After the design rationale has been captured and stored, its content will need to be accessed. These systems can be difficult to implement and to search, as the rationale for a particular design is often re-conceptualized as the design evolves. The criteria for a rationale need to be well-matched to design process procedures. Because design interweaves many levels of decision-making, there have to be several threads involved in development and classification of these criteria, such as process rationale, structure rationale, interaction rationale. Design of highly complex systems or complex environments. Design methodologies for very large systems

The capture and representation of designs can involve digital preservation (7.5.5). FACADE preservation ((sec:facadearchitecture)). Virtual historical environments (11.10.2).

3.8.8. Designing Ecologies and Environments

Users will often re-tailor designs for their use in their own way.

3.9. Data Models and Databases

Typically, databases do not model general concepts; rather, they store data about specific instances. Data models are systems for specifying information structure. The capture a specific set of attributes which are useful for a given set of activities, tasks, and systems. Databases implement these data models. Statistical data models. Structured data. These models literally support or limit the ability to express certain relationships about the data.

In this section, we briefly consider the Entity-Relationship model and the Relational Model. These implement basic set relationships and entities which are very similar to Aristotelian approaches for categorization described earlier. Later, we consider the Object-Oriented model (3.9.3) which includes grouping and inheritance relationships. There are also many specialized data models such as the RDF Data Model (-A.4.1) and several GIS data models (9.10.2). rNews data model.

3.9.1. The Entity-Relationship Data Model: Entities, Attributes, and Relationships

Entities and attributes of those entities which may be involved in a task. The Entity-Relationship model adds some basic details and constraints to that model. This is one type of conceptual model. The ER model is a semantic data model that employs “entity classes” and relationships to model a complex system. An “entity class” is a group of objects or events which are the basic units in the model. Individual members of an entity class, such as a particular person or object, are known simply as “entities”. However, the distinction between entities and entity classes is often ignored and people will speak of an entity when referring to an entity class. These entities are related to categories and classes as we discussed above but they are not quite the same; hey are ad hoc constructions for a specific task. For an entity class such as VIDEOS, the specific entity “Gone with the Wind” could have attributes such as Title, Director, Year, and Length (Fig. 3.53). Data dictionary (Fig. 3.54).

Figure 3.53: An entity class such as VIDEO has several attributes. (example from MS Access)

Field Name	**Field Type**	**field min**	**field max**	**title**	**order**	**group**
Title	text					
Director	text					
Year	integer	1970	2020			
Length	integer	2	20			

Figure 3.54: Fragment of a data dictionary which describes properties of the attributes.

Defining the influential conceptual units. Entities of one entity class can be related to entities of another class. A STUDIO may be responsible for a particular VIDEO. When groups of data statements, or particular entities and their corresponding attributes, are formed into diagrams, we call these diagrams “entity sets”. When constructing a database, we may use entities in many data statements to illustrate the complex relationships that exist between entities of different classes. Fig. 3.55 shows a simple Entity-Relationship Diagram (ERD).

Figure 3.55: A simple Entity-Relationship Diagram (ERD) for an online video business (attributes are not shown).

The Relational Model organizes sets of related attributes into tables. Fig. 3.56 shows tables with examples of the entity classes in Fig. 3.55. This use of tables is efficient because it keeps related attributes together. There are additional details about the Relational Data Model in (-A.4.1).

VIDEO	**Title**	**Director**	**Year**	**StudioName**
	North-by-Northwest	A. Hitchcock	1959	MGM
	Toy Story	J. Lasseter	1995	Disney
	Crouching-Tiger	A. Lee	2002	Columbia

Figure 3.56: Relational tables and sample values for the VIDEO and STUDIO entities.

3.9.2. From Data Models to Databases: Databases as Information Systems

While a database program may apply a data model to some data, that is only part of what is needed for the database to be useful. Rather, databases need to be implemented as part of complete database management systems (DBMS). These are complex sets of services which serve human needs. We consider the broader context of information systems in terms of the services they provide (7.0.0).

Database Queries and Boolean Logic

Some queries place constraints on complex combinations of attributes. Booleans are generally simple relationships; AND, OR, NOT for combining attributes (Fig. 3.57). We can see the formal properties of Boolean logic with "truth tables". Fig. 3.58 shows the AND and OR relationships. In the OR relationship, the output is TRUE if either one of the inputs is TRUE (if either x OR y is true, then z is true), while in the AND relationship, output is TRUE only if both of the inputs are TRUE (if x AND y are true, then z is true, but not otherwise). The NOT relationship simply reverses the sense of a relationship so the NOT AND relationship has a TRUE output only when both inputs are off. Used for metadata searches.

Year=1959 AND Director='Hitchcock'
(Year>1795 AND Director='Lasseter') NOT (Title='*ToyStory*')

Figure 3.57: Some examples of Boolean queries. The example would match all entries in a movie database where the Year of production was 1959 and the Director was Hitchcock. Parentheses are used to group relationships. So, in the second example the Year and Director must match and from the those some may be deleted.

OR		
Input 1	**Input 2**	**Output**
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

AND		
Input 1	**Input 2**	**Output**
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

Figure 3.58: Simple Boolean logic truth tables.

Boolean logic is used in the database query language SQL Among other information retrieval applications, this is underlays metadata searches. Some Boolean queries are so complex that many users do not readily understand them. For that reason, many users have designed various interactive search interfaces and protocols. Some of these query formats involve visualization and spatializing, or even free-text visual search interfaces (10.7.3).

Supporting Database Retrieval

Users need to interact with the database. This generally requires a query language to mediate interaction between the user and the data model. A query language gives the rules by which valid queries are constructed for a given data model. Queries are a useful way for users to interact with information systems. The "query semantics" of a particular information system describe the range of concepts that can be searched in that system. The most widely used query language is the Structured Query Language (SQL), a very common way for database developers to interact with a database. Formal queries must be coordinated with the data model.

Because the attributes in a relational database are organized into tables, responding to SQL often means combining data from different tables. Data from one table may need to be linked with data from another table by means of a key attribute. Fig. 3.59 shows an example of using SQL for searching. Fig. 3.60 shows the result of the SQL script. In particular, the fields from the tables have been "joined" with the key "StudioName". Despite its name, SQL is more than a query language in the narrow sense. a programming and a system management language. It can create tables and control the state of the database.

```
SELECT VIDEO.Title STUDIO.Email
  FROM VIDEO STUDIO
    WHERE Title = 'North-by-Northwest' AND
      VIDEO.StudioName=STUDIO.StudioName;
```

Figure 3.59: An example of the SQL instruction for a low-level join operation on a relational database table.

VIDEO.VideoTitle	**STUDIO.Email**
North-by-Northwest	orders@mgm.com
Toy Story	orders@disney.com
Crouching Tiger	orders@columbiapictures.com

Figure 3.60: The result of a query on the tables in Fig. A.33. Specifically, there was a "join" of terms from the two tables on the attribute of STUDIO.Name followed by the "selection" of two of the columns.

Part of designing the database, we need to consider what attributes at truly distinctive for a given entity[31].

Using Database Queries

Database query languages (3.9.2). Fits with visualization. Query previews.

Identifying the most typical queries. Understanding failed queries.

Database Applications

Many natural data sets are messy. This can occur when the identification of entities is not well defined or when data entry is done carelessly. Many operating databases have duplicate entries. Thus, the data needs to be cleaned. Merging data sets. Processing data sets. The same record appears at several points with small variants. De-duplication of database records is an example of data cleaning. One approach would be name normalization, A stable organizational environment for managing a database is essential to their development and maintenance. Information assurance (7.10.3). Data curation and management of large data sets (9.6.3).

3.9.3. The Object-Oriented Data Model

Object-oriented models have objects (also called classes) which are similar to the entity classes for the E-R model. However, because the object-oriented model also tries to capture processes, these classes also have "methods". Thus, if we had a database which stored temperatures, we might have different methods for displaying them in either degrees centigrade or Fahrenheit.

These same ideas are the basis of object-oriented programming languages such as Java or C++. Objects can also be the foundation of a data model. There is message passing between objects and what the behavior is specified with methods which operate on that data. The object-oriented model has "declarative" rather than "procedural" descriptions (i.e., "methods") (Fig. **??**).

The object-oriented data model also includes properties such as inheritance. Earlier, we saw inheritance of attributes (2.1.4). A hierarchy of programming language classes also allows inheritance of methods (Fig. 7.48), for instance, the specification of services.

When the program is run, it create specific instances of classes that follow the program. The classes are "instantiated". Facilitate reuse of code.

Objects communicate by message passing. Indeed, these messages can be considered like documents as boundary objects. Agent societies (7.7.8) and multi-agent systems (7.7.8).

There are many different computer languages and many ways to implement a program in a given language. Object-oriented languages facilitate the principles of object-oriented design such as: *Encapsulation:* Wrap up the object as a coherent set of entities and processes. Use *message passing*: Objects are discrete modules that communicate by *Interfaces*. These define protocols for interaction with other modules. By their nature, systems are complex and involve many levels of description.

While the goal of these approaches is to make the design of large systems more modular and to optimize reuse of code. However, in practice it is sometimes difficult to cleanly separate resulting in "object entanglement" so implementing large projects can still be challenging. Picking sets of coordinating sets of objects which can be composed effectively; such "aspect-oriented design" is a fundamental object-oriented strategy. Start with entities and attributes.

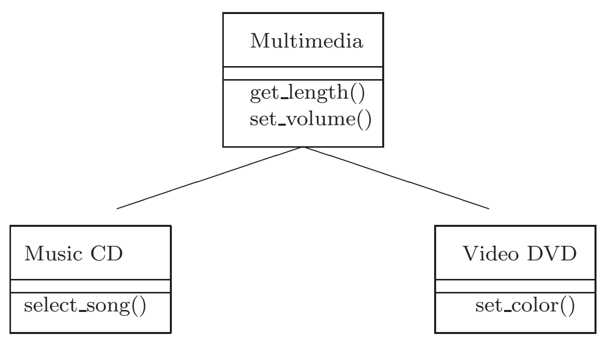

Figure 3.61: Methods may be inherited across a class hierarchy. For instance, controls for playing different types of multimedia objects may be inherited from a generic multimedia class to specific items. Setting the volume would be a property for both CDs and DVDs but setting color would be useful only for DVDs. (UML style) (finish drawing)

3.10. States and Discrete Systems

Classifiction systems describe entities but object-oriented systems describe processes.

Formalisms which are helpful for describing specific processes. Natural systems and designed systems. Systems (1.3.1). Discrete system models versus dynamic system models. Object-oriented design with UML.

3.10.1. Basic Components of Discrete-System Models

Data models are used for specific applications but we might also want to model entire systems. In this section, we focus on discrete models for systems later we will consider modeling complex systems (-A.10.2).

Class Models

Classification (2.1.2). Data models. These specify how the entities in an environment fit into a classes. These are used in both entity-relationship and object-oriented models.

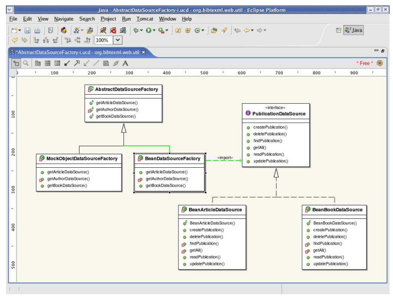

Figure 3.62: UML Class diagram. (check permission)

States and State Machines

Temporal dynamics. A state is a condition with a fixed temporal extent. We may say that a person is in a state of bliss or a state of terror. This is, of course, often a simplification but it turns out to be very useful for modeling. A "state machine" is a collection of states and the transitions between them. In the simplest version, the transitions are fixed. For the traffic light in Fig. 3.63, the state space is "Green," "Yellow," "Red" (Fig. 3.63). Another example of a state machine might specify the states of a video player (off, play, rewind, fast forward). Taken together the combination of states is called a state space. State machines can be extended in many ways such as StateCharts, ATNs and RTNs (6.5.1). Markov Models.

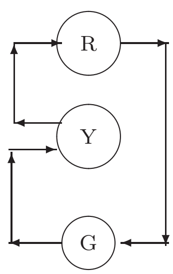

Figure 3.63: A traffic light as a simple state machine. The state transitions occur after a fixed amount of time. (redraw)

We have seen state machines; a statechart is a more complex state machine. This may include nested states as shown in Fig. 3.64.

Concurrency

We'd like events to happen concurrently. Concurrent streams Threads. Synchronization. (Fig. 3.66).

This is a variation of data-flow diagrams which show how data moves through the system.

3.10.2. Modeling Systems with the Unified Modeling Language (UML)

We have now seen several component models but it will be helpful to have a unified framework describing overall systems. Such a notation would have to be able to represent the many possible ways in which components are inter-related. Moreover, systems are complex and operate at many levels and they

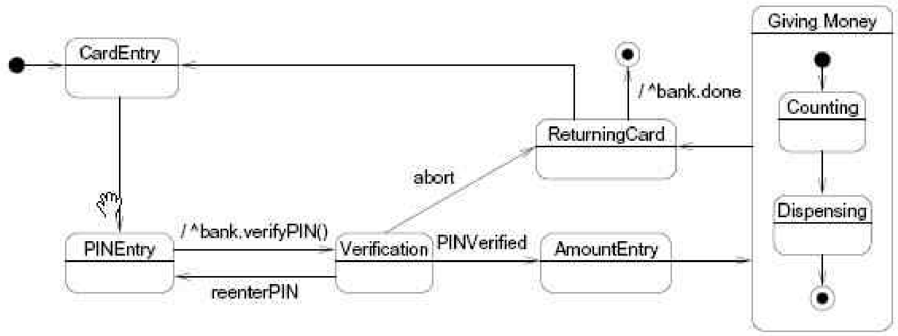

Figure 3.64: State chart for an ATM machine. Note that the start points are indicated with the bulls-eye. Also note that the "Giving Money" state is a hierarchical state with two nested sub-states. (redraw) (check permission)

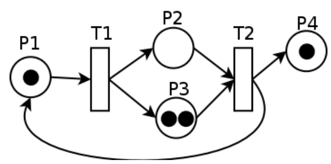

Figure 3.65: Example of a simple Petri Net. All the states preceding a gate must be occupied by tokens before the transition occurs. In this case, the P2 condition has not been met so that T2 is not triggered. These are used in workflow models and are an essential component of UML activity diagrams. UML activity diagrams (explain) (redraw)

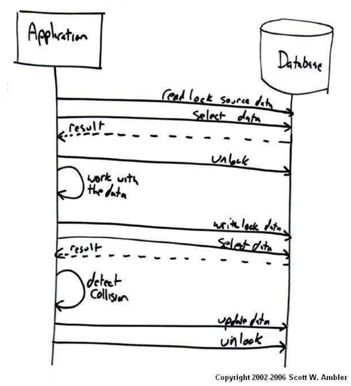

Figure 3.66: Concurrent streams. (redraw)

have processes which change over time. Many formalisms have been developed for describing the components of systems. The Unified Modeling Language (UML) is one of the most comprehensive. It is a family of modeling languages which incorporates (unifies) several levels of description. Indeed, the full UML includes 13 different components. The components can be grouped into three categories: Structure Diagrams, Behavior Diagrams, and Interaction Diagrams.[1] There are other approaches for modeling some of aspects covered by UML, but UML is the most comprehensive package. In the following sections, we focus on some of the more important types of Behavior Diagrams and Interaction

[1] The complete list in UML2 is:
Structure Diagrams: Class diagram, Component diagram, Composite structure diagram, Deployment diagram, Object diagram, Package diagram.
Behavior Diagrams: Activity diagram, State Machine diagram, Use case diagram.
Interaction Diagrams: Communication diagram, Interaction overview diagram, Sequence diagram, Timing diagram.

Diagrams. Specifically, here we look at State Machines, Activity Diagrams, Use-Case Diagrams, and Sequence Diagrams. Several of these models are used in contexts other than UML.

There are other formalisms ides UML for some aspects and we will also discuss those; UML is simply the most unified package. There are now many style guidelines for UML tools. Boundary objects may be explicitly designed as interface between subsystems.

Sequence Diagrams

Sequence diagrams are a type of Interaction Diagram. Communication among these units can be described message passing. Emphasize the messages among the objects. Message passing. The data and the processes associated with it can be taken as a unit which allows us to extend the relational data model. Behavior among objects needs to be specified. Messages trigger actions. This is not necessarily a linear flow. Programming as event processing.

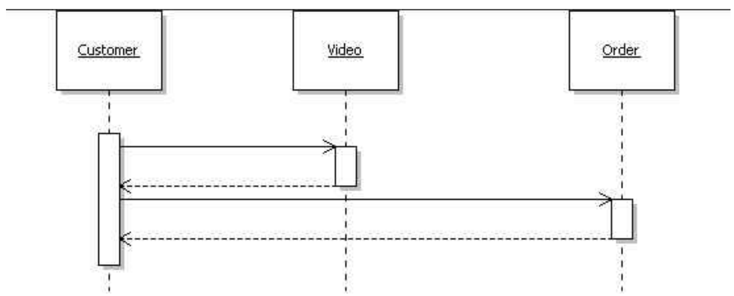

Figure 3.67: Sequence diagrams show how messages are passed among objects. The customer may explore the attributes of a video and how they would place an order. (redraw) (match to previous figure)

Activity Diagrams

Activity diagrams are focused on the decision points (Fig. 3.68). Activity diagrams are similar to flow charts which are familiar in programming. Activity diagrams can specify workflows. Petri nets (3.10.2) and workflow. Activity diagrams can show data flow.

Petri Nets add triggers to state machine transitions. These can are a model for managing access to information objects. When do events get triggered. Combinations of Petri Nets can form a workflow network. Indeed, Petri Nets are essential for workflow.

Examples of use. Swimlanes (Fig. 3.69). Coordination (3.5.3).

Workflow reuse. Workflow editor (Fig. 3.70).

Use-Case Diagrams

Use cases describe the groups of activities in an organizational task. They help to specify functional requirements. The main purpose is to facilitate the design of information systems.

Use cases are related to modeling tools such as object-oriented design (3.9.3) and to use interface design approaches such as scenarios and personas (4.8.2). The use case, generally implies several tasks which need to be completed and these can be the subject of task specifications. Included and excluded methods.

3.11. Process Models

Workflows.

Functionality.

Exercises

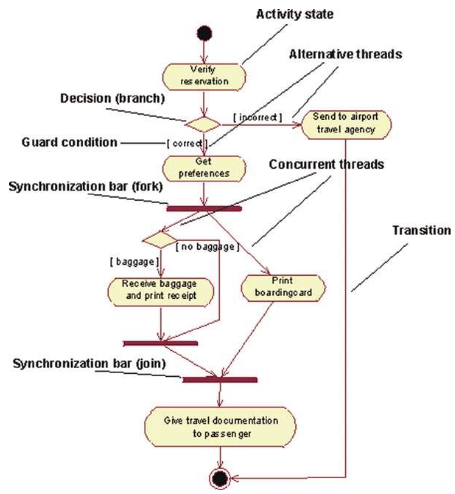

Figure 3.68: An activity diagram is similar to a flowchart, for the steps in a login and command execution (adapted from[28]). (redraw) (check permission)

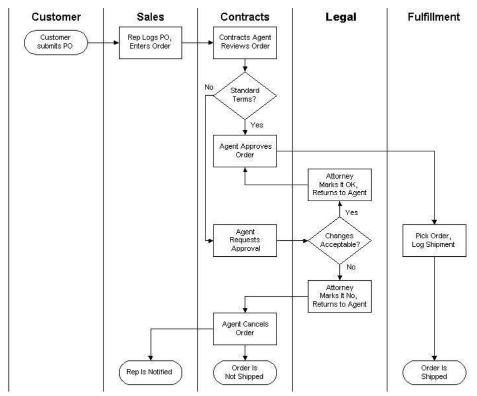

Figure 3.69: UML swimlanes show grouping of activities. (redraw) (check permission)

Short Definitions:

Affinity diagram
Algorithm
Aspect-oriented programming
Asymmetric information
Building blocks (search)
Class hierarchy
Current awareness
Decision tree
Design rationale
Design science
Encapsulation
Formative design
Game theory
Heuristic
Known-item search
Legacy software
Lemons problem
Means-end analysis
Object-oriented data model
Opportunity cost
Perceived relevance
Planning
Process model
Refinding
Relevance judgment factor
Reservation price
Search intermediary
Sequence diagram
Source selection
State space
Strategy
Summative design
Unified Modeling Language
Unit task
Utility (information access)
Workflow
Zero-sum game

Review Questions:

1. Everyday information use. (3.1.1)
2. Is playing music a “task”? Explain your answer. (3.1.2)

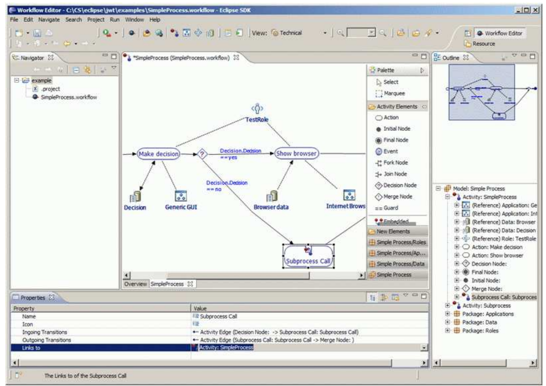

Figure 3.70: Workflow editor. (check permission)

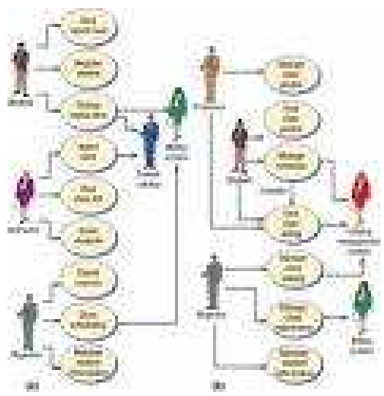

Figure 3.71: We expect that individuals fill specific roles when dealing with a complex system. These roles are known as use cases and they are illustrated with a use-case diagram. (redraw) (check permission)

3. Distinguish between “queries” and “questions”. (3.2.1)
4. How is text filtering different from text retrieval? (3.2.3, 10.9.0)
5. Explain the difference between “pre-coordinated” and “post-coordinated”. (3.3.0)
6. Describe the steps you might take to search for the query: “reactions to the use of the drug L-Dopa for Parkinson’s Disease”. Describe the processes you used and the difficulties you encountered. (3.3.1)
7. Calculate precision and recall for the data in the following table. (3.3.3)

		Retrieval		
		Retrieved	**Non-Retrieved**	**Total**
Relevance	**Relevant**	10	10	20
	Not-Relevant	20	60	80
	Total	30	70	100

8. What is relevance? Why is it difficult to define? (3.3.3)
9. List ten decisions you made in the past 24 hours. Explain how you actually made the decision and suggest how you could have been more systematic about it. (3.4.1)
10. The following table shows a payoff for different actions. Suggest the most rational action for this set of payoffs. (3.4.1)

		Person A	
		A does not keep a contract	A keeps a contract
Person B	B does not keep a contract	0/0	-1/1
	B keeps a contract	1/-1	1/2

		Actual Signal	
		Present	Absent
Observer's Judgment	Yes		
	No		

11. Create a decision tree to describe the choices you might make to determine what classes to take next semester. (3.4.1)
12. What are the advantages and disadvantages of decision trees. (3.4.1)
13. Explain the difference between a "false positive" and a "false negative". (3.4.1)
14. Give the "truth value" for the following Booleans (3.9.2) based on the "truth tables" in Fig. 3.58:
    a) TRUE AND TRUE
    b) FALSE OR TRUE
    c) (TRUE AND FALSE) OR (TRUE)
15. Fill in the cells in the following table. Explain why a "false alarm" is a reasonable description when an outcome is predicted but does not occur. (3.4.1)
16. Find an example of a systematic design activity and describe it. (3.8.0)
17. Give definitions of problem solving, design, and planning, and distinguish among them. (3.8.0)
18. How is a database different from a knowledgebase? (2.2.2, 3.9.0)
19. In what ways are data models a type of representation. (1.1.2, 3.9.2)
20. List some databases you frequently encounter. What is plausible data model for one of those databases? (3.9.2)
21. Distinguish between "entities" and "entity classes". (3.9.1)
22. Contrast conceptual data models with implementation data models. (3.9.2)
23. Explain what is meant by inheritance of methods. Give an example. (3.9.3)
24. Explain the difference between flow charts and data-flow diagrams. (3.10.1, 3.10.2)

Short-Essays and Hand-Worked Problems:

1. Pick a college friend or older relative and characterize his/her use of information. What strategies does he/she use for finding information? What other information would be useful for him/her? (3.2.1)
2. Give a list of questions people might generate if they were planning to (3.2.1):
    a) Buy a new car.
    b) Get surgery for a knee injury.
3. Identify the most typical information needs addressed by the following (3.2.1):
    (a) Television news programs.
    (b) Food contents labels.
4. Interview a friend about how he/she meet their needs for medical information. What other strategies might you suggest for them? (3.2.1)
5. Discuss with a young teenager the information seeking strategies they would employ to decide what movie to see over the weekend. How could those strategies be improved? (3.2.2)
6. Contrast the cognitive processes involved in browsing an information repository with those in searching that same repository. (3.2.3)
7. Talk to the reference librarian at your local library. Describe the types of questions that the librarian is asked, the responses they make, and the tools they use to answer the questions. (3.2.3)
8. It is sometimes claimed that searching is more accurate than browsing. How could you validate such a claim? (3.2.3)
9. Build a filter for blocking articles having to do with automobiles from being displayed on a Web browser. (3.2.3, 10.3.2)
10. What are the tradeoffs between searching and browsing? (3.2.3)
11. Can searching be described as problem solving? (3.2.3, 3.7.1)
12. Describe tasks for which you would you use the search strategies (a) "building blocks" and (b) "pearl growing". (3.3.1)
13. Give an example of building blocks strategy for retrieval. (3.3.1)
14. Plan and describe a systematic search about one of the following topics: (3.3.1)
    a) The effect of the Raj in India on education.
    b) The effect of information systems on education in North America since 1980.
15. Describe how you would apply the building blocks approach for a queries such as (3.3.1):
    a) QUERY
    b) QUERY
16. Give an example of (a) successive fraction and (b) pearl growing techniques for a complex search (3.3.1)
17. If a person asked the questions listed by the librarian in the previous question, what might they be searching for instead of (or in addition to) the superficial interpretation of the question? (3.2.1, 3.3.2)

18. Find (a) a friend, (b) a student, or (c) a craftsperson who has an information need. Interview them and report on that interview. (3.3.2)
19. Develop a set of FAQs for a course you are taking. Suppose that you can use only 10 questions. Develop a system for selecting those questions. (3.3.2)
20. If someone claimed to be interested in researching "the use of paper in making dollar bills" what questions might you ask them in an interview to clarify their interests? (3.3.2)
21. How is the definition of relevance related to definition we adopted for information? (1.6.1, 3.3.3)
22. Describe how you might measure and predict the "utility" of document retrieval choices. (3.3.3)
23. Describe the types of experts you might employ for a Delphi analysis of future directions for your university. What are some of the limitations of Delphi? (3.4.3)
24. What do you think the process and the concessions of a negotiation involve? (3.4.4)
25. Observe a negotiation. Describe the process and the concessions. How did it differ from your response to the previous question? (3.4.4)
26. Given an example of BATNA in negotiation. (3.4.4)
27. To what extent is a social organization an effective metaphor for organizing computer systems? (3.5.3)
28. Discuss the "coordination costs" for a group of students doing a class project together (3.5.3)
29. As a member of an organization, how can you raise awareness of another group's information needs so that relevant information could be forwarded to them? (3.5.3)
30. Describe some of the advantages of paper as a technology for supporting task completion. Describe some of the disadvantages. (3.5.4)
31. Examine a desktop of a friend or colleague and describe its organization. Do the same for a child. (3.5.4)
32. There are many metaphors for controlling a set of information resources and tools. Describe a possible design of the control panel for a fully computerized automobile dashboard. (3.5.4)
33. Are algorithms representations of processes (3.7.1)
34. Develop the plan for completing you homework for the next week. What constraints did you consider? (3.7.2)
35. If a process is knowledge, is it information? (1.1.2, 3.8.0).
36. How do design meetings differ from other types of meetings? (5.6.4, 3.8.7)
37. Create a sample relational table for the ORDER attribute in Fig. 3.55. (3.9.2)
38. A grocery store might use a database for inventory control and marketing. Describe what types of queries these users might use for these applications? (3.9.2)
39. Suppose you were designing a database which was the inventory for a book store. What entities would you identify? (3.9.2)
40. What are some of the strengths and weaknesses of the object-oriented model? (3.9.3)
41. Describe the relationship between organizational design and the software it uses? (3.9.3)
42. Draw a state machine to describe the steps you take to cook dinner. (3.10.1, 4.10.4)
43. Draw a state diagram for: stop, play, pause, fast-forward, and rewind functions of a cassette tape recorder. (3.10.1, 4.10.4)
44. If you were designing a system for keeping student grades in a university. (a) List the types of users who might have to access the system. (b) Pick one of those user groups and do a use-case analysis. (3.10.2)

Going Beyond:

1. How is the notion of sensemaking related to the notion of relevance (3.1.1, 3.3.3)
2. Observe an information-intensive situation, such as the use of information by teachers, business managers, or by a government worker. What do they actually do? (3.2.0)
3. Does echo-location by a bat show it has an "information need". (3.2.1)
4. How has hypertext affected reading styles and how has that affected the way books are printed. (2.6.0, 3.2.2).
5. How can people find things if they don't know what they are looking for? (3.2.2).
6. Pick a topic in the news and then identify the relevance of several articles from a local newspaper to that topic. (3.3.3)
7. Compare the models of economic rationality with models of rational choice in picking information sources (3.3.3)
8. Analyze a decision you made. Explain the process you used. Analyze whether that was an effective strategy. (3.4.1)
9. What information does a manager need to make decisions? (3.4.1, 7.3.1)
10. Develop a model of decision making and describe how that could develop a user interface for a decision support system. (3.4.2)
11. What tools would you provide to help the mayor of a small town to make decisions about the issues facing the town? (3.4.2, 7.3.1)

12. Give examples of when negotiation is simply a process of finding an equilibrium and other times when it involves persuasion. (3.4.4)
13. Develop a simulation for the coordination costs among a group of 100 workers, each of whom needs to communicate with two other randomly selected individuals. The communication occurs at random intervals and the net cost of each of these interactions takes a total of 10% of the worker's time. (3.5.3).
14. How did the introduction of photocopies in about 1965 change the use of documents in offices? (2.3.1, 3.5.4)
15. Is a database a document? (2.3.1, 3.9.0)
16. Are attributes different from entities? (2.1.2, 3.9.1)
17. Explain the difference between "descriptions", "representations", and "models". (1.1.2, 2.2.0, 3.9.1)
18. What is the data model for XML? (2.3.3, 3.9.2)
19. Explain how XSLT might be used with SQL to place materials into a database. (2.3.3, 3.9.2)
20. Draw the truth table for the NOR function which is the negative of the OR function. (3.9.2)
21. Describe the following Boolean query about a book using the Dublin core attributes (3.9.2):
(Title='Ulysses') AND (Date>1900)
22. How would you modify the state diagram for a simple traffic light (Fig. 3.63) to include a green arrow signal for turn which came or 15 seconds before the regular green light. (3.10.1)
23. Give an extended UML example for a bank's transactions. (3.10.2)
24. Describe some of the limitations of UML as a representation for systems. (3.10.2)

Practicum:

1. Build an E-R Diagram. Implement a Relational Database. (3.9.1)
2. Conduct a reference interview.
3. Propose a design.
4. Delphi Method.
5. Problem solving.
6. Planning.

Teaching Notes

Objectives and Skills: The student should be able to complete a task analysis and develop a simple interface based on that analysis. Students should understand the development of distributed system models and be able to describe the basic principles of design science.

Instructor Strategies: The instructor might emphasize conceptual foundations such as decision models or practical activities such as techniques for planning or task modeling.

Related Books

- Ahmed, P.K., Lim, K.K., and Loh, A.Y.E. *Learning Through Knowledge Management*. Butterworth-Heinemann, 2002.
- Biermann, A. *Great Ideas in Computer Science: A Gentle Introduction* 2^{nd} ed., MIT Press, Cambridge MA, XXXX
- Collins, H., and Kusch, M. *The Shape of Action: What Machines and Humans Can Do?* MIT Press, Cambridge MA.
- Connoley, T., Arkes, H.R., and Hammond, K.R. *Judgment and Decision Making*. Cambridge University Press, New York, 2000.
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- Gharajedaghi, J. *Systems Thinking: Managing Chaos and Complexity: A Platform for Designing Business Architecture*. Butterworth-Heinemann, Oxford UK, 1999.
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Chapter 4.
Models of Human Behavior: Individuals

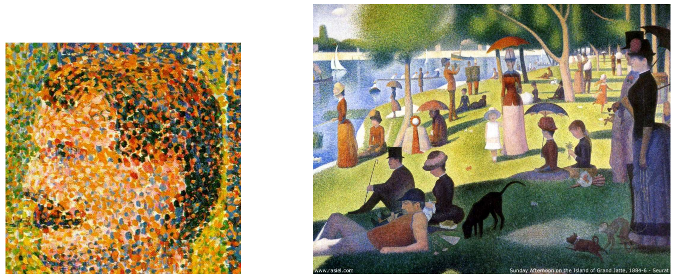


Figure 4.1: The human cognitive system fills in gaps. This occurs at both the perceptual level and for high-level expectations. Here we see examples of pointalist paintings. (check permission)

4.1. Describing Human Behavior

We have lots of ways of describing why people do things: For instance, We say that a person has knowledge, attitudes, beliefs, intentions, emotions, affective states, and personality. These approaches are sometime described as a "theory of mind" but the issues go beyond what is usually considered mind to cover all sorts of behavior. Folk Psychology. Constructs are often not consistent.

4.1.1. Cognition and Emotion

One on hand, people are very sophisticated information processors. On the other hand, the way they process information is very different from the processing of information by most computers and human information processing is frequently (if not always) affected by human emotion and needs. Emotion and cognition are two, sometimes competing, systems. Each with strengths.

It's clear that people process and make decisions based on information but what can we tell about what they are actually doing? People seem capable of the most amazing and sometimes he most perplexing actions. There's generally a simple connection between people's behavior and simple factors such as what's happening around them or the time of day. Obviously, social interaction is vital to people. In just about everything people do, information is vital. This approach has an emphasize the processes rather than the content. Later, we consider models of cohesion such as sense-making and attempting to reach consensus.

Integrated intelligent system. Many heuristics for approximate reasoning. Many capabilities. Learning, self-aware, collaborative. Principle of least effort to minimize energy. This even applies to cognitive effort. The person is part of a social group. Biological constraints (4.6.0).

While some behaviorists believe it is not productive to study the representations people use when reacting to their environment, most other psychologists do consider cognition and human information processing mechanisms. However, we can't see inside their heads to understand how that occurs. the mechanisms have to be inferred and many different models have been proposed. One such model, which is termed Human Information Processing, is based (roughly) on symbolic processing. People often process that information in what appears to a straightforward and sensible way. Many other times, that logical information processing appears to be biased by self interest or jumbled by emotion. People process information very differently from most computer-based information systems described earlier. Indeed, it is not clear whether the types of representations used by typical computer-based information systems are appropriate for human cognition. Symbolic and non-symbolic processing. The focus of the study of cognition is on mental processes rather than interaction with external information resources.

Qualitative models of causation (Fig. 4.19). Language is largely qualitative. Qualitative reasoning[35].

Here we focus on identifying general principles and then we will look at different styles of interaction with information systems. People acquire information from the environment encoded and stored in memory, and later recalled The human mind can itself be modeled as an information system (Fig. 4.2). This is essentially the same as a generic structure of an information system described earlier. Unlike information systems we build the cognitive system works must be inferred. However, this basic model is far too simple to give an accurate picture of how the human mind works; high-level cognition can affect perception, the context of our experiences may affect our memory of them, and our imagination can create situations that never existed. Cognition has implications for system design. In addition, learning is interwoven with social and emotional factors which we will consider in the next chapter.

Understanding the way humans process information can help in the design better ways for people and systems to interact: an understanding of sensory principles allows more fluid interfaces; analysis of motor control encourages easier interaction; knowledge of cognition allows more efficient information displays. In the end, the user is the most integral part of any information system. By seeking to find common principles across individual performance and behavior, we can develop guidelines to aid in the process of system design. Once we understand the commonalities across entire communities of users, we can direct attention to the creation of models focused on small groups and individuals. Understanding of the principles of human cognition and information processing will facilitate the development of user models that will support human-computer interaction. We will move from discussion of perception and pre-attentive processes to memory and cognition, and finally roughly following the levels of the basic model of human information processing (Fig. 4.2).

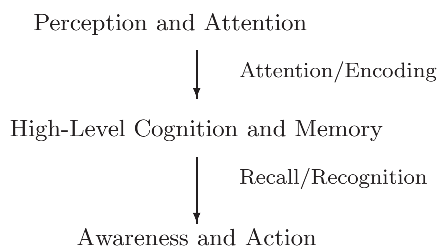


Figure 4.2: A simple model of human information processing.

However, human beings are clearly very different than current silicon information systems. Human beings have heterogeneous representations, complex motivations, and they are highly adaptive, They can reflect some of the contingencies of the environment. However, they are not perfectly adaptive. The human information processing model of human cognition is based on using information systems as an approach. This is effective in many ways, but it also reveals biases from imperfect information use.

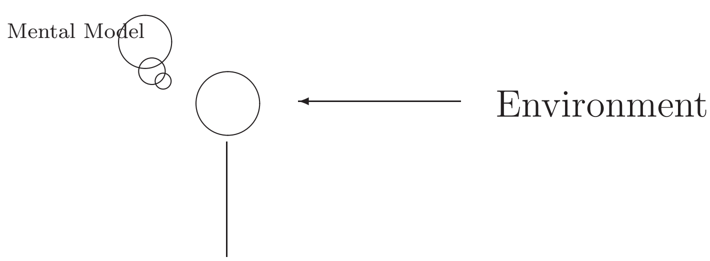


Figure 4.3: People actively interpret what is going on in the world based on their experiences.

Increasingly, we are understanding the details of brain structure (-A.12.2) and its relationship to cognition. This helps to inform models of human behavior.

Interaction with external sources of information. Considering the effort required for the information processing.

People detecting patterns. Static patterns. Patterns in motion.

4.1.2. About Cognitive Models

Theories about psychological processes rather than attempting to explain specific behavior. Mind and Brain. Information Processing in the Brain Modularity of brain processing systems.

Caution about Homunculus models.

Brain and mind as a self-organizing system. Cognitive systems[4]. Self-awareness. Increasing importance of Sensory processing, emotion, incentive, and brain science (-A.12.2).

Social Brain. Face recognition and empathy recognition regions in brain. Social signals. Mirror neurons and judging intention. Empathy (5.5.3). People generally have the sense that their experiences are coherent. However, there are may causes of which they are not aware[55]. Consciousness as an interpreter via narrative (-A.12.2). Neural simulations.

Cognitive architectures.

4.2. Perceptual Processing

4.2.1. Sensory and Pre-Attentive Processes

Hierarchical filtering to generate object comprehension. Everything we learn about the world is in some way derived from our senses. According to Fig. 4.2, a person senses and processes stimuli in a bottom-up fashion (10.1.5). Human sensors can be viewed as inputs to complex information processing system That is, our senses provide us with data about our environment, and we synthesize those pieces to create on overall sensation. Hubel and Wiesel. There may be interactions among the varying layers of mental processes; for instance, the human recognition element of cognition is probably an "up-down" process. indicating that there is no one formula for determining exactly how we interpret our environment. The interpretation of sensory stimuli is integrated with high-level cognition, The world around us assaults our senses, but our senses capture and refine those stimuli.

Before normal attention there is some pre-attentive processing. This intermediate stage gathers the information collected by the senses and performs a "quick-sort," organizing the information into broad, spatial categories. While it is not fully understood how pre-attentive processing works, it is known that perceptual groupings, form segmentation, color categories, textures, and clustering are all examples of visual pre-attentive processing. The well-known vase/face illusion Fig. 4.4 illustrates pre-attentive processing and suggests that this is an emergent or gestalt process. Perceptual principles of similarity.

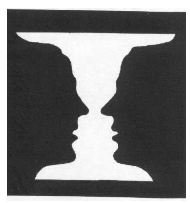


Figure 4.4: The vase/face figure-ground illusion is an example of emergent perception. Note how attention shifts between the faces and the vase. (redraw)

4.2.2. Attention

There is far too much information that exists in the world for our minds to capture and process all of it. People focus their attention on those areas of the environment that are likely to provide the most salient, or useful information. Attention is the direction of information processing resources to some part of the environment. We may miss information that is right in front of us if we are not attending to it. As we shall see later, planning presentations to manage the viewers' attention is part of the design of digital objects. Attention can be as simple as turning toward an information source. Attention as information seeking. Attention and motivation/emotion.

Perception is often thought of as hidden — we cannot control the way that our mind and senses work together to process the stimuli of the world. In contrast, attention is dynamic — people are able to direct the focus of their attention. One example of this ability is the "cocktail-party effect," in which a person can attend to one specific conversation while filtering out all the other conversations that are taking place around them. Similarly, we can attend to one small part of a complex visual scene (Fig. 4.5); this is compared to a searchlight that emphasizes parts of the visual field. Attentional limitations are also seen in language processing.

Figure 4.5: Attention may be compared to a searchlight with which some objects are highlighted compared to their background. (check permission)

People pay attention to things that are meaningful to them. Orientating toward information sources.

Resource-limited models (4.3.3). There are many implications of losing attention. Texting while driving, when working with mobile devices, or air-traffic control. Task-switching.

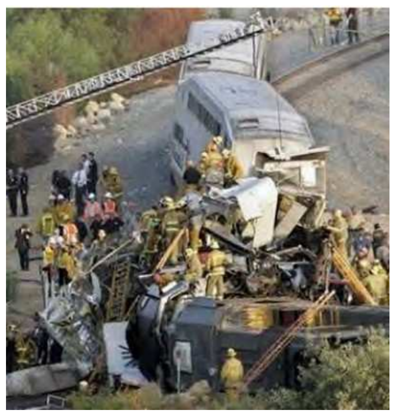


Figure 4.6: Texting requires has a high attentional load and multitasking. Texting by train engineers is the cause of many accidents such as this one near Los Angeles. (check permission)

Managing the attention of viewers improves effective information design. Authors may attempt to direct the attention of viewers using a variety of devices. Unusual features draw attention, as do changes in content. The advertising industry makes good use of these strategies to grab the attention of the public. Magicians manipulate attention. Attention and selective exposure to information.

Distraction from too little or too much information. Information overload. Attention and cognitive resources. Task stress. Fig. 4.7.

Eye movements seem to be a fairly reliable indicator of attention (Fig. 4.8). The pattern of the eye movement reflects the instructions to focus on the people in the picture [68]. As we shall see, eye movements have also been used to gauge attention during reading of text (10.2.0) and animations.

There are biases and distortions in attention [42]. Attention economy. Capturing eyeballs.

Figure 4.7: An airplane is a tightly coupled human-machine system. On one hand, in an emergency there can be too much information and the pilot may be overwhelmed. In other cases, such as when the airplane is on auto-pilot the human pilot may become distracted. (check permission)

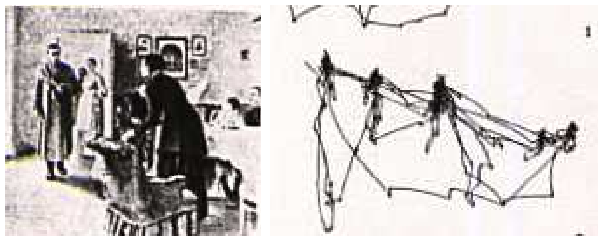


Figure 4.8: A person's eye movements while looking at an image provide clues as to what they are thinking The observer of the image on the left spent most of the time on people's faces as indicated by the eye tracks (right)[68]. (check permission)

Risk Aversion

Even simple statistical decision rules can be more effective than subjective human judgment. A simple statistical model using SAT scores and high-school grades is often more successful at predicting graduation rates than human judgment about the likelihood of student success[51]. This may, in part, be due to attentional biases (4.3.4) but also to the difficulties people have in doing accurate calculations with probabilities. However, there is some evidence that expert decisions in natural environments do not show bias. Use heuristics for decisions. Challenge to rationality (8.8.3); for instance, people tend to avoid risk.

4.2.3. Sensory Modalities: From Sensation to Cognition

Human senses allow us to receive information about the world. Indeed, our senses have implications for the selection of representations and for user interface design. People can often work around the limitations of modalities. We focus now on visual processing as we move from general principles of perception to principles related to the senses and vision in particular. Objects and images have visual properties such as size, brightness, color, texture, orientation, and shape. These visual elements are particularly relevant to the design of visual displays, and in developing visual effects in multimedia.

How do we understand and represent the world is also be a significant issue for image processing and virtual environments. As we described earlier (4.2.1), “pre-attentive” visual processing occurs prior to attention, as the name suggests. One example is the detection of regularities in texture which show how objects can be perceived against a textured background.

Furthermore, pre-attentive object perception seems to involve three different levels of representation. a primal sketch, a two and a half dimensional view, and a three-dimensional view that we perceive as our world view. These are similar to the stages which are often employed for machine vision. The $2\frac{1}{2}$-D sketch is like an artist's use of perspective in a drawing or painting.

Depth perception is also an element of visual perception. At the sensory level, our binocular vision — having two eyes — is one factor that gives us depth perception, by means of which we can tell whether an object is near or far. The mind uses many cues for depth perception, however. Some of these cues include relative motion, linear perspective, and familiar size (Fig. 4.9). Depth perception may also include high-level inferences based on perceptual models of the world[48], such as the understanding that

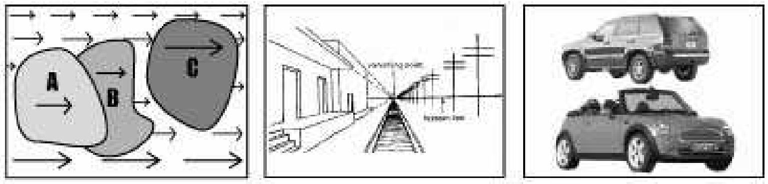


Figure 4.9: Some cues that people use in interpreting depth. (a) objects in the background seem to move more slowly than those in the foreground (b) objects in the distance appear smaller than those in the foreground, (c) apply world knowledge about the relative sizes of objects. Note that these involve relatively high levels of cognitive processing. (redraw)

Other Sensory Modalities

The traditional notion of five senses — sight, hearing, touch, taste, and smell — is highly simplified. A much larger range of sensors contribute to our perception of the world. Taste itself is composed of four different types of receptors (salt, sweet, bitter, acid) located on different parts of our tongue. The varying levels at which different food or drink stimulate each of these receptor types determine what we perceive to be the taste of that substance. Touch also provides vast amounts of information: touch reveals distinctive shapes and can indicate spatial and temporal patterns. Touch is also related to the sensation of temperature and pain. Although it is not widely recognized as a sense, the vestibular sense, or sense of balance, is mediated by the cochlea in the inner ear. Without it, we would be unable to stay upright. Proprioception is yet another type of sensory perception is which is the awareness of one's body in space. Touch and working in the world.

Even at a low-level, sensations are overlaid with cognition. Our understanding of the information provided by one sense will affect (often enhancing) our understanding of another. Smell and taste interact; we can imagine the taste of a substance from its smell, and something that tastes terrible becomes much more palatable with a pinched nose. Much of hearing is influenced by what we see, from the reading of lips to the reading of body language.

A well-designed Web site applies many cognitive principles. uses stimulating colors and sounds to help guide its use. Notice the small bumps on the "F" and "J" keys of your keyboard? They are a tactile orientation for touch typing. A system's use of sensation can even mean the difference between a person's using it or not.

Perception of Motion and Change

Action and behavior (11.4.1). Causation (4.4.2). Parsing events. Events.

Multimodal Integration

Synergistic senses.

4.2.4. Effectors and Physical User Actions

Ultimately, people make things happen with physical action. We will focus on motor behavior and the implications that this can have on the design of information systems. In normal life, people have many ways of interacting with their environments; in the world of computers, that has not been the case. Increasingly, however, interaction with a computer through a single stylized interface is disappearing. Almost any intentional behavior can now be captured and used as computer input. The term "multimodal" is applied to input devices beyond the keyboard, mouse, and joystick. Multimodal input devices allow input by speech, gestures, or handwriting. This revolution, though, has not altered the fact that human interaction with computers comes down to physical motion. Understanding human motor coordination might help us to predict the efficacy of interaction.

For those devices, requiring physical interaction, we can consider principles of motor behavior. We can distinguish “ballistic” motor behavior from motor behavior tuned by sensory feedback. Ballistic motor behavior assumes a fixed action pattern — like swinging a baseball bat or a golf club. However, with sensory feedback motor behavior the input is modified. Increasingly, sensors as interfaces. They are cheap and widely deployed. Wii and gestures (Fig. 4.10). Recognizing actions (11.4.1) and gestures. Location technologies for wireless (-A.15.1). Touch screens.

Figure 4.10: The Wii remote does motion recognition. (check permission)

Coordinated Motor Actions

It is often, but not always, easy for people to coordinate multiple actions. People interact with their environments with simultaneous, multiple modalities. Driving a car takes many coordinated physical actions and the input of several senses, and yet it is easily learned by most people. We often use both of our hands at the same time, fluidly coordinating their actions. Swiping touch screens. Multimodal interaction.

More subtly, we also see frequent coordination or reference between multiple inputs, such as when speaking people use facial expressions or hands gestures to amplify their words. This coordination between multiple inputs may be thought of as a type of referential semantics (6.2.3) in which the meaning of one set of actions (facial expressions or hand gestures) are dependent upon the meaning of the set of actions to which they refer (the words of the speaker). It is difficult for a computer to determine the meaning of referential semantics; meanings are contextual, cultural, and often ambiguous. Multimodal interaction and gesture input.

Skilled Motor Performance

Many complex activities, such as driving a car, involve feedback from the environment that allow adjustments to be made. But others activities, such as piano playing, tennis, and typing may not allow time for feedback. Procedures. The time required for nerve impulses to be sent from the brain to an extremity signaling for an action to be taken and for another signal to be sent from extremity back to the brain with the information that the action was completed, means that the instructions for a second action must be on the way before the first action is executed [44]. When signing your signature, you are moving your hand much more quickly than you could if you were consciously controlling it with feedback. This difference can be seen between hunt-and-peck typing and touch typing. Brain science (-A.12.2).

Sensorimotor Control (Haptics)

Simulated naturalistic systems should combine motor responses with appropriate sensory feedback. This interaction of sensory-motor control is also called “haptics”. A surgeon in training in an augmented reality environment (11.10.1) experiences the feel of cutting simulated tissue before working on a live patient; a participant in a game might want to feel one light saber hitting another; a musician playing a virtual instrument might benefit from feeling the responsiveness of the instrument. Additional sensations such as tactile vibration could thus improve the performance of motor tasks in a virtual environment[23] and, haptics could, for instance, support the experience of an interactive virtual museum. Force feedback.

Complex Decisions and Taking Action
Planning.

4.3. Cognitive Structures and Processes

Earlier, in this chapter we considered perception and attention, which are the first stages of human information processing. We discuss categories, memory and decisions, and emotion, which are later stages of human information processing. From cognition to affect. One topic in psychology focuses on examining cognitive structures. Motivation, learning. Matching to brain structures and cognitive function (-A.12.2).

4.3.1. Cognitive Representations

Human beings can be viewed as information processing systems, albeit complex ones. Start with very basic models.

What representations do people use when thinking? How do people recognize and use categories? As we noted earlier, it is common to analyze complex processes in terms of either structure of function (1.6.1).

The default approach to cognition is that the human mind is like a symbol-processing computer. Cognitive representations. Indeed, there are many ways in which that's not accurate but it still permeates a lot of thinking. Moreover, there are many indirect implications of that approach. Many models are based on rationalistic information processing. the models of human cognition are inferred and, in many cases, they seem likely to be approximations.

Natural-level categories.

Cognitive models are sometimes inspired by traditional computational models. In the models, cognitive processing is thought to work like a computer's CPU. There is a notion of fixed processing capacity with regard to human cognition. That is, the processing capacity of the mind is static, and that in order to store more information (i.e., memory), the new information and the already-stored information must be organized and nested in such a way as to reduce the demand on the finite powers of the brain.

Symbolic representations and frame. Cognition and categorization (2.1.2).

4.3.2. Human Memory Processes

Memory is the cognitive representation for stored information (1.1.2). There are many models for the structure of memory and how it works. Categories, discussed in the previous section, are believed to play a large role, helping to organize information and reduce the processing power necessary to retrieve memories. In some cases, memory by humans appears to follow hierarchies and simple inheritance[26], such as those we considered for knowledgebases (2.2.2). However, experimental data does not confirm this. Searching memory as a fundamental cognitive activity. Multiple memories.

Memory biases.

Models of human memory often divide it into working memory or short-term memory, and long-term memory (Fig. 4.11). We may remember some telephone numbers for only a short while we may remember others indefinitely. Even if they have an explanation, it often seems more like a story than a systematic explanation.

Models of human lexical-semantic memory, that is, memory for words.

Two types of retrieval processes from human memory are often considered. "Recognition" (1.4.4) involves identifying a stimulus that is presented, such as recognizing the correct answer on a multiple choice question. "Recall" is recovering items from memory without prompting, such as answering a fill-in-the-blank question. For user interfaces, a menu system involves recognition processes, while a command language generally requires recall of the correct command. Recognition is usually easier than recall.

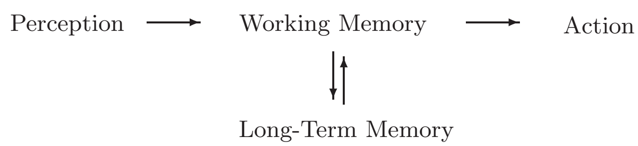


Figure 4.11: A very simple le traditional model of human information processing structure is based on the analog to a CPU. It has a working memory which manages processing and interacts with the long-term memory. This model needs to be expanded by considering the importance of context.

More Complex Models for Memory

Episodic memory is the memory for events. Autobiographical memory. Indeed, there may be a connection between episodic memory and semantic memory. The memories of multiple contexts eventually becomes meaningful.

Parallel Distributed Processing (-A.11.4). Visual and auditory relationships are very different from verbal semantics. Indeed, there is evidence of the existence of separate cognitive processing channels for verbal and non-symbolic (often multimedia) information [57]; This is a type of poly-representation. That is, there are multiple, sometimes overlapping, representations.

Memory for narrative and conceptually structured information. Transactive memory. Relying on association to help memory.

Errors and Forgetting. Retrieval failure. Errors in human inference. Overlay a memory trace. Distributed memory traces.

4.3.3. Architecture of Cognition and Resource-Based Models

We need to consider not only individual components but also how the individual pieces work together to form an overall architecture. Here we consider some basic cognitive architectures which have been proposed for human cognition and later we will consider architectures for intelligent agents which may include approaches such as machine learning (-A.11.0). While we can recall events from years past with seeming perfect detail, others remain hazy, indistinct, or even absent. What then are the limitations to accessing information that has been stored in human memory?

Architecture of cognition. The most successful of these models is ACT-R [**?**]. It has been applied to student models for tutoring systems (5.11.3) and, as we describe below, for multi-tasking.

Managing and allocating cognitive resources. Make good use of available mental energy (-A.12.2).

General model of cognitive resources. Cognitive-load.

Human information processing capability is finite – clearly, a person cannot process all the information in the environment. We often find it difficult to do two things at once because our attentional and cognitive resources are limited. The effort required to perform cognitive processing is known as the "cognitive load". Accidents associated with cellphone use while driving may be the result of a high cognitive load brought on by trying to carry on a conversation while trying to control a car. Furthermore, people manage their cognitive load, indeed, they generally minimize effort.

Multi-Tasking

Multi-tasking. Attention and use of resources.

Talk and walk at the same time. Activity production.

Declarative and procedural memories.

Problem-state block [**?**]

The amount of attention a person devotes to stimuli generally determines the "depth" to which those events are processed; that is, it affects the extent to which they are associated with other facts and the likelihood that they will be remembered. Because of this searchlight property, computing resources can be directed to the parts of a highly interactive interface that affect the user [1]. Attention and orientation towards.

4.3.4. Human Reasoning, Inference, and Decisions

Beyond the basic cognitive representations and processes, additional phenomena are of interest. Inference. The descriptions thus far have generally focused on cognitive structure. The "priming" effect in human cognition suggests that if a word such as "bird" is mentioned, then related concepts, such as "robin," will be activated and therefore more likely to be retrieved. Syntactic priming.

Expectations are intertwined with inferences. We should consider how people make inferences from the information they collect. not just logical inference (-A.7.0) such as deduction and induction. But there, may also be systematic probabilistic inference. Representation interacts with inference.

Everyday inference. Reasoning by logic versus reasoning by analogy. Abduction. Heuristics. Causal narratives. Social inference. Case-based reasoning.

Expertise and decision support systems help people to base their inferences on the most relevant factors. Economic rationality (8.8.3). Rationalizations. Age of Reason. Institutions to support reason.

Information Availability and Bias in Inference and Decision Making

Another non-rational pattern is based on the cognitive "availability" and salience of information. People often focus too much on information that is readily available in their memory. They may make a judgment based on the "availability" and "accessibility" of information in their memory (Fig. 4.13). We have already discussed that individual memory is fallible. In addition, people are often poor at predicting true probabilities of events. People often buy into the "gambler's fallacy," which is the belief that winning on one trial predicts future success. Even when allowing for such limitations, people often do not seem to act rationally. They may be self-indulgent or let their emotions control their choices. This illustrates the danger of relying on a "gut reaction". Often the probabilities of highly visible, but infrequent events are overestimated. This also implies that framing a problem is critical. That is, the context in which the problem occurs needs to be carefully described. Since human reasoning may be biased, systematic attempts to de-bias the analysis may be useful [66]. Subjective probabilities.

Figure 4.12: Framing affects decision outcomes.

One source of bias results from people trying to minimize cognitive effort (4.3.3) in decision making. A person who is engaged in many complex cognitive activities may use simple cognitive processing strategies – a jet fighter pilot needs to make decisions under pressure. The decisions that fighter pilots often face are formalized with algorithms (-A.9.3), which although simple, don't always accurately reflect all the variable present in a given situation. Because the use of information in decision making is so obviously important, the decision to seek more information may seem the most rational act in almost every situation. However, even this principle must be weighed against other factors, such as the required immediacy of action (as with fighter pilots), the actual existence of a truly "correct" course of action, or the simple ability to comprehend the various possibilities. Indeed, cognitive effort may be a factor in the willingness of people to carefully analyze a situation. When an exact solution is too difficult to calculate, people may be rules of thumb or "heuristics' but even then they are susceptible to bias. Even

> The frequency of appearance of letters in the English language was studied. A typical text was selected, and the relative frequency with which various letters of the alphabet appeared in the first and third positions in words was recorded. Words of less than three letters were excluded from the count.
> You will be given several letters of the alphabet, and you will be asked to judge whether these letters appear more often in the first or in the third position, and to estimate the ratio of the frequency with which they appear in these positions.
>
> Consider the letter R.
> Is R more likely to appear in the
> _ the first position?
> _ the third position? (check one)?
> My estimate for the ratio of these two values is ________ :1.

Figure 4.13: Most people stated that the letter "R" is more common in the first position than in the third position of a word. Actually, the opposite is true. Their confusion may be explained by the "availability" hypothesis because people more easily think of examples of words that begin with "R" than those that have "R" in the third position ([42], p167).

professionals seem to be affected by cognitive biases in perception[27]. And even experts judgments may be clouded especially outside their area of expertise.

Heuristic and Analogical Reasoning

A lot of human reasoning is informal. In some cases, it is based on heuristic reasoning or simply on stories (6.3.6). Family resemblance categories. Metaphor versus analogy. Analogical models (Fig. 4.14). Analogies at several levels. Reasoning by analogy often leave a lot out. If we say that one situation is like another and therefore should do again what worked before, the similarities may be apparent but the differences may not. Culture (5.8.2). [39]

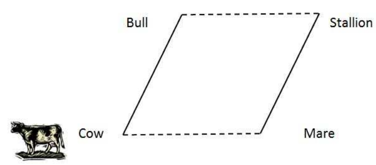


Figure 4.14: A simple model for analogy involves shifts on two attribute dimensions. In this case: gender and species. (redraw)

Verbal analogies. Analogy in science. Mental models. Reasoning by analogy and heuristics to save cognitive energy.

Sembl game. Network thinking. Less obvious links between objects.

Do People Use Plans?

We have seen that plans are fundamental for most AI models of interaction. However, it's not clear that people actually use plans. This may affect many sorts of interaction which is based on intentional actions. An alternative model is situated action.

4.3.5. Cognition and Learning

Adapting to the environment. People are highly adaptable. Learning is ubiquitous. Learning a skill. Leaning by doing. Learning by association. Here, we consider cognitive mechanisms of human learning, but later we will consider social aspects of learning (5.5.4). Implications for education (5.11.0) and machine learning (-A.11.0). Rather, people come into new situations with processes and expectations on which to build. Habit formation. Indeed, language learning seems to be neurologically fixed (-A.12.2). Human learning vs machine learning.

Representations are interrelated with learning. Indeed, learning may be considered as changing a representation.

One simple way to learn would be to remember patterns and sequences of actions which have proven useful. This reflects the structural approach. This idea fits some evidence from cognitive psychology that people "chunk" information into conceptual units. Expert chess players learn the relationships among the pieces on a chess board so well that that they immediately analyze a configuration of pieces in terms of those relationships. They "chunk" the positions differently than do novice players, who tend to view each piece independently of the others.

A lot of human learning seems to come simply from associations and correlations. A child may learn the sound of a key turning in the lock is followed by the entrance of his/her mother. After a few occurrences (associations) the child learns that one things leads to the other.

Generalization. A second principle of learning is known as "transfer of training". That is, learning one thing may facilitate learning a second thing. Learning Spanish may help a person to learn Portuguese. The learning of one thing may inhibit the learning of a second thing (negative transfer); learning Spanish may make it more difficult to learn Mandarin. Another example, could be the keys on a calculator pad; there are competing ideas regarding their design (Fig. 4.15). Transfer components of the design to other tasks.

1	2	3
4	5	6
7	8	9
*	0	#

7	8	9	+
4	5	6	-
1	2	3	x
C	0	=	/

Figure 4.15: Alternative keypad layouts: a telephone keypad and calculator layout. Office workers with both types of keypads sometimes have difficulty transferring when switching from one to the other.

4.4. Complex Cognition

Coherence and constraint satisfaction. Cognition applied to problem solving (3.7.1) and planning (3.7.2).

4.4.1. Concepts, Concept Networks, and Conceptual Models

Concepts

Concepts are basic units of thought. As suggested earlier (1.1.4), concepts are abstract ideas. They are related to but separate from the words used to describe them.

Earlier, we described the notion of entities (3.9.1)and we examined formal systems for presenting them in databases. However, the notion of a entities as building blocks for complex conceptual systems is quite general. We might apply it for descriptions of concepts in human cognition since concepts have a relatively stable structure of attributes. When entity-like structures are applied in modeling concepts, they are termrf frames. These are essentially the same as the notion of schema ((sec:data schema)(. The attributes are said to fill slots in the frame (Fig. 4.16). More complex structures based on frames are also possible. For instance, frames may be arranged hierarchically.

Concept Schemas, Maps, and Networks

In any system, several components need to work together. Thus, we need to move from individual concepts to sets of concepts and from there to the description of interoperating components. We might like to understand the relationship among concepts for

so we might make a map. Relationship of a set of concepts. Data diagrams are one example of schemas. Document description. Topic maps. Concept maps can be cognitive organizers when presented to people who want to find out about a new domain. That is, they would be a type of conceptual model as described below. They can direct attention to important sections of the text, and make readers

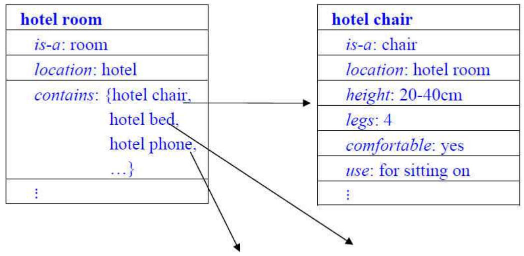


Figure 4.16: Frames and slots. (redraw)

aware of important connections between ideas. However, the presentation of a concept map before a reading can influence what is remembered about that reading by creating an expectation, which sometimes serves as a substitute for actual memory. After the fact of reading, a person my remember what they were told a particular passage said, as opposed to what it actually did. There are simple type of hypertext map (2.6.2). NASA library of concept maps. Mind map.

Fig. 4.17 shows a map obtained from a student after that student had read an essay. The student has drawn an illustration of how she thinks the concepts are related. These are like semantic networks (2.1.4).

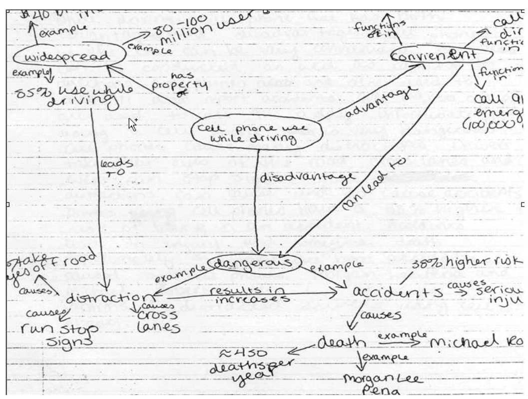


Figure 4.17: A subjective concept map was generated by a student to show how they believe concepts in this domain are connected to other concepts[24]. (redraw)

Conceptual Models for Explanation and Description
Models of a specific concept. Informal and Formal Conceptual Models.

4.4.2. Events and Causation

Events. From events to narrative (6.3.6).

Causation as a type of inference people make. Inference of causation often depends on models. Understanding causation in physical systems is often relatively straightforward. As illustrated by Fig. 4.18 we can confidently say that when a rolling pool ball hits a stopped one, that the impact starts the second one rolling. Is causation anything more than correlation[41]? Just because the sun has always up in the morning, are we sure that it will come up tomorrow morning? Causation is essential to narrative. Causation and agency. Determinis, causation, and free will.

The language of causation. "The cause" versus "A cause". When can we infer that there has been a cause? Understanding of causation is often associated with developing models. Scientific models can help provide confidence about these assertions, but even those are still simply confirmed from cumulated observations. Judgments about causation of social activities is trickier than judgments of physical causation. Causation in attribution (5.5.2) and in science ((sec:sciencecausation)). Reasoning about causation. Necessary and sufficient conditions. Causation as a state change. Covariation and temporal sequence. Multiple causation: INUS [?]. Causation versus means-to-an-end.

Causation also affects mental models and expectations (4.4.4) as well as decision making ((sec:decide)).

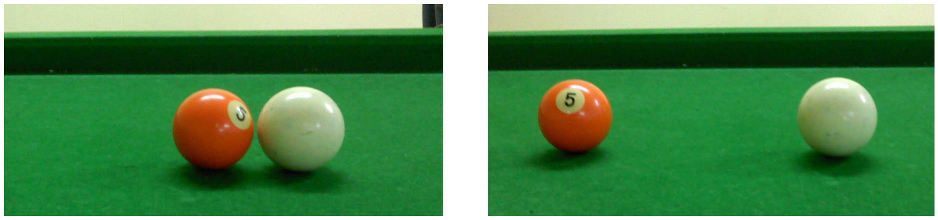


Figure 4.18: When one billiard balls hits another one which is at rest, the second one then starts moving. So long as there is not a long delay, we conclude that the collision caused the second ball to start moving.

Causation of the behavior of complex systems is hard to asses. Complex causes: Multiple causes and causal chains. Indeed, for complex systems, causation is often indirect and difficult to isolate. In cases where the rate of adaptation is slow, it is useful to understand the relationships.

Social causation is based on intentions and is far different from physical causation. Multiple factors to combine for any event but usually we identify just one or two as the cause. Minimal set of sufficient causes. More on causation (-A.10.2).

Complex causes: Multiple causes and causal chains. Indeed, for complex systems, causation is often indirect and very difficult to isolate. Because of the complexities there dangers in inferring causation. Our expectations about causes will bias perception and understanding. Informal causal models. Causal misconceptions and credit assignment (-A.11.3)(Fig. 4.20). Some of the problem nay be the mental models (4.4.4) and even the category systems.

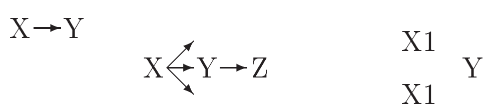


Figure 4.19: Qualitative causal graph. (not finished)

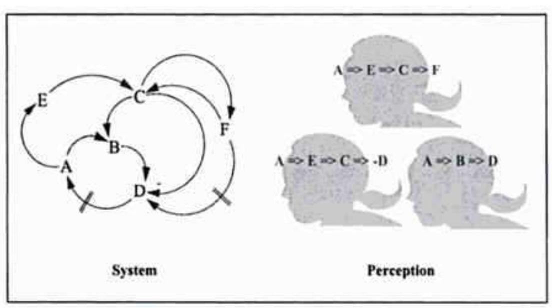


Figure 4.20: People interpret the causation of complex systems very differently. These interpretations also affect later decisions and memories. (check permission), (redraw)

Discourse (6.3.2). Narrative and plot (6.3.6).

Causal relationships in complex systems (-A.10.2) may be model with system dynamics models (Fig. 4.21). These are composed on stocks and flows (Fig. 4.22). Stocks are reservoirs which store values and can create delays in processes and flows link stocks.

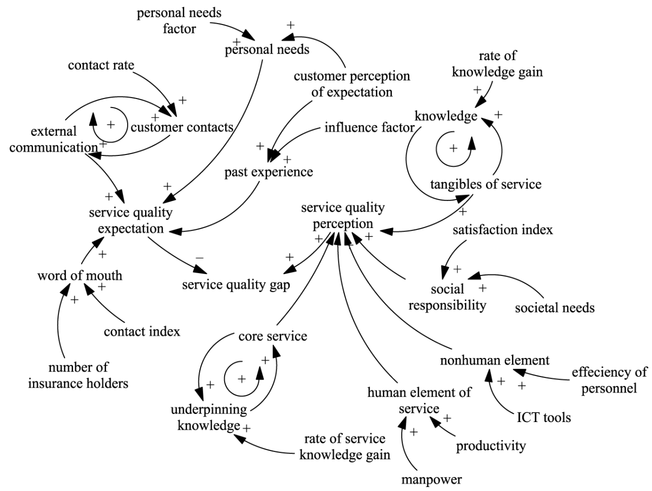


Figure 4.21: Causal loop models as developed in the field of Systems Dynamics provide approximations to complex systems. (redraw)(check permission)

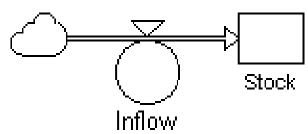


Figure 4.22: The basic components of system dynamics models are stocks and flows. Stocks are reservoirs and flows control the rate of flow into the stock. (redraw)(check permission)

4.4.3. Expectations and Memory

We rely on expectations all the time. Mental models are what are in a person's mind. They are the expectations or causal narratives people have about situations. Whereas a conceptual model is external to a person, the mental model is internal; but, they are closely related. Expectations as preconceptions.

Expectations seem to affect memory. Retrieval failure or changed memory. Human memory is very different from representations housed by traditional databases; it is not exact and the memory itself can be affected by expectations, prejudices, or stress. If a person is asked to recall a story, there are often omissions and intrusions of new material (Fig. 4.23). These are story schemas. Distortions may be amplified because a story does not conform to expectations. Similarly, our memory of the events we observe may be flawed by expectations. Narrative and human experience (6.3.6). For human cognition, the representation is confounded with the cognitive processes so they may not be distinguishable. Social expectations based on culture and norms.

4.4.4. Mental Models

Mental models are one model for how expectation arise. People may develop mental models to represent their understanding of procedures (3.5.1). Procedural knowledge, however, varies greatly in its complexity, function, and type. Automobile mechanics need to understand cars at a different level than do auto drivers. In cognitive terms, people need a mental model of an appropriate level for whatever task they need to complete. Computer users generally need to know more about the options in the interface than about the internal workings of the computer, whereas a computer technician needs a detailed knowledge of both.

Mental models are a way of storing expectations. Engaging with mental models is sense-making. Mental models for social action.

The representationsused by mental models are unknown. Observations of the way people interact with simulations of complex systems suggest that they often understand those systems in qualitative, rather

... So the canoes went back to Egulac, and the young man went ashore to his house, and made a fire. And he told everybody and said "Behold I have accompanied the ghosts, and we went to fight. Many of our fellow warriors were killed, and many of those we attacked were killed. They said I was hit, and I did not feel sick".
He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried.
He was dead.

... He did not know he was wounded and returned to Etishu. The people collected round him and bathed his wounds, and he said he had fought with the Ghosts. But in the night he was convulsed and something black came out of his mouth.
And the people cried: "He is dead".

Figure 4.23: A Native American story called "The War of the Ghosts" (fragment in top panel) was recalled two weeks later (bottom panel) with many confusions[16]. The difference seems to show the simplification of the original passage and the intrusion of expectations. (check permission)

than quantitative terms. A wine-maker might simply know that adding more sugar to a fermenting bottle of wine will increase the alcohol content without knowing the chemistry involved. Collaborative mental models. From static mental models to dynamic mental models which represent actions. We might even say that a person's reality is the sum of all their mental models. People may also have mental models for social interaction.

Mental simulations. Structure building framework.

4.4.5. Diagnosis and Troubleshooting

Diagnosis and troubleshooting attempt to understand the causes of difficulties with a complex system. Many examples from medicine to IT to auto repair. Medical reasoning (9.9.2). Debugging computer programs. Reasoning for scientific information. (Fig. 4.24). Indeed, a great many activities ranging from tutoring to answering reference questions and providing customer service involve some type of diagnosis.

Diagnostic categories.

Diganosis can rely simply on a rote decision tree ((sec:decisiontree)). Or, if human judgement is used it involves matching the behavior of a system to a mental model ((sec:mentalmodel)) of that system. However, as with many inference tasks, there prior assumptions or reliance on misleading information can lead to errors.

The initial presentation of symptoms can be explored by additional observation and testing. Such tests allow the systematic decomposition of problems and elimination of alternative. Testing and problem solving to rule out alternatives. Experience in selecting effective tests. (4.1.1) such as generate and test. Critical thinking (5.12.0).

Diagnosis is more challenging when there are multiple faults and especially when the symptoms of those faults interact with each other.

Qualitative reasoning models for automating diagnosis.

4.5. Beliefs and Attitudes

We make a broad range of attributions about the mental states such as beliefs, goals, attitudes, opinions, and values. These are informal, and often contradictory, descriptions.

While some models of human cognition assume that the representations of information is based on Aristotelian categories, other representations have also been considered. Models of beliefs and attitudes often seem to assume fuzzier representations. In a sense, they are like prototypes. Moreover, in some

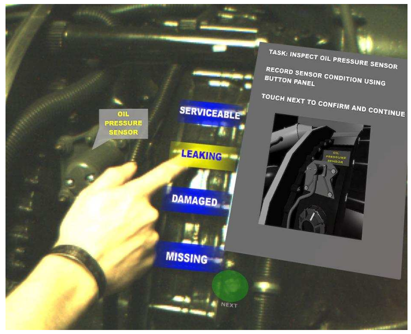


Figure 4.24: Support for diagnosis and repair with an augmented reality overlay[32]. (check permission)

cases, all of these terms sometimes refer to a general orientation and at other times to more specific issues. Beliefs often reflect expectations about social interaction. Opinions, which are generally thought not to have a strong affective component, are covered elsewhere. Attitudes are related to beliefs but include some emotion. Values. Opinions.

Inferences about future events. Optimism bias [?] relative to an objective view.

4.5.1. Beliefs and Belief Systems

Beliefs

Beliefs are the expectations about the state of the world upon which a person act. Belief is intertwined with the confidence. Beliefs may reflect expectations and inferences. Some beliefs may be the result of extensive inference from other knowledge or beliefs.

Beliefs for conceptual organizations and beliefs about the state of the world.

Two senses of beliefs: "I believe it is raining today." versus "I believe in you."

Framing a debate to emphasize certain beliefs. Reasoning about beliefs.

Beliefs and what is considered to be valid evidence. Beliefs from a trusted source. In modern society, many beliefs are based on scientific principles. Beliefs and science. Mental models as beliefs about actions and outcomes.

However, many intutions are simply incorrect. A simple example is the gambler's fallacy described above.b

People's misconceptions. Complex narrative. True believers. World views. Handling contradictory evidence.

The beliefs of one person can seem tenuous. What should we make of claims about UFO? Even when a claim is disproven, some people may continue to believe in it and just modify it slightly[33]. [63]. But, it's also true that everyone accepted some things on faith. Beliefs apply particularly to social attribution and categorization (5.5.2) of social motives since we have little confidence about them. Pseudo-science (9.2.2).

Figure 4.25: Some people believe that UFOs are staged; some people do not. (check permission)

Given the ambiguity, people's beliefs may often reflect positions that benefit them. But what is the cause-effect.

Accepting the accuracy of a fortune cookie. Horoscopes (Fig. 4.26). Conspiracy theories. People may use narratives to make inferences about beliefs. Conformity and beliefs.

> It won't be one of your greatest days. If you've been on a roll at work or school, then today may introduce a slight slump, thanks to pesky influences. Take a leaf out of Gemini's book and take it slowly: don't rely on it all working out: a plodding, measured pace will ensure fewer mistakes!

Figure 4.26: Horoscope example. People believe such statements apply to them even if they are entirely generic. (check permission)

Belief Systems

Belief systems are networks of inter-connected beliefs. They are coherent to a point. Beliefs and cultural values (5.8.2). Core beliefs. Ideology. Cultural origins of belief systems.

Many belief systems are internally coherent and are readily accepted when accompanied by social pressure. Shifting from one framework to another under extended subtle pressure is sometimes termed "brainwashing".

Belief systems are often not based on logic; rather they are often based on culture (5.8.2) and self-interest. Many belief systems are internally coherent and are readily accepted especially when accompanied by social pressure.

Stories of causal relationships. This is sometimes described as "creating a narrative".

Representing Beliefs

Some efforts have been made to model such beliefs (-A.7.4)[58]. It's unclear whether the detailed beliefs are stored or whether there is a continual process of interpretation from the core beliefs. Indeed, sometimes elaborate belief systems may be constructed based on just a few core beliefs. These are often associated with culture.

How do people make inferences based on belief systems. Beliefs vs conceptual systems (1.1.4).

Figure 4.27: Belief network.

4.5.2. Attitudes

An attitude is an orientation toward an object or concept. As such it, it more than a purely cognitive connection. An attitude incorporates a context which makes them fuzzier than concepts. It may be viewed as emotion inflected cognition. The term is sometimes used interchangeably with beliefs but more generally, attitudes include an affective component (4.6.2). Attitudes are widely used to explain behavior. For instance, attitudes are considered useful predictors in determining adoption of a new technology (7.9.6).

Unlike models of inference discussed earlier, inference involving attitudes is more like constraint satisfaction. This is also sometimes described as field theory which can be thought of a a type of constraint processing.

Attitudes are inter-related and generally coherent. Theory of Reasoned Actions. Among other factors attitudes and beliefs often reflect a person's self-interest[9]. Conformity is a tendency for the opinions of members of a group to converge. High-status individuals often can be opinion leaders. Relationship to norms (5.3.1).

People are usually attracted to people with similar values and they also tend to adopt additional values from those other people. Thus, values tend to cluster within a group and may be polarized from other groups [?].

Figure 4.28: "Well Heck, If all of you smart cookies agree, who am I to dissent?" As an illustration of conformity in conflict with an expectation for independent judgment. (redraw-K) (check permission)

Selective Exposure Theory (Confirmation Bias)

Attitudes seem to affect the willingness with which people accept new information. People tend to seek out opinion statements that are consistent with their beliefs and avoid opinion statements that are inconsistent with their beliefs. We may have a certain attitude toward one political party or another, and even a great deal of rational evidence may not convince us to change that opinion. However, there are also times when people will seek out perspectives which are contrary to their own.

Not only are attitudes correlated with actions, but attitudes seem to affect the selection of information sources. A person from given political party may prefer literature consistent with that party's message. Though, of course, there are also some times when individuals will seek on opinions and facts which do not support their own beliefs.

From Attitudes to Intentions and Actions

Attitudes generally seem to predict behavior. When they do not predict behavior we may look for other constraints. A person many not act on their attitudes if are being paid to do something else. We might get a better indication of a person's likely behavior by asking them about their intentions (Fig. 4.29). Even a decision to act may not result in a completed action if, the person is physically blocked from being able to do that. While attitudes are generally predictive of behavior, and the usual assumption is that attitudes actually cause behavior (e.g., Fig. 4.29) an alternative model suggests that in some cases, behavior causes attitudes[18]. This difference has implications for attitude change.

Intention versus practical action. BDI model for plan recognition (3.7.2) and agents (6.5.3). Propositional attitudes.

Forming and expressing a plan makes it more likely for that plan to be acted on.

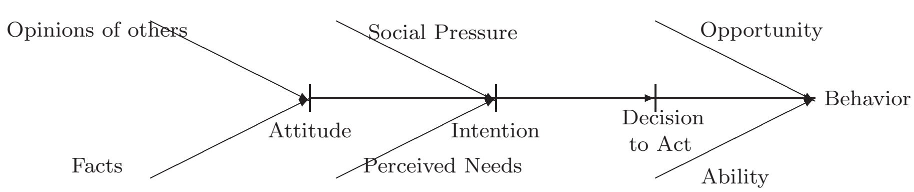


Figure 4.29: The usual model for attitudes proposes that attitudes lead to intentions and eventually to actions. We may have an attitude about voting. That is carried into an intention, a decision to act, and ultimately actual behavior. [9].

Attitude Formation and Change

Attitude change can be hard. While attitudes are resistant to change, we can explore the situations in

Figure 4.30: An alternate model of the relationship between behavior and attitudes, behavior may be used to infer as attitude: Behavior may be determined by past experiences and not by attitude. The same logic could also be applied to the origin of beliefs.

which do change. Information plays a part in the development of attitudes, but other emotional factors also contribute. One of the most important factors is source credibility. Indeed, this is consistent with sensible information literacies (5.12.2). There is a relationship to argumentation and rhetoric (6.3.5) through the presentation of reasoned arguments.

Persuasion includes both attitude change and ultimately changes in behavior. Advertising is an everyday example of persuasive speech. Some advertising is primarily informational, in that it simply tells you about a product, but advertisers also use other, more subtly persuasive tactics. Persuasion and belief revision.

A new car may be advertised as making you likely to catch the attention of attractive members of the opposite sex. Other techniques include an appeal from a person of apparent high status, or grabbing a person's attention and goodwill with images of dogs or children, which has the halo effect of generating goodwill toward the product. Fear can facilitate attitude change. For instance, in showing the health consequences of cigarette smoking. However, many people eventually learn to ignore that message. Dual processing models are information processing models for how persuasion might work.

Social media, data mining and persuasion.

Persuasive technologies. Persuasive games.

Attitude Change Simply makeing specific plans may enhance the likelihood of action.

4.6. Emotion, Affect, and Motivation

While we have focused on information systems; human being, of course, also depend on a biological system – their bodies. People have biological needs for air, food, water, minerals, and moderate temperature. People are not just neutral information processing machines, but there is a close connection of information processing and decisions with their biological needs. Social interaction has a strong aspect of emotion and affect. Brain science (-A.12.2). Social affect and the social brain (-A.12.2). For instance, there is a distinct part of the brain devoted to face recognition. Relationship of cognition to emotion. Emotion is more automatic. Embodied Action.

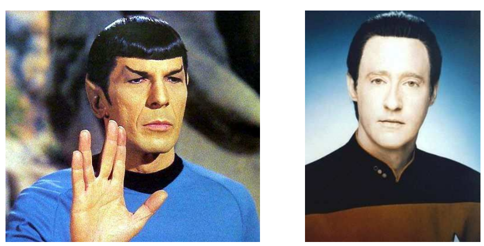


Figure 4.31: The conflict between human reason and human emotion is a common theme of science fiction as illustrated by the characters Spock and Data in *StarTrek*. (check permission)

4.6.1. Physiological Arousal and Emotion

It turns out to be important to distinguish physiological around from emotion. Unlike learning, emotion is transitory and generally does not change a person's mental representation. However, there is research to the contrary. Regardless, we may also judge emotions in others by observing individuals and drawing conclusions about their situations (5.5.2).

An individual may experience dissonance — a discrepancy between the expected and actual outcomes of events and a generalized physiological reaction. Simple physiological arousal is a strong component of emotion. Indeed, one theory even asserts that emotion *is* simple generalized physiological arousal, to which the individual applies a label consistent with the situation. This is a type of social categorization (Fig. -A.115). Interaction with cognition, such that the "fight or flight" reaction can be minimized if it the cause of the noise is benign. A violation of expectations often leads to at least a mild emotional reaction and to learning. It is accompanied by a surge of dopamine which is a potent neurotransmitter (-A.12.2).

Emotion affects cognition and decision making presumably because it reduces cognitive processing capacity[46]. Emotions can be too immediate and powerful to allow much analysis outside of them, yet these very same emotions demand immediate action. Emotions affect memory and attention. Emotion reduces human information processing capacity (Fig. 4.32).

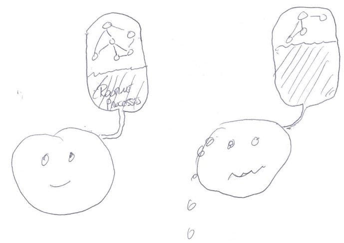


Figure 4.32: Emotion reduces cognitive processing capacity.

Humor and surprise.

Fear and aggression. Violence and arousal and video games[13] (5.9.4), (11.7.0). Bio-sensors can also be used for health monitoring.

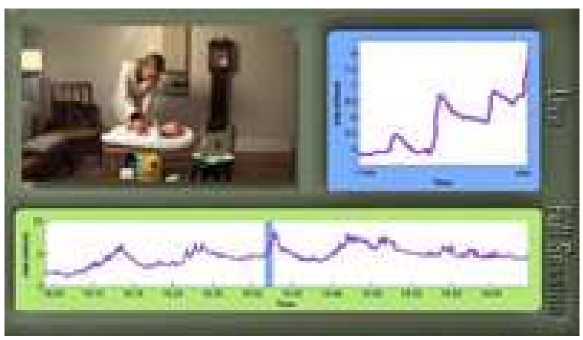


Figure 4.33: Designing for affect. Wearable bio-sensor[7]. (check permission)

Two models: imitation and catharsis. Increasingly, interfaces attempt to monitor and adapt to human emotion; this is an example of expressive and affective computing (4.6.2).

Determining Emotions in Ourselves and Others

Important to know the reactions of others. Emotion as signaling to others. While emotions serve a biological function such as spurring us to action in the face of danger, or bonding us to another to aid in the propagation of our species, the expression of emotions also serves a social function. We have a rich vocabulary for describing emotions, from "hate" to "love," and we freely apply those terms to ourselves and to other people. Emotions perform various functions in society, primarily serving as a basic means of communication between individuals. Guilt, for instance, is a fairly specific reaction and does not have specific correlates. Attribution (5.5.2). Emotions demonstrated by gestures. Social significance of smiling[65].

Facial displays. Identifying the different types of emotions. Perhaps emotions can be explained as a type of social categorization[56]. One theory suggests that individuals cannot accurately sense their own emotional states, and so use external cues in their environments (such as the reaction of other individuals) to help them determine their own emotions[62]. When we observe emotions in other people, we may depend on biological signals such as extremes of facial expression (Fig. 4.34). However, there is much research indicating that these extreme facial expressions are not culture specific; rather that they are understood by everyone, regardless of the culture in which they were raised.

Avatars generating appropriate facial expressions.

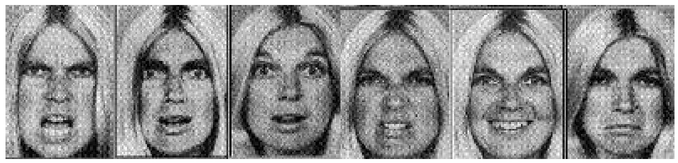


Figure 4.34: Expressions which are at the extremes of the Facial Affect Coding system: Anger, fear, surprise, disgust, happiness, and sadness[31]. (redraw-k) (check permission)

4.6.2. Affect and Aesthetics

Affect

Affect is a weak form of emotion. Affect and communication of social intent. Regulation of affect and self (5.5.1). Affect is interwoven with attention (4.2.2) and higher-level cognitive processing. Affect from social interaction. Mining affective texts and speech (10.5.3).

Experience management. Entertainment (1.6.1). Group interaction. Affect and tutoring. Affect is integral to almost all human action. This is it natural to incorporate it into under interfaces. Games (11.7.0). Affective design. This may include designing to induce and manage affect. Or designing to develop a meaningful interaction with an artifact. Gamification supporting user engagement.

Pleasure and Aesthetics

Some objects and environments give people pleasure. This is often by blurring conceptual or emotional boundaries.

Interest and engagement. Aesthetic responses, such as the pleasure from a piece of music, are weak types of emotion.

Mere familiarity can have a big effect on preference. Remarkably, mere exposure to stimuli leads to preference for them[69]. Similarly, as suggested by so called "hidden profiles", people prefer positions with which they are familiar[6].

Pain. Anger.

What is beauty? Mood. Engagement. Music selection systems.

Rap. Poetry. Trope such as a turn of phrase or allegory.

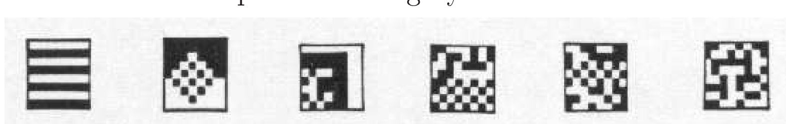


Figure 4.35: People show more interest in patterns with a moderate level of complexity such as those in the middle of the diagram as compared to the ones on either end (adapted from[19]). (check permission)

Entertainments provide an emotional ride.

Interaction with Emotion Inducing Information Resources

Comparable to information behavior which we discussed earlier. Aesthetics. Everyday aesthetics. Art:

Visual (11.1.1), music (11.3.2), and dance (11.5.1). Presumably, horror movies are popular because they provide an emotional jag. Self-management of aesthetic material. That is in some cases, people clearly enjoy strong emotions.

People also sometimes prefer visual novelty and complexity [20]. When viewing artwork, often the greatest preference is for objects with moderate levels of complexity (Fig. 4.35); complexity seems to affect interest and attention. People manage their moods; they generally avoid boredom and often seek excitement [12] [70].

Increasing difficulty of video game levels. Anger management.

Memorials. Reconciliation. Commemoration. This can also be seen as a type of cultural record (5.9.3).

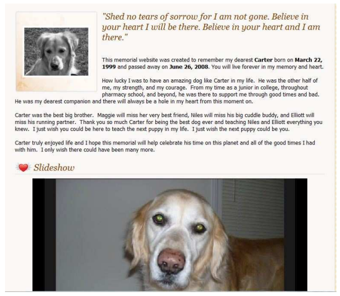


Figure 4.36: Pet memorial Web site. (check permission)

Figure 4.37: Attachment to objects. (check permission)

4.6.3. Motivation

The basis of motivation is survival needs such as food, shelter, reproduction, and related needs such as sleep. People will also work to avoid things which hurt them some of which are indicated with the painful stimuli. People often prefer novelty. There are advantages for people to explore and know about their environment.

Maslow's needs. This could be considered a motivation ontology. There are also many types of social motivation. Sociability, social recognition, and social engagement are often highly motivating. Social factors, such as fear, shame, or anger also play a role in an individual's decision-making process. Social approval and status can also be highly motivating. Social pressure. (5.0.0).

Pure information processing does not focus on motivation. Indeed, in Western culture there is a long tradition of considering the mind as something separate from the body. The expression "The mind is willing but the flesh is weak" echoes this belief. Because these two components are often thought to act independently, this notion is called "dualism". However, there are many reasons to dispute this traditional separation. Models of emotion and information processing. This is also related to other dualisms such as intention vs action, and belief vs conduct. The physiological system can be seen as complex system that seeks homeostasis although this can be complicated by addiction (-A.12.2).

Intrinsic motivation for, instance, in games. Mediated intimacy. Emotional health. Empathy (5.5.3). Motivation and brain science. Motivation and addiction.

SIMS modeling motivation.

Incentives and Rewards

People will clearly work for rewards. Extrinsic and intrinsic rewards. Setting up contingencies and incentives. As noted in the following section, money for rewards adds complications. User engagement as an incentive. How should we structure incentives?

Gamification points and explitic rewards. Resistance to explicit rewards (4.7.0).

Incentive can have a negative effect. For instance, a person who is paid to read a statement with a controversial opinion may later change his/her own opinion toward the controversial opinion later if paid a small amount but that change is less is the person is paid more. Sense-making is derived from dissonance. People make inferences not only from what they say but also from the conditions in which they say it. Complexity of actual motivation but also the perception of motivation.

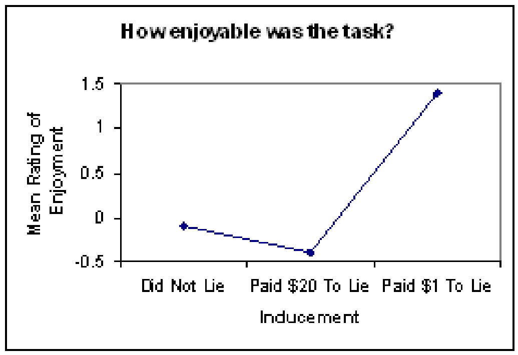


Figure 4.38: Dissonance illustration. (check permission) (redraw)

Learning, Affect, and Motivation

There are many reasons we learn but one of strongest is learning based on motivation. However, motivation is essential for instrumental learning. That is, for learning how to do things which fulfill goals. Attaining motivators is rewarding. Motivation and working for rewards. Motivation seems directly tied to learning. We are more likely to learn something if there is a clear motive for doing so. Biological systems also show adaption and a kind of learning. The human body stores excess food in the form of fat to protect against times when food is not available.

Social interaction is itself a strong motivation. Because they are essential to human life, the basic human needs are interwoven with human social organization, family, and culture. Social motivation and altruism. Social isolation reduces social control mechanisms. [34].

Cognition, Social Factors, and Motivation

Cognition can affect the perceived value of rewards. For instance, a person may discount value of an actions if the reward is perceived as being too large. Activities in the real world have multiple tradeoffs. Contingencies and incentive. People may not take an immediately-available alternative and to wait for another one. While this "delay of gratification" may be beneficial, it is difficult to learn[54]. Internal monitors. Internalized motivation. Self-efficacy[15]. Self-regulated learning. People's judgment of their capabilities.

4.7. Psychology in the Wild

In one sense, this whole chapter is about psychology. In the sense here, psychology describe decisions and tradeoffs of the whole organism. Bias toward stability.

Many apparently common-sense expectations about behavior such as the response to policy mandates are wrong.

Frequency of exposure effect.

Judgment of responsibility. Internalization of trust.

Saving face. Information avoidance. Self-expression. Interaction of concepts, beliefs, attributes, emotions, and motivation.

Information overload. It often isn't possible to access all information about a topic. So, there has to be triage. That is, picking and choosing the most promising sources. Information phobias. Psychological disorders.

Interacting with other people. Social incentives. Karma points.

In some cases, human behavior can be easy to understand. We have seen that aggregate crowd behavior can be predicted reasonably well. Similarly, behavior in constrained situations can often be predicted well. Human behavior in more complex situations is very difficult but would be very useful to predict. Similarly, developing intelligence agents with plausible human behavior would be of great interest for interactive environments such as games and teaching. Artificial Psychology. Application to avatars and video games (11.10.3). Conversational agents (11.10.4). Parallel to artificial intelligence. Affordances. Modeling attributions. Modeling and predicting human behavior.

4.8. Human-Computer Interaction

The field of HCI deals with the design and development of interactive user interfaces. There are many dimensions to the interaction of people with information systems. Some of the interaction depends on the task, some of the structure of the information, and some on the cognitive processes and affective responses of the person, or perhaps of a team working on a project. Thus, human-computer interaction can deal with very narrow tasks and very specific interaction techniques and on the other hand, it can deal with relatively complex sequences of actions as people complete tasks. The emphasis on interaction broadens into considering the impact of activities than the interface design itself or the task activities employed and those issues are discussed later. Hierarchy of levels of interaction. Increasingly resembles social interaction rather than tool-based interaction.

Design process with prototyping.

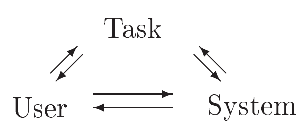


Figure 4.39: Task-Users-Systems. Here the focus on the interaction between the user and the system.

Interface

System

Figure 4.40: Hierarchy of levels of interaction.

Persuasion, simulation environments. Embodiment. Interaction with social agents.

Constraints for design can include technology, organization issues, user capabilities.

Specific application of cognitive issues in problem solving and task completion. We already explored some issues for supporting collaborative interaction. Detailed understanding of the tasks to be accomplished and the steps needed for completing them.. Activity theory (3.5.1). Applying design methodologies such as scenario-based design (3.8.0).

Technology both reflects and shapes organizations and society. In some cases, complex information systems are a poor fit and are rejected. Finding a balance between system needs and user needs and abilities. This is does with use cases and interface design principles (4.8.2). TAM (7.9.6). Agency and user control. How much should a user know about what a system is doing on their behalf. Markus' interaction theory.

When we consider interfaces for complex activities, we need to include understanding of the task the user is tying to accomplish. This, then, involves consideration of requirements; in particular use cases (3.10.2). Design (3.8.0)steps include: Goals, claims, assumptions, technologies[60].

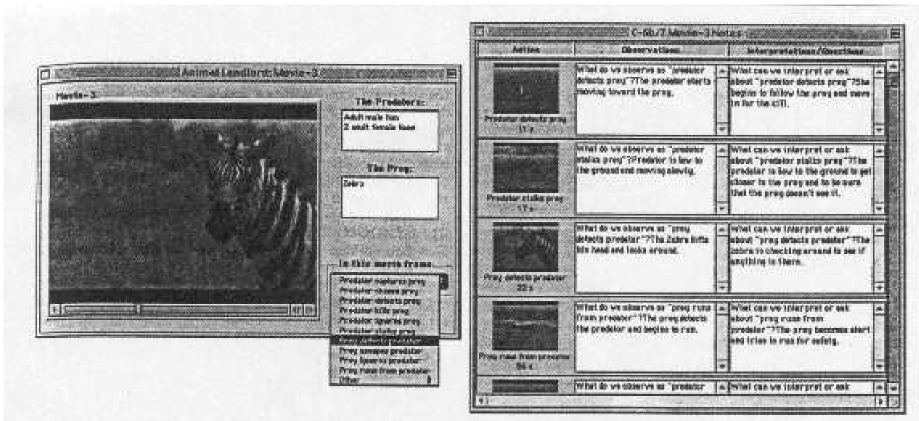


Figure 4.41: Structured input. (check permission)

Ergonomics and human factors.

Genres of interaction: command languages, WYSIWYG, mobile/social.

4.8.1. From Interface to Interaction

Both people and computers are very flexible. Both are able to adapt (or be adapted) to new situations, often in unlikely ways. Interactive systems limit and direct a user's behavior.

Confidence in estimates of utility (-A.9.4). Economic analysis (8.7.0).

One such heuristic claims that "an interface should strive for consistency". Consistency provides users with expectations of where to find things and facilitates the transfer of skills from one task to another. Consider the design of desktop interfaces — a person with no knowledge of a particular program is able to navigate through it fairly easily because of design consistency. However, all such heuristics are limited. There can be consistency within a single tool but may be inconsistent with the design decisions made for other tools.

Dimension	Description or Example
Internal	Within a single tool.
Desktop	Across a set of tools on a desktop.
Real-world	Virtual environments are consistent with the "real world".

Figure 4.42: Three dimensions of consistency for user interfaces (adapted from[36]).

Building applications based on user interface requirements (7.9.1) and designs (3.8.0)

Design and evaluation are closely intertwined but we will try to discuss them separately.

4.8.2. Interaction Design and Evaluation

Different levels of design – from task to action.

Applications versus environments. Desktops (3.5.4).

Interaction Design

Design for complex and interacting activities. Several strategies have been proposed for designing interfaces. Ultimately, design reflects cultural values.

Scenario-based design and activity scenarios [22]. Scenarios have: Actors, background, goals, and sequences of actions. Claims analysis provides explanations for some of the design decisions. Consider different types of users. Use cases (3.10.2).

Design of user interfaces and design of computer programs [?] or, of information systems. Interface design prototypes and as part of the design cycle (Fig. 4.43). Story-board and scenario-based design.

Design for engagement and sociability.

Figure 4.43: Lo-Fi vs Hi-Fi prototypes.

Interface Engineering

When the user behavior is highly predictable, systematic support can be developed. Perhaps, we could use them to engineer an interface, much the way that other engineers design a bridge or a rocket. Quantitative models focus on data and specifics to increase usability. Predictive models for interface design might be based on psychological principles. Specifically, we can apply models of perception (4.2.1) and motor behavior to predicting the time users spend making responses. However, the details of the predictions have not proven to be very insightful. State-based models (3.10.1) can describe interaction sequences (Fig. 4.44). This is also related to full use-case diagrams (3.10.2).

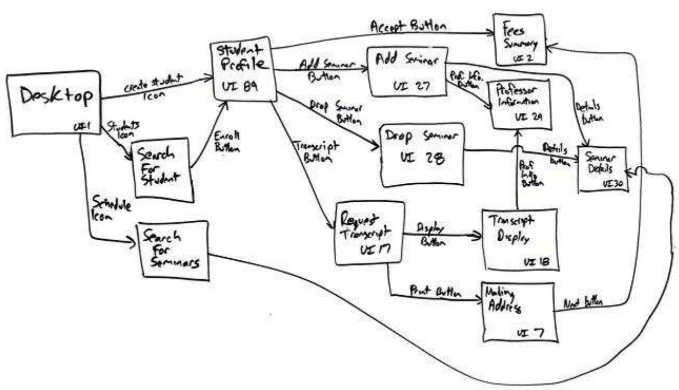


Figure 4.44: State diagrams for interaction with a user interface. (redraw) (check permission)

Eq. 4.3 suggests that a response is simply the sum of component activities (cf. [21]). Thus, we might expect the amount of time spent to move a mouse to a target would simply be the sum of the time for understanding the task (C), the time for finding the target (P), and the time for moving the mouse (M). We might estimate that a task would require 1.1 seconds of cognitive time, 0.3 seconds of perceptual time, and 1.0 seconds of motor time for a total of 2.4 seconds. While this approach works well, it may be limited by not allowing for the user to do two of these activities simultaneously.

$$response\ time = cognitive\ time + perceptual\ time + motor\ time \tag{4.1}$$

$$R = C + P + M \tag{4.2}$$

$$2.4\ sec = 1.1\ sec + 0.3\ sec + 1.0\ sec \tag{4.3}$$

Fig. 4.45 shows how formulas like Eq. 4.3 calculates the times of experienced users completing edits with two text editor deletion commands as a function of the number of characters being removed. A projected third command (dotted line, Method S) might save a few seconds in the region where it crosses the functions of the other two commands. To determine whether it is worthwile to add the new command, we need to compare the benefit of time saved with the difficulty involved for the user in having to remember the additional command. Multiple feedback mechanisms.

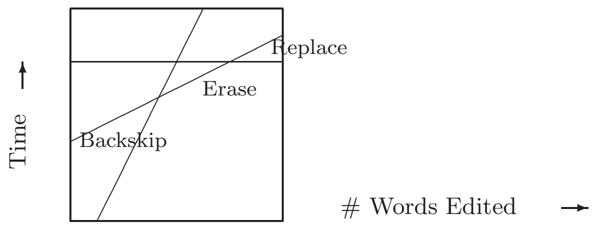


Figure 4.45: There are (at least) three ways that a word substitutions could be made with a text-based word processing system. This model attempts to predict the time for each of those options. Give such predictions, we might then be able to decide whether including all three commands was useful given the extra effort required to learn and remember the command[21].

There are many other factors which must be considered in any tool design such as the amount of time the user will spend with the tool and, thus, the number of features and options which that user will be able to remember. The physical characteristics such as display size, its "form factor", can affect the effectiveness of a device (Fig. 4.46). A large display gives a sense of physical presence and, indeed, of social presence (5.6.5). Protocols.

Figure 4.46: Small and very large display form factors give very different effects. Attempting to display complex information on a small screen. (check permission)

Minimizing errors.

Task and Job Analysis

This follows the workflow specification. Understanding what needs to be done versus re-designing the tasks. Representing tasks. Hierarchical task models. Task operators. Beyond workflows to include mental times and user knowledge. Indeed, a wide range of formalisms have been proposed. There is an ongoing debate about the relationship of these relatively formal task models compared to narrative-based approaches such as scenarios.

This specification can also be useful for documentation (7.9.6). At a deeper level, the task specification is also related to the user's cognition. GOMS. Cognitive task analysis (CTA) extends task analysis

(3.5.4). What do people actually do to complete a task[37]. Cognitive task analysis - what is the task from the user's viewpoint.

4.8.3. Evaluation Strategies

Expert reviews. Experiments. Discount usability: think aloud, heuristic evaluation.

In a cognitive walkthrough, the designer describe the features of the system to another person[67]. A similar technique can be used in evaluating complex multimedia productions[40]. Combine technological developments with human needs. Cognitive walkthrough for metadata.

4.9. Individual Differences

People differ from each other in many ways. There are physical differences such as height and behavioral traits such as handednesss. Presumably, these are based in physiology. There are also learned differences such language and culture as well as social role differences.

Rather than focusing on general principles of behavior and cognition, we could focus, instead, the ways in which individuals differ. They differ in the languages they speak, in their physical abilities, and in their preferences. The origins of these differences are widely debated; in some cases these differences may be biological and in other cases the differences may be due to experience or education. Representations can be built into applications

The origin of individual differences may be different experiences, cultures, and expectations or it may be more deep seated such as physiology and genetics predispositions. Knowledge work, or the process of obtaining or constructing new knowledge, is highly individualized. Every individual has a method of working that best suites them. While standard techniques and processes may be important and useful to know for virtually all people working within a given area, the ways in which these techniques are applied by individuals are too numerous to list. Information systems are applied differently by different users. The difference of adapting to the users and adapting to the tasks of the users is often confused.

Digital divide.

4.9.1. Cognitive Differences

These cognitive differences are intertwined with other differences among individuals, such as age. Fig. 4.47 shows a test for spatial ability. Spatial ability seems to be relatively consistent to be related to activities such as navigation, and it predicts the ease with which a person can use a graphical interface[8]. Spatial neurons (-A.12.2).

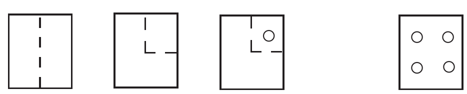


Figure 4.47: Paper folding test for measuring individual differences in spatial abilities[8]. The student is asked to decide if holes punched in a folded piece of paper, as shown in the sequence on the left would produce the pattern in the unfolded piece of paper shown on the right.

4.9.2. Age

Passages. Stages of life. Individual differences in information needs. Youth services (7.2.1). Role in proving community information.

Children

At one extreme of the age spectrum, children have limited knowledge and cognitive processing skills. Children learn differently from adults. While strict developmental categories has proven to be too simplistic[59], Classification systems to help children locate materials may need simplified categories. Young people generally have more difficulty finding facts than complex information. Difficulties of young people in formulating queries for search engines and then in understanding the results of search engines. Cognitive abilities by age. Working with children in developing user interfaces[43]. Language and age (6.1.3).

Older Adults

At the other extreme, elder users, who make up an increasingly large segment of the population, often have limited perceptual motor abilities, or they may have age-related diseases. As we discuss when considering differently-abled users, age affects us all. Eyesight deterioration is a common consequence of aging. Management of chronic pain.

Figure 4.48: Big buttons can help the elderly. However, even if the buttons are large the functionality can still be a challenge. (check permission)

Age limitations.

4.9.3. Disabled Users

Human beings are fragile. Varying degrees of abilities. As a result of accident or birth, people differ from one another in their abilities to perform certain tasks. Some of these differences are based on physicality, while others are based on cognition. Impairments may affect one or the other of these components. How do we compensate for these differences? Often this just means that a response for a given action takes longer. However, if a system were designed to better meet the needs of a differently-abled user with more thorough interface engineering, this response-time delay could become negligible. Impairments due to health-conditions.

Everybody is "differently-abled" in some sense. People can be color-blind, very tall, very short, unable to hear, to smell, to see, unable to walk, unable to run fast, uncoordinated, bad at math, bad at art, or even temporarily "differently-abled" such as being unable to use their hands when driving. Allowing systems to be tailored to suit individual needs would allow more people to participate in more tasks more effectively. Ideally, we would have tools which are usable by everyone – that is they should have universal usability. Substituting modalities and motor capabilities. We might support brain damaged patients or senior citizens.

Disabilities research to provide compensation for the disabilities.

Assistive technologies. Stakeholders for assistive technologies.

Sensory Disabilities

There are many ways for people to acquire information about their environment. Some modalities are better than others for imparting certain types of information. Music is obviously best delivered using an audio modality. Some modalities may be substituted for other modalities.

Visual impairments range from poor sight to color blindness, to complete blindness. There is a correspondingly large range of visual enhancements that can to overcome a visual deficit. These include providing descriptions of actions to support interactivity; magnifying text using video; touch screens that also involve speech for developing a mental map of a Web site; speech versions of text documents or descriptive videos. However, vision may even be replaced in some circumstances. Speaker characteristics can be controlled in text-speaking programs so that a different inflections can represent links, for example. Menu options can be spoken rather than displayed, and Braille generators are getting cheaper, though there remains the difficulty of representing images in Braille. Reading disabled and automated text-to-speech reading programs. Adoption of assistive technologies - who are the stakeholders.

Ebooks for the blind. Labeling graphics. Mobile phone apps for blind. Color identification. Sceen identification.

Screen-readers. Closed-captioning can be used for people with hearing loss to allow them to read what is being said. An avatar (11.10.3) can train students who want to learn lip reading[25] (Fig. 4.49). Alternatively, automatic lip reading systems might be developed.

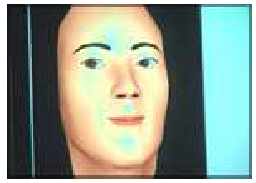


Figure 4.49: An avatar can help teach lip reading[25]. (check permission)

Motor Disabilities

Until recently, computer effectors have been primarily limited to keyboards and mice. These have proven very effective for the majority of users, but some people may have difficulty with these devices. Some motor-impaired users can simply switch to standard devices such as track-balls. Other options are typing via head motions, or using speech control for a Web interface. In some cases, one can enter text by blinking, or control a keyboard by blowing into a tube (Fig. 4.50). More fundamentally, if a task can be decomposed and reduced to its most fundamental and necessary elements, it can then be optimized for different modalities.

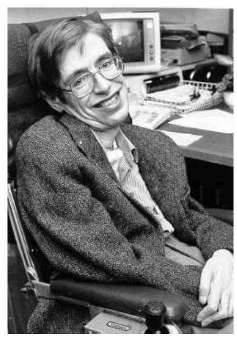


Figure 4.50: The physicist Steven Hawking has Amyotrophic Lateral Sclerosis (ALS), also known as Lou Gehrig's Disease, a neuromuscular disease. He often uses a speech synthesizer that is controlled by eye and mouth movements. (check permission)

Cognitive and Learning Disabilities.

Cognitive and learning disabilities are often neurological. Whether present from birth or brought on by trauma or disease, people suffering from a cognitive or learning disability may find it difficult to utilize many common programs and systems. However, information systems can be designed to better suit their needs (Fig. 4.51)[61]. Aphasia is the loss of the ability to understand spoken or written words, and it can be caused by an injury or disease that targets the language centers of the brain. Image-oriented design can help those with aphasia to use information systems. Brain science (-A.12.2).

Type	**Description**
Autism	Difficulty in social interaction
Aphasia	Language disorder. Difficulty with understanding.
AD/HD	Lack of continuity in attention.

Figure 4.51: A few examples of cognitive and learning disabilities.

Computational behavioral science (Fig. 4.52). Analysis of autistic behaviors. Automated behavioral analysis. Diagnosis (4.4.5, 9.9.2). Interactive environments for teaching autistic individual skills to cope.

Another major group of disabilities is learning disabilities. Dyslexia is a cognitive impairment which affects the use of language This can include difficulties in both reading and writing (Fig. 4.53). It is

Figure 4.52: Detecting autistic behaviors from multimodal analysis[2]. (check permission)

often typified by difficulty associating spoken words with the same word when it is written; letters in a word appear to be out of order. Design-based aids for dyslexia can often be relatively simple: font changes and re-readers can help people with dyslexia process information (10.2.0). Brain science and dyslexia (-A.12.2). Also, schizophrenia.

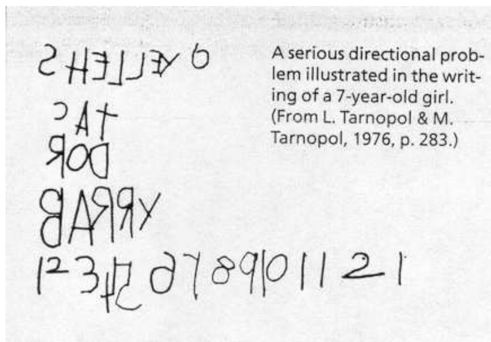


Figure 4.53: Example of writing by a dyslexic[64]. (check permission).

Personality Traits?

A person's behavior is often determined by factors such as the immediate task they are trying to accomplish (3.0.0). A personality trait we ascribe to another person is a models for our predictions about that person. People tend to develop habits to engage in or deal with similar tasks or situations. In many cases, what is called "personality" may simply be a consistent reaction to a consistent environment[53]. Still, there seems to be a type of homeostasis by which people tend to revert to those environments in which they are most comfortable functioning. Individuals interact with their environment. Personality versus roles.

Indeed, it is vvery difficult to make any generalization about categories of people.

4.10. Personal Data, Personalization, and User Models

Big data in science ((sec:bigdatasci)). Medical data.

4.10.1. Application Usage Characterstics

Shopping data.

4.10.2. User Models

We would like to capture, represent, and apply distinctive characteristics of users such as preferences, affective state, needs, and history. In conversations, participants adapt to one other (6.4.0), making allowances for accent, vocabulary, or personality. Indeed, adaptation is a characteristic of many sorts of interaction. Information systems can be designed to adapt to the differences among users. It may often be easier for a system to adapt to the user than for the user to adapt to the system.

User models may be contrasted with mental models (4.4.4), which are expectations that the user has about the computer. Just as a user's behavior is often greatly affected by the tasks in which they are engaged, a user model might be coordinated with the computer's task model that is used for a particular job (7.9.3). Properly coordinated user and task models could allow the system to make routine decisions for people as opposed to allowing them to have an optimal set of choices; this would decrease the complexity of the system, and allow it to be utilized by a wider variety of people. The values of these independent variables can be obtained explicitly from the user. Or, they may be inferred indirectly (implicitly) from some aspects of the user's actions. This can be the basis of complex services such as personalized travel recommender systems. Privacy, data integration. Predicting online behavior.

Assessment to fill those models. Personal assistants that learn.

Affective user models. Adaptive hypertexts and drama management.

4.10.3. Personalization

Personalization can be based on user attributes. Personalization versus situational context. Personalized search (10.11.4). Explicit and implicit personalization. What information about users to capture? Algorithmic personalization may narrow a person's exposure to diverse viewpoints.

Meta-design and human crafters.

Cross-platform tracking and personalization.

Beyond personalization to prediction of a person's behavior. Anticipating and predicting what the person is doing.

Customizable technologies.

Type of Independent Variable	Examples
Tasks	homework assignments
Skills and knowledge	know a location, know how to program
Attitudes and transient personal characteristics	mood, hunger, interests
Stable personal characteristics	marital status, education, languages spoken
Culture and norms	
Demographics, group membership	age, political party

Figure 4.54: There are several levels of detail from predictions can be made about people (adapted from[11]).

Personalization often means specializing by tasks in which a user is engaged. Networking and new computational resources allow transactions to be personalized much more easily than used to be possible. When considered broadly, user models often include task models and even queries. An important factor in the effectiveness of the predictions is the stability of the behavior[52]. There are many applications of user models, such as a personal aerobics instructor moving at your optimal pace, a recommender system (5.5.5), or personalized language generation (6.4.0). Tutoring systems and statistical student (user) models (5.11.3) such as the geometry tutor[14].

Personalization has great commercial appeal as well. Advertisers would like their materials to be relevant to users; this is the idea behind targeted advertising. Advertisers look for user attributes that are most applicable to their particular advertising goals. This streamlines advertising and reduces costs for both the distributor and the consumer. Real-time targeted ads. How to pick the best-match advertisement to present given the fragmentary information about users. Auctioning impressions based on real-time web interaction.

Mass Personalization with Big Data.

4.10.4. End-User Programming

Programming allows the specification of complex constraints. Some programming languages such as Java and C++ are general-purpose. Other programming languages are specific. Among those, some are designed for the end user to do the programming. When programming a VCR, a person may specify the time recording should start and the channel to be recorded. Programming with command languages or by moded states. Spreadsheets. Automate repetitive web-based tasks such as gathering information from an ecommerce tasks. These are often involve lots of semantic structure. End-user communities which can share tools. This can also be used to set personal options – that is personalization. However, programming a VCR is notoriously confusing for some people (Fig. 4.55). End-user programming in the home.

Figure 4.55: VCRs allow users to do limited programming to set functions. However, doing that programming is notoriously difficult for many users. (screen-dump)

4.11. Personal Information Management

Personal information management (PIM) is often close to the tasks in which people are engaged. There are many kinds of personal information such as address books, photographs, voice mails, medical records, and letters. Some of these are digital and some not. And, probably all of us have lost track of some of our personal records.

Importance of family (5.1.1) for personal records. Mechanisms for family record keeping.

In some cases, PIM applies to everyday information but also information management for groups and teams. PIM versus group and team projects. Social Memory (5.13.3). Collecting material about separate individuals to form a picture of a larger group. Different styles of personal record keeping[50]. PIM and personal email (10.3.2) especially nearly complete searchable mail records.

Personalization and privacy.

Citizen archivists. Self archiving. Digital lives (10.3.1) of authors. Personal data. Coordination personal archives. Management of personal sensor data. Self-monitoring for self-improvement. Comparison to institutional archives.

Family bible. Chinese genealogy.

4.11.1. Personal Information Resources and Collections

Information management skills (5.12.0). Organizational work activities. Folders. Connection to social media preservation. Ultimately, this relates to questions of the self and identity (5.5.1) and the nature of archives.

Personal Collections

What a person collects for him/herself outside of a public or organized source. Personal collections of information resources Collections (7.1.3). Memories. Value. Amusement.

Diary. Personal reflections. Creation and use. Personal narratives (6.3.6).

PUT - Personal Unified Taxonomy. Personal ontologies. But, ultimately, these are primarily social creations.

Personal reference collections. Personal photos, Personal notes. Management of personal records (7.4.1).

Cognition (4.3.0) memory and PIM.

Personal search: search organized by personal relevance.

Project and team archives (5.6.4).

People often go back and search for something they had previously found; this is known as "refinding". Landmarks can help people in finding information they have already seen [30]. However, personal information systems do not necessarily enhance personal productivity [5] (8.8.1). Personalization (4.10.2). Subjective importance. Retrieval by context.

Privacy and protection of personal infornation (8.3.1). Right to oblivion ((sec:oblivion)).

Information literacy (5.12.0). How do people learn that information resources are useful for answering their needs. Making the awareness of information needs a higher priority.

Storing and preserving personally created information such as blog postings personal Web pages.

Overlapping personal information spaces. Team and group information spaces.

For effective use, people need to manage their information artifacts. Some online records are easy to find, but others are only located after extensive searching, or perhaps stumbled upon accidentally. By keeping an archived record of important or useful websites, the Web itself becomes a more powerful information tool. Most Web browsers make this particularly easy by providing a "favorites" or "bookmark" function. Along the same lines, a personal bibliography [3] serves much the same purpose. This is a list of all the books that a person possesses, or has read, with useful metadata associated with each one. Within an individual book, a person may place a bookmark to indicate a passage to be remembered, or to mark their spot. An information environment can be further extended with "altering services". These notify users of changes in their information environments and they include Email news alerts.

Lifelogging

While PIM focuses on materials that a person creates, Lifelogging has been proposed to passively record a person. This could be done, for instance, with audio or video camera they carried around all the time. Lifelogging tools could also support reminiscence. Personal image collections. Supporting reminiscence. Autobiography. Diary. (Fig. 4.56).

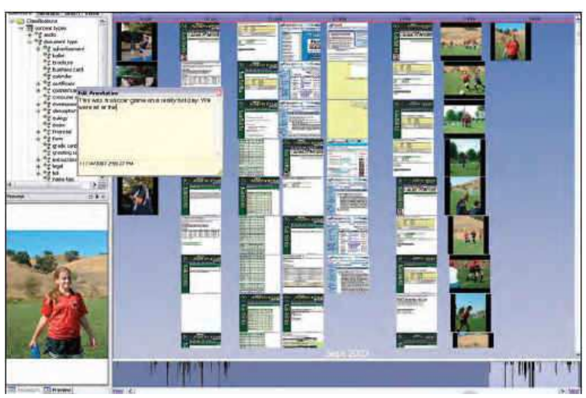


Figure 4.56: Interface for reflecting on Lifelogs (from[17]). (check permission)

There are several variations: Long-term personal information management. Personal information management [28]. Personal collections and digital libraries. Personal image preservation [49]. My Life bits. Sensors. People's systems for information organization evolve.

4.11.2. Personal Task Environments and Workspaces

People develop personal information systems for personal information such as cooking recipes. Intensive personal information management. Cellphones to calendar systems[29]. Balancing effort and estimated benefit in organizing information. Allowing commercial organizations such as banks to keep personal information about you. Managing group information such as the information of your family. Some tools and some information sources (e.g., an appointment calendar) are used so frequently that they belong on the desktop Information management beyond personal workspaces. Preservation of personal information is related to archives which we will consider later (7.5.1). Preservation of personal and family photos. Desktop computers (3.5.4). Desktop searching. People often click on the same URL time many times. Searching personal media archives.

Personal Task Support

Individuals will have different strategies for completing the same tasks. various strategies for organizing their information and task environments. Some information environments are personal information spaces (Fig. 4.57). Offices and desks are perhaps the most traditional information workspaces. Often, they are dominated by collections of paper documents, sometimes in disarray. The way in which a person organizes his or her office or desk can be an indication of strategies facilitating access to the information needed to accomplish tasks (Fig. 4.58)[47]. Setting personal records such a calendars and contact lists. Personalization (4.10.2).

Figure 4.57: A refrigerator door can both store information and provide reminders.

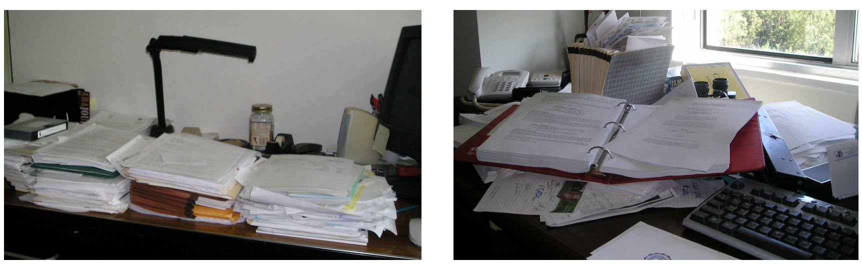


Figure 4.58: Examples of personal information management strategies: A neat office (left) and a messy office (right).

Task Interaction Histories

Many activities repeat with small changes. A person doing them may want to review the steps in a search or to modify the steps in it. Keeping track of the tasks in which a person is engaged. Tasks such as searching are often repetitive. A valuable question to ask is, what does a person believe about what he or she is doing; what do they expect? What data can be recorded about their actions? This may be useful for searches involving many components. The memory of task completion can be organized around task semantics; query histories can be maintained (10.7.1).

We can distinguish between individual user models and collective histories. Towards performance support and help systems (7.9.6).

People know a lot about themselves — their motivations, the approaches to tasks, and the tasks in which they have been involved. Keep track of what a person has done; a user's history can be helpful in planning future activity. "Bread crumbs" can provide a trail for the user to follow to show where they have visited previously. Coordinated with person's memory and current goals. Repeating previous searches. Making small changes as a complex search with parameters previously derived. Saving search histories. Characteristics of user searching behavior. Local web sites versus remote web sites.

Coordinating various tasks, and keeping records of search notes, strategies and plans, as well as of one's thoughts on the topic and navigation already performed, can all provide a context for continued use. Ad hoc search procedures.

Visualization of interaction histories could show what the user has done in a given session. The semantics of action sequences user's viewpoint; users have a unique perspective based on their own memories of what they have been doing, and the landmarks and salient events they have observed. Some activities are engaged in by many people. The cumulative traces left by various users could indicate areas of productive interaction for new users. Scroll bars are one way of representing user histories (Fig. 4.59).

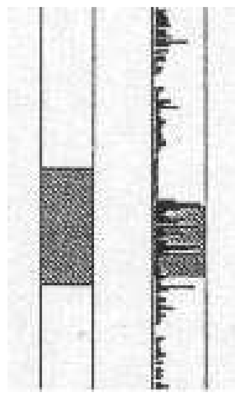


Figure 4.59: Rather than simply showing a slider (left) a history-enriched scrollbar (right) can show graphically which parts of a document have been accessed most frequently[38]. The users may find it useful to navigate to sections of a document which have been of interest to others. (redraw) (check permission)

Exercises

Short Definitions:

Assistive technology
Attention
Attitude
Autism
Categorical perception
Cognition
Cognitive load
Concept map
Conceptual model
Delay of gratification
Dyslexia
End-user programming
Emergent perception
Emotion
Episodic memory
Form factor (display)
Force feedback
Gestalt
Habitability
Individual differences
Mental model
Mixed-mode initiative
Personalization
Situated cognition
Short-term memory
User model

Review Questions:

1. Distinguish between "sensation," "attention," "perception," "cognition," and "emotion". (4.2.1, 4.2.2, 4.3.0)
2. Compare cognitive representations with database representations. (4.3.1)
3. Describe some types of visual impairments. (4.9.3)
4. Complete an interface usability calculation. If $C = 0.8\ sec$, $P = 1.4\ sec$, and $M = 1.2\ sec$ what is R? (4.8.2)
5. Distinguish between "user models" and "mental models". (4.4.4, 4.10.2)

Short-Essays and Hand-Worked Problems:

1. What are the limits of the searchlight metaphor of attention? (4.2.2)

2. Why are people likely to exaggerate the likelihood of highly visible or unusual risks while apparently underestimating the likelihood of more common risks? (4.2.2, 8.8.3)
3. Were the representations we use for electronic information systems are relevant to human cognitive representations of information? (4.3.1)
4. Have you ever heard a piece of music but not been able to remember its name? How could that be explained by the dual-coding model of memory? (4.3.2)
5. Give an example of attempted attitude change by an organization or politician. In what ways is it likely to be effective? (4.5.2)
6. Propose an advertising campaign to convince people to stop smoking. Describe why you feel it would be effective.(4.5.2)
7. How is "motivation" related to "goals"? (4.6.0)
8. How would you develop a user interface that would adapt to a user's information processing load? (4.3.3, 4.8.0)
9. Propose a cognitive explanation for why people so often fail to remember to add attachments to their email messages. (4.3.0, 4.8.0)
10. List the advantages and disadvantages of the two calculator designs in Fig. 4.15 (4.8.0)
11. Give some examples of the use of metaphor in human-computer interfaces. (4.8.0)
12. What are some of the ways visual interaction could be replaced with audio to support visually impaired users? What are some of the limitations of this approach. (4.9.3)
13. Describe what resources are available in your university library to support information access to students with disabilities. (4.9.3)
14. What are some difficulties that a person might have in learning to use a spreadsheet? (4.10.4)
15. Describe some techniques which might be useful for implicitly collecting data for a user model. (4.10.2)
16. What are the tradeoffs between individual systems for organizing information and common systems for organizing information? (4.11.2)
17. Describe your system for organizing your own desk or your online workspace. How could it be improved? (4.11.2)
18. Test the back button of a Web browser. Describe the algorithm the browser uses to move back. (4.11.2)

Practicum:

1. Interface design.
2. Device design.

Going Beyond:

1. Is there an objective "reality" by which we should measure the quality of a person's perceptions? (1.6.2, 4.2.1)
2. Information can be transmitted between people via different modalities? How could you quantify the information capacity of modalities? (4.2.1)
3. How feasible would it be to develop applications that are specifically independent of interaction modalities and then have them adapted to the user's modalities? (4.2.1)
4. Some animals have very sensitive sensory mechanisms. What is distinctive about the hearing of bats, the vision of owls, and the olfaction of dogs? Could artificial sensory organs be developed which modeled these? (4.2.1)
5. Is it possible to say that some sensory modalities allow people to acquire information faster than other sensory modalities? Give some examples. (4.2.1)
6. Do two people experience perception in the same way? Is your perception of the color green the same as your friend's perception of green? (4.2.1)
7. Develop a detailed model for how people coordinate multiple complex motor behaviors, such as singing and dancing. (4.2.4)
8. Compare the psychological notion of a "stimulus" with the concept of "information". (1.6.1, 4.3.0)
9. Our definition of "information" is related to the psychological notion of "stimulus". Explain this similarity. (1.6.1, 4.3.0)
10. How much confidence should we have in what people say about their own thought processes and motives? (4.3.0)
11. How reliable are people's statements about their own information processing? (4.3.0).
12. How accurate is introspection? How well can a person tell the mechanisms of their own thought processes? (4.3.1)
13. How do people know what they don't know? (4.3.1)
14. How is long-term memory related to mental models. (4.3.1)
15. What role does human memory and learning plan in attitude change? (4.3.2, 4.5.2)
16. Several noted psychologists such as George Miller and Herb Simon have argued that chunking is a fundamental process for organizing information in human memory. What is the evidence for that? Do you agree that it is a fundamental aspect of memory? (4.3.5)
17. How can we validate concept maps such as the one shown in Fig. 4.17 (4.4.1)

18. Do attitudes cause behavior or does behavior cause attitudes? (4.5.2)
19. Develop a cognitive model for the processing of attitudes? (4.5.2)
20. Describe some of the ways the principles of cognitive psychology are relevant to the design of user interfaces? (4.8.0)
21. What do we mean when we talk about a "computer user". What are some problems with that construct? How does it apply to embedded computing? (4.8.0)
22. How many bits of information are transmitted (a) by vision, (b) touch ? (4.9.3, -A.1.0)
23. What are the limits in the predictability of user behavior? (4.10.2)
24. Give some examples of representations that might be applied to user models. (4.10.2)
25. Interview professionals to determine how much time they spend searching for different types of information and what difficulties they have. (4.11.2)

Teaching Notes

Objectives and Skills: Be able to apply the principles of human perception and cognition in systems design.

Instructor Strategies: A course with practical orientation might emphasize user interface design, while a conceptually-oriented course might emphasize human information processing systems.

Related Books

- Hutchins, E. *Cognition in the Wild*. MIT Press, Cambridge MA 1996.
- Lamberts, K., and Shanks, D. R. (editors) *Knowledge, Concepts, and Categories*. MIT Press, Cambridge MA, 1997.
- Marr, D. *Vision: A Computational Investigation into the Human Representation and Processing of Visual Information*. Freeman, New York, 1982.
- Mates, B.T., Wakefield, D., and Dixon, J.M. *Adaptive Technology for the Internet: Making Electronic Resources Accessible to All*. American Library Association, Chicago, 2000.
- Norman, D.A. *The Psychology of Everyday Things*. Harper Collins, New York, 1998.
- Palmer, S.E., *Vision Science: Photons to Phenomenology*. MIT Press, Cambridge MA, 2002.
- Picard, R. *Affective Computing*. MIT Press, Cambridge MA, 2000.
- Rogers, T.T., and McClelland, J. *Semantic Cognition*. MIT Press, Cambridge MA, 2004.
- Rosson, M.B., and Carroll, J. *Usability Engineering: Scenario-Based Development of Human-Computer Interaction*.
- Solso, R.L. *Cognition and the Visual Arts*. MIT Press, Cambridge MA, 1997.

Chapter 5. Models of Human Behavior: Social Interaction and Social Structures

Groups, organizations, and even societies process and use information. The previous chapter focused on how individuals use information. Here we consider how groups of people seek for and use information as well as how information affects the social interaction. Applications of information systems. Toward the end of this chapter, we will consider education, which combines individual and social aspects. Broader implications for society are described in Chapter 8.

Understanding the way that information is communicated through different types of structures can give us insight into both ourselves and new information system designs. There is a continual interplay between the social environment and the individual with one influencing the other. Here we emphasize interpersonal interaction. later we will consider large-scale economic and political systems. People are almost always evaluating what other people are doing. Expectations and representations predominate. In social systems, like other complex systems, making changes in one factor may have an unexpected effect in other, seemingly unrelated, parts.

People are highly social and a lot of the information people obtain is from others. We are all embedded in a complex network of social interactions. Ultimately, social interaction reflects ways in which people meet biological needs such as food, shelter, and family. This is the root of most norms. Information exchange is a big part of social bonding, but the information is not always unbiased.

Society is simply booming and buzzing. It's difficult to capture much about it in a systematic way. Social as a relationship rather than an entity. Interaction level of analysis. Intermediate level of analysis for how people create, live with, interpret, and change social structures[47].

In short, there is a question about the best level of analysis for huamn behavior. Is it at the level of the individual, the level of society, or some combination of the two. There should be a balance between the individual and society. The key notion is the interdependence of agency and structure. Social aspects of activity theory (3.5.1). There is a difficulty in applying the techniques of natural science to social science (9.2.1).

The previous section included several aspects of social structure, but of course, structure and process work together. Societies may be aggregates of several different cultures and social rules facilitate interaction across those social unit. There are many aspects to human interaction and the cumulative result of all of these interactions is society. One model for social organization suggests that it is composed of subsystems[80]: Goals, resources, coordination, persistence across time. Political, economic, and cultural sub-systems. Other models assume there are interacting components but assume that the structures are more ad hoc (5.1.2). These subsystems are continuously finding an interplay. For instance,

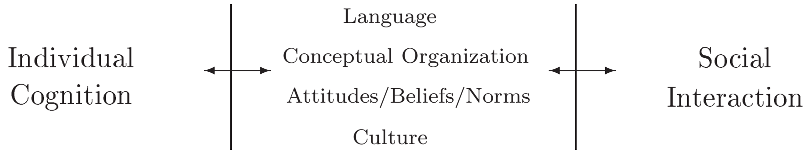


Figure 5.1: There is a continual interplay between individual cognition and social interaction. Language, culture, and attitudes mediate between the two levels. Indeed, the personal and social are so intertwined that it is often helpful to consider them as two sides of the same coin.

the balance of politics and economics is seen continual interaction of government and commerce.

Grand social theories ((sec:socialtheory)). Cohesion models. Conflict theory. Structural models vs functional models.

Social networking systems have given a voice to many individuals and contributes to the claims of the "wisdom of crowds". Surely, this is not a universal effect and there is also "madness of crowds". When people have minimal information, they often follow other people what other people are doing[61]. However, in many cases, this works out well but it can also create a herd mentality. In the extreme, we observe fads and manias.

Socialization is the effective meshing of individuals into the social fabric. Social media and social reading. Socio-technical systems.

5.1. Social Structures and Social Networks

In any social group, there many types of social interaction: family, friends, work, clubs, neighbors. These can be characterized by sets of nodes and links. We can model the interaction among people as links in a network in which the individuals are nodes. Charting the path of information and the means by which it is spread can tell us a great deal about the efficient transfer of information and the way that individuals gather it. Structure and processes. Ultimately, we many want to consider more dynamic interactions among people but the network model give us a good place to start. These mirror Web structure and information networks (2.6.3).

Literal social networks can be modeled by graph theory (-A.3.0). However, social interactions are often not tidy. These cover a wide variety of phenomena and they show systematic patterns. Social networks are an idealization. They do not show organizational structure very well. They show more complex patterns and eventually need to expand to other phenomena. We can think there being several layers to social networks. A social network as a simple network as a graph formalism is simplistic but is a good place to start. There are distinct links based on kinship and social roles. Nonetheless, this the notion of a social network is a useful conceptualization. Organizational interactions as a type of social network. One has to be careful that the measure of social networks actually represents engagement among the participants.

5.1.1. Everyday Social Structures and Activities

Beyond simple version of a social network there are, of course, rich types of social interaction. Pleasure of sociability. Group dynamics and cohesion. Conversation (6.4.0). Social dominance. Social skills such a relationship planning.

Social interaction tends to become structured. Structural view of social relationships. How have information systems affected family structure and interaction. Perhaps they have strengthened other institutions which serve some of the functions that families used to serve. These many be thought of as constituting community and culture. People interact to develop shared meaning.

Institution roles such family, school and professions provide structure. Social interaction as creating obligations and responsibilities.

The aggregate social interaction is society. Interacting with people is an inherent part of being human, but it can be seen as a bargain we accept – we accept society's rules in return for its benefits. This view of why we participate in society is known as the "social contract"[16].

Impression management revealing information to others. Impression management following roles[49]. Roles as determines behavior versus a result of other factors.

Structure and Interpersonal Interaction

There are common elements to all social groups; structure and shared expectations are such elements, though they can take many forms. Each group develops its own social contract that specifies the various member roles as they pertain to different elements and/or responsibilities. It is not clear what effect the information systems have on social interaction in the long run. Can different systems counteract the isolating effects of geographical separation? Do information systems help us to communicate better with the people around us, or do they usurp our attention? Division of labor. Social representation.

Structural properties of graphs. Triadic closure.

Social balance theories[55] are related to the gestalt principles which we discussed earlier (4.2.1). This is illustrated in Fig. 5.2 and it is related to the earlier discussions of field theory and gestalt psychology. Society can be viewed as a self-organizing system. The dynamics of such balance theories rapidly becomes more complex if Pat is a woman and the others are men. Signed network.

Figure 5.2: Two examples of stable valenced social networks. "Mutual admiration" (left) and "The enemy of my enemy is my friend" (right). A "+" means likes and a - means dislikes.

Some organizational structures are better suited to certain tasks, or actions. The theory of structuration [?, ?]. proposes that the relationship between structure and action (of any system involving people) is dynamic — that is, one affects the other and vice versa. The structure of an organization will affect the way the intended task is carried out, but the task that is to be carried out will, in turn, affect the way an organization is structured. Allowing for this relationship, the structure and processes of an organization with a given goal or task should be emergent; that is, they should be allowed to grow out of the demands of the task, while at the same time being stringent enough to accomplish the original goal. Intermediation between the social and individual.

Family, Clan, Tribe, and Culture

Family support and interaction. Emotional need satisfaction. Complex relationships. Parents, values. Factors such as imitation and familiarity are large determinants of learning. A type of social capital (5.2.1). These social groups are based in biology, emotion, and those inclinations are further enhanced by interactions such as gift exchange.

While some information systems have resulted in greater isolation among people; for instance, many people spend more time viewing television alone[84] and less time interacting with each other.

On the other hand, many other information systems allow people to interact more easily with one another by means other than face-to-face interaction. Closer family interaction through video links. amily interaction with through email. Family members who are physically separated can keep in touch with each other via computer, while a remote Internet camera allows parents to see their children during the day at pre-school. Family-entertainment games. Overall, interactive information technology seems to bring people together more than isolating them. Effects of television viewing on social attitudes[78]. This type of anonymous interaction has consequences.

Supporting how children play together. Many forms of exchange in these social interactions including nuanced exchange of information.

Home. Roles in household chores.

Computer-mediated family communication.

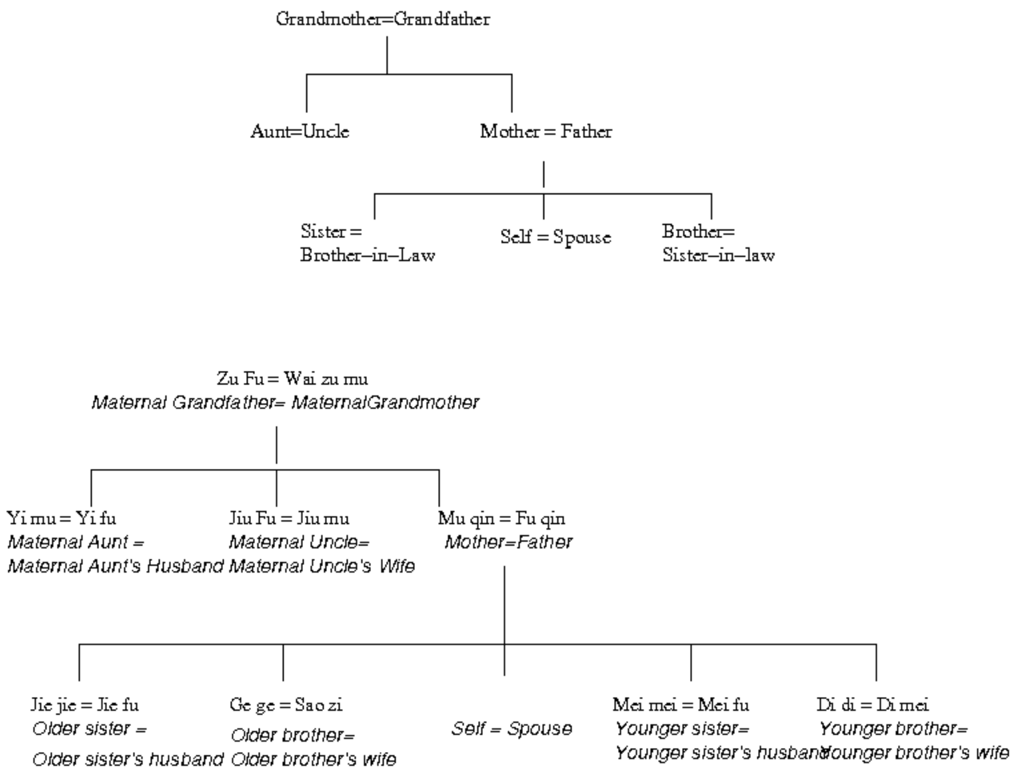


Figure 5.3: Chinese kinship (lower panel) relationships are much more specific and complex than those in Western European cultures (upper panel). (redraw)

Figure 5.4: Ching ming.

Extended families. Clans. Tribe. Culture (5.8.2). May have norms and rules of their own.

Friendship

People bond and form friendships. There is a Web of friendship. For both family and friends there are affective relationships such as caring, empathy, and jealousy. Simple factors such as physical proximity is a significant factor in friendship; distance can have a great effect on the likelihood of interaction between people[44](Fig. 5.5). It is easier to establish and maintain friendships when there is a physical presence. Information systems have extended the opportunities for social interaction and overlaps in cyber-space can also lead to friendships. Physical proximity also has a big effect on collaboration among researchers[20].

Figure 5.5: To a surprising extent, friendship in an apartment complex is determined by simple factors such as whether people's apartments face each other. In the student housing complex shown in the picture, those students whose apartment exits faced each other were more likely to be friends than those students whose apartments faced away from the others (adapted from[44]). (check permission)

Sociability is congenial engagement in social interaction. Beyond simply completing tasks, people develop friendships, empathy, and perhaps community. Sociability can simply be pleasurable. Information exchange as a mechanism for social bonding. On one hand, games can be very isolating. Some people spend hours playing games. However, some interactive games and other types of social interaction sites, can increase sociability[83]. Indeed, sociable displays facilitate social interaction. However, there can also be negative sociability such as spiteful comments and back biting.

Impression management for online presentation. Do we believe the information as entered?

Matchmaking. Similarity predicts long-term relationship success. Niche dating sites. Compatibility index and examples of compatibility factors. Interpersonal attraction. Sharing calendars.

Language similarity contributes to the stability of relationships. Relationship development. Bonding from sharing information. Social skills (5.2.1). Sociability.

5.1.2. Social Rules and Structuration

Where do social structures come from? Structure and function (1.6.3). Social interactions can be fluid but for most situations, we have expectation about how behavior. Typically, there are "rules" that govern group behavior and practice. These rules may be tacit (social norms); or, they may be formal procedures instituted by an organization or even the written laws of the nation or state. These rules, formal (such as the second one below which taken from *Roberts Rules of Order*) or otherwise, provide structure and for a group to function effectively. Task groups also need to be effective at information processing. Agency. Tradition. Adaptive structuration as changes evolve.

> I'm going to skip the remaining items on the agenda. I'll assume that everyone agrees with them. If you have questions, let me know by email.

> 2. What Precedes Debate. Before any subject is open to debate it is necessary, first, that a motion be made by a member who has obtained the floor; second, that it be seconded (with certain exceptions); and third, that it be stated by the chair, that is, by the presiding officer.

5.1.3. Social Networks

We all have a circle of acquaintances. We can think of these acquaintances as forming a web or network of social contacts. Especially if we focus on those contact with which we have a specific type of interaction, we might think of the network of interactions in formal terms. A social network is

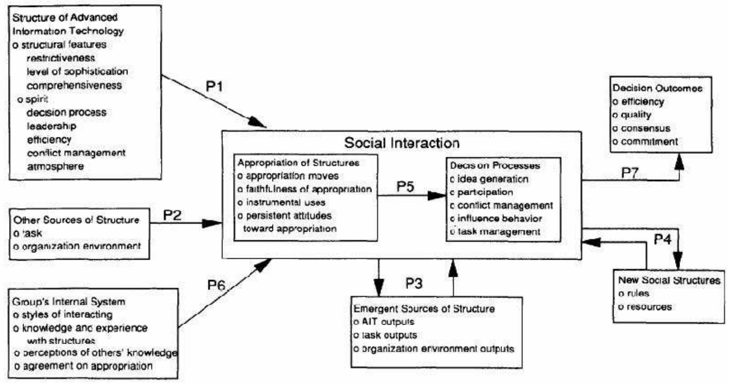


Figure 5.6: Factors affecting adaptive structuration. (DeSanctis and Poole) (check permission) (redraw)

sometimes considered in this formal sense and other times the notion is used more loosely. Interaction with some of those people is restricted to a specific topic while with others we have a spectrum of interactions. The strength of weak ties.

Formal Models of Social Networks

Describing social networks with graphs. Simple graph theory approach. These implement single-link-type social networks. This is highly constraining because relationships among people a highly nuanced. Like a hypertext, the link is either present or absent. However, that is probably a simplistic model. Although the expression social network is widely used, its definition is more complex.

A social network may simple be formalized as matching formal graph structures. Friendship networks. Affiliation networks (-A.3.0).

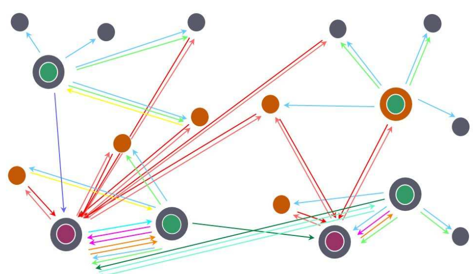
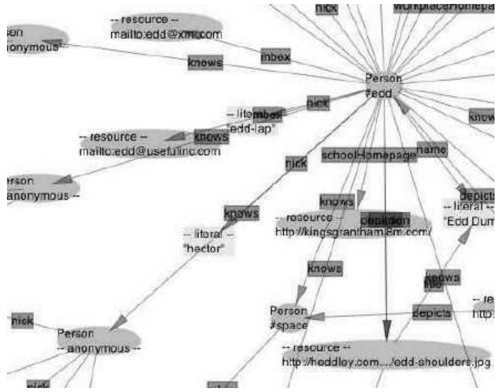


Figure 5.7: Because social interactions are complex, a social network should be thought of as an idealization. Of course, people are not all the same and the links between people are multifacetted. (redraw)

While social networks are often modeled with simple connections among undifferentiated nodes, actual social networks involve many groups of people and different ways of interacting with them. Many attempts have been made to develop formal descriptions of social networks based on graph theory (-A.3.0). In some cases, there complexity of social relationships is reduced to one dimension. For instance, a Friend-of-a-Friend (FOAF) network uses URIs to identify people and the mapping between people is accomplished through RDF. (2.3.3) (Fig. 5.8).

Many factors affect the developed of social relationships such as: proximity and eulture. Work relationships are often influenced by organizational structures and professional relationship. Forming interest groups and coalitions.

To the extent we accept that social networks are simple collections of nodes and links, we can calculate properties. For instance, we might characterize the participants by their centrality in the network.




```
<rdf/rdf:RDF
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:foaf="http://xmlns.com/foaf/0.1/">
<rdffoaf:Person>
   <rdffoaf:name>Edd Dumbill</foaf:name>
   <rdffoaf:mbox rdf:resource="mailto:edd@xml.com" />
<rdf/foaf:Person>
<rdf/rdf:RDF>
```

Figure 5.8: Example of a FOAF network and fragment of RDF for it[7]. FOAF is often use for personal URIs. (redraw) (check permission)

People may try to move to the center. This creates the self-organizing system (-A.10.4).

Dynamics of social networks. From social networks to agent simulations. There can be multiple interlocking social networks.

Spread of Information in a Social Network

There are several different ways people get information from other people and for such person-to-person communication, the structure of a social network and a person's position in it affects the information they receive. In terms of the the entire network, we can view diffusion of information. Consider the communicative patterns of people in the hypothetical communications network in Fig. 5.9. Medical information (9.9.0).

Protocols for coordinating communication within a network.

These variations in structure across organizational boundaries have obvious implications for management — managers must determine whether a more controlled or a more spontaneous environment t suits the goals of the group. Social networks are not just passive, but may be actively developed. Informal social networks may be cultivated to obtain information that may exist outside normal organizational channels.

Interaction of groups of specialists which have to work together but they do not have the same terminology. In some situations the information flows through the links but in other situations the basic network is not a good description. When a new idea emerges, it spreads, or diffuses, across individuals or across group boundaries. People learn about it and accept it at different rates, often at a rate that depends on their connectivity. Diffusion of information is facilitated by communication, and, of course, the pattern of diffusion is affected by communication patterns. Fig. 5.9 shows how information might be communicated by spreading person to person. Cultural change. Beyond communication, social networks impose constraints on their members. This is the "strength of weak ties".

Doctors in small towns. Emergent phenomena. Viral contagion and epidemics (-A.3.5). Gmail "Don't forget Bob" service. Information cascades from diffusion finally catching hold.

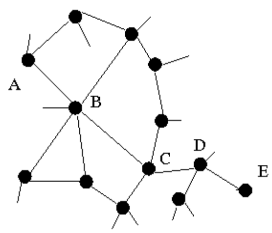


Figure 5.9: Information may diffuse across networks of individuals. Information held by Person A can be communicated through a series of individuals eventually reaching Person E.

One example of diffusion within a defined group is how awareness of a procedure spreads through the medical community. This can be contrasted with how information spreads through the blogosphere, or Web log community on the internet. In this example, information or awareness spreads almost exponentially as it pops up in different forums and chat rooms across the Internet (-A.3.5). Social networking with technology. Information systems can greatly affect social interaction. MySpace.

As we suggested above, the simple view of social networks is only a first approximation. In our information-rich society, there are also other ways to get information such as by broadcast media. Spread of information by media.

As we have seen with mobile networking Cellphones. Twitter. 140 character limit. Micro-blogging. Twitter is ofter used for asking questions of a close circle of friends. Frequent updates of data and low propagation delays.

Fig. 5.10. (10.11.2).

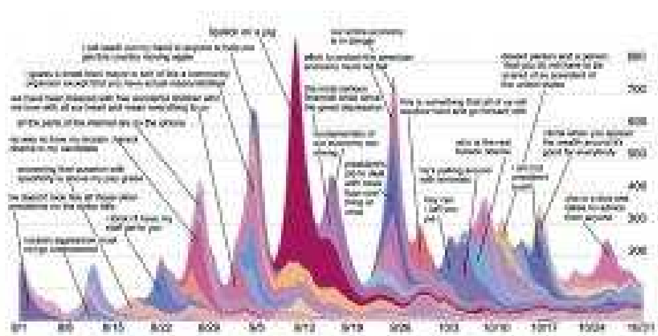


Figure 5.10: The frequency of postings about a given topic are a function of two factors. The figure shows data about items from the 2008 US Presidential Election. (from Kleinberg). (check permission)

Rumors which spread from person-to-person. are an example the diffusion of information; Urban legends. Debunked at snopes.com. This is a type of viral dissemination and in some cases, it can be described as an epidemic contagion. Rumors regard something people are willing to believe. However, this model is too simple; the spread of information may be seen as related to the spread of a disease (5.1.3). In fact, information diffusion is also affected by factors such as the message and the communication channels. Because it occurs like a disease spreading this is sometimes called viral dissemination. This could be implemented in a whisper campaign or it could be circulated by blogs. Person-to-person information exchange is rarely the only was people get information. There are many types of communication models. Micro-blogging.

5.1.4. Social Media

Social media supports social interaction beyond simple communication In many cases, social media are based on social networks. Location-based social media. Coordination with traditional media. Social search. Sentiment analysis.

Posting personal information on sites. Mining personal information. Social media networks are different from basic social networks as they project recommended links. Social media as an extension of physical world. See faces of the people you are linking to (Fig. 5.11). Greater customer feedback and the chance to market goods through social media.

Personalized newspapers in the sense of telling you what your friends are doing.

Real-time trends identified from social media. Mining social media.

Social media and advertising based on knowledge of people the personal data people provide in the network.

Cliques and linking. Harassment. Cyber-bullying.

Social media and impression management. What people reveal about themselves.

Figure 5.11: Social networking sites allow people to specify sets of links.

Some people reveal a lot about themselves in these sites and they forget that the information can often be widely seen. Postings and links to friends may be systematically mined by either the platform provider or by others who gain access to it. Privacy issues. Scraping personal information from social media sites. Evolution of social media networks. These also allow social interaction and building social relationships. Reciprocity. Niches.

Using Social Networks to Facilitate Social Interaction

Platform (7.8.2). Social, mobile, cloud. One-way links vs mutual (two-way) linking. Many advantages of platforms in coordinating services. This coordination occurs both in terms of the content but also in terms of the usage. Designing social networks and designing online communities (5.8.2).

Social media Networking to keep in touch with people. Citizen journalism (8.13.7). Twitter. Social media have led to aggressive direct marketing to the voters. Social media contributes to viral marketing. Social decision making (8.4.3). Build by buzz and exclusion. How to get re-tweeted.

Supporting Sociable Interaction

Postings on social media sites as publishing. Social gaming. These social networks are different from natural social networks. Automated and immediate communication with all friends. Supports social exchange. Games (11.7.0). Fig. 5.12 Supporting sociable interaction. From the gaming sites perspective, the goal is often to get people to interact more to get them to reveal more personal and social interaction details and which which can be monitized through advertising.

Self-improvement from social interaction even when it is computer-mediated.

User enriched web resources in which people have added value to a repository such as Ancestry.com.

Social media approach to brand management.

Figure 5.12: Farmville. (check permission).

Crowd-powered systems.

Inciting violence or criminal activity with mobile phones.

Political activism with social media. Facilitate low-risk activism.

Social Media Business Models

Building loyalty to the site through engagement. Eventually want to monetize the association. Optimizing metrics to rate the rate of conversion from non-paying. Retention on site. Related to romantic Match making (5.1.1).

Social media analytics.

Spreading opinions quickly. "Dell Hell" Controlling firestorms of negative publicity.

Linking social media to TV viewing. Commentary about TV shows.

EdgeRank is a weighting formula for showing newsfeed messages. It weighs several factors from multiple sources. Is a message from somebody you "like"? Have other people responded to a message?

$$Liking * Goodpost * How\ old \tag{5.1}$$

Search from social media (10.11.1). Facilitating search with social networks. Questions sent to Facebook pages. Characteristics of different social media sites.

Text data mining for social web sites as a predictor of events and trends (10.5.0).

Personal data in social media sites has proven extremely valuable to advertisers.

5.1.5. Connectivity

Modern information systems allow people to connect in many ways such as email, SMS, social networking. Modality (5.6.5).

Time management and prioritizing email based on understanding of user characteristics.

Social networks don't tell us about the amount or type of interaction exchanged between people. Across time and space.

The Internet and mobile communication devices have greatly expanded the speed and amount of connectivity.

Families ((sec:families)) and connectivity. Online communities.

5.2. Social Capital

Social capital consists of social resources which help people to accomplish their goals. Social capital is distinct from economic capital but it can, sometimes, translate into economic capital. Social capital is often based on non-political groups such as the family but social capital can sometimes blend into political power There are several forms of social capital based on social relationships such as interpersonal trust and reputation.

5.2.1. Social Relationships

There are two types of social capital for relationships: Bonding and bridging [84]. Participation in communities of practice (5.8.2) can build social capital. Social skills such as putting people at ease.

These are social resources which allow people to take advantage of social interaction. Some sources of social capital include family, and physical proximity but social capital can be built by networking. Social capital as filling holes in the social network [32] and [31] (Fig. 5.13). In fact, we recognize the importance of social networking. Building social capital from social exchange.

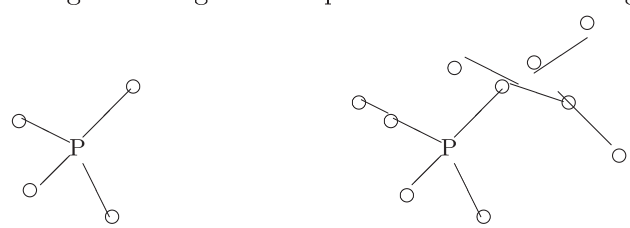


Figure 5.13: The person (P) on the right would be said to have more social capital than the person on the left because that person connects more people. Indeed, social capital can be created by growing networks around them.

Centrality and position in social networks.

5.2.2. Reputation

Personal and Organizational Reputation

Reputation are expectations about another person. be it the work they will do, the advice they might give, or the opinion they will hold. Reputation can affect a person's position in society. A good reputation leads to trust which we discuss below. Reputation is context dependent. Organizational reputation. Privacy vs. reputation.

Email phishing often depends on people having inadequate models for what is trustworthy [13]. Reputation and trust can also be attacked by smears. Rumors spread fast on the net. Sorting out what offers are believable can be a challenge. Scams. There is a danger that reputation and trust can be manipulated. Manipulating reputation and trust of con-artists. Whitewashing. Attacking a person's reputation online is known as a "Joe job". Reputation improvement as a type of public relations.

For online interaction, we often form a judgment about a person's reputation based on relatively little evidence. Online companies, such as online auctions, which connect people to other people take steps to make sure their buyers and sellers have a credible reputation. Many such reputation systems are based on history — buyers and sellers on auction sites have a generalized record of their transactions available to the public. If they have a history of making bad deals, people will be hesitant to do business with them, and they may even be barred from using the system. Reputation management systems should not be able to be spoofed. Nonetheless, it is possible to develop an elaborate scam for fraud. By setting up numerous bogus identities that all vouch for the superior character of the target individual an individual's trust rating can be artificially inflated. An individual could buy and sell items to and from themselves over a period of time, thus artificially creating an excellent buyer/seller rating.

Social media background checks.

Linking many sources of reputation together. Should conduct a type of due diligence.

Product and Service Reputation

Reputation requires great consistency in performance and outcomes. Reputation allows people to hold people or organizations responsible. Professional reputation.

A brand name is developed by having a reputation for fulfilling promises, providing quality information, or delivering a good product, A brand name can provide evidence of predictable levels of quality (8.12.5), and boosts user/buyer confidence. Thus, branding plays a large role in maintaining user loyalty [90]. Branding involves both a consistent product and a consistent message about that product. Branding in a market niche often commands a premium price. While a brand is a valuable asset, it's value can be lost by mismanagement. Brand control versus interactive brand development through social media [?].

Attempts to provide a quantitative system for reputation (5.2.2) for establishing trust include metrics such as Karma points. Reputation economics. Points economy. Economy of recognition (Fig. 5.14).

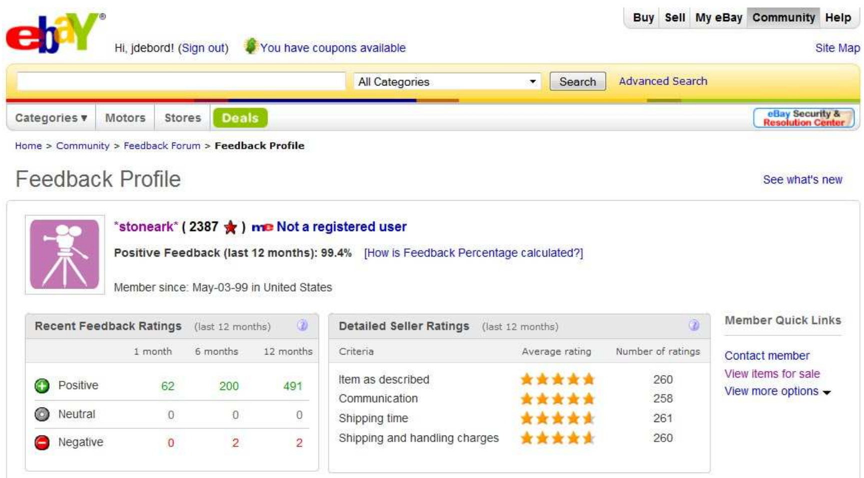


Figure 5.14: Reputation ratings from eBay. (check permission)

5.2.3. Trust

Reputation is one factor which enable trust. Emotional aspectsof trust and rational/technological aspects. Trust is the expectation that other social agents will do what they have committed to doing. Trust from reliable procedures.

Perception of trust is naturally related to reputation. While people often do what they are promise, and to function in society we need trust. However, people can't always be trusted. Trust from professional status (e.g., information professionals). Ultimately, trust stems from reciprocal power. Trust from having a way to get revenge - a balance of power.

Contract example.

Trust is often the result of constrains outside a given interaction. One of the foundations for trust is family and other social ties. Trust from a contract (8.11.5). But, of course, that contract must be enforceable. Many applications which need trust. Trusted systems (8.5.4). Trust for documents and records (7.5.1).

Trust from spot checking actual results. Trust information organization, sharing, and prioritization.

Trusted Information Sources: Reputation is developed by good practices, which signal a respect for quality information. Information sources should be cited, and there should be an indication that the information is timely. Perception of trust. Authorities. Reference works.

Interpersonal Trust

There are many other sources of trust. Past experience with a person (agent) often give us trust. Likewise, cultural similarity may also give a sense of trust. There can also trust for organizations provided they earn it. We consider many sources of evidence when deciding about trust whether it is trusting a person or trusting information. However, many of these are subjective and depend, for instance, on attribution (5.5.2). Furthermore, as we noted earlier, such subjective trust can be abused with a systematic attempt at distortion. Knowing the history of a resource – its provenance – is essential for trusting it.

Trust is essential for social interaction. We often need laws to back up trust and reputations. Trusting what other people say[107]. Many organizations or systems can be, and often are, trusted on the basis of reputation without direct individual contact.

Trusting friends based on a network of social relationships. Value of verbal commitments and promises.

At the interpersonal level, trust is a matter of perception and attributions (5.5.2) — if we like someone, we might trust them in spite of our own better judgment. When people act in social situations, other people may form opinions of them; a person's reputation is the impression of that person held by others. This reputation is dependent to a large degree on the trust which is associated with them. Trust is typically established from a combination of two things: association with or recommendation from another trusted individual, or past behavior. Reputation management systems track electronic reputations, and they typically work on one or both of the previously mentioned principles (recommendation or history).

Developing procedures which create trusting interactions among people. It is difficult, if not impossible, to function in society without trust. That trust can also be abused.

Formal Models of Trust and Trusted Systems

Reputation and a history of providing accurate information help to establish trust with the public. Trusted systems (8.5.4). When institutions and laws help to build trust, people are more willing to participate with them. Ecommerce applications for trust (8.12.5). Security and banking supported by institutional metrics such as audits.

Informal trust is often not enough, stronger social constraints such as legally enforced contracts (8.11.5) have been developed. A contract has explicit consequence for actions. With formal mechanisms (such as enforceable contracts) trust can be propagated from one entity to others. If I trust you, then people who trust me may also trust you. Chain of trust. Fig. 5.15

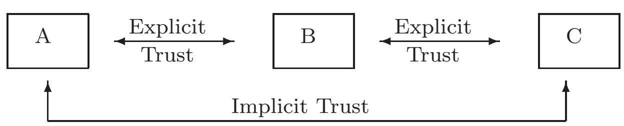


Figure 5.15: Chain of trust. A and B trust each other and B and C trust each other. Should A and C trust each other? For instance, if I am a trusted computer user on system A should I also be a trusted user on system C?

5.2.4. Managing Online Reputation

5.3. Social Control

Rewards vs coercive control. Groups have many ways to control their members such as censure, punishment, and economic control. Bullying.

5.3.1. Norms and Social Practices

Norms are expectations people have about appropriate social behavior. Norms help to maintain social structure and culture. Each culture has its own conventions for proper conduct (5.8.2). The differences may be relatively small, such as the topical differences that exist between Western European cultures, or they may be more significant, like the differences between Middle Eastern and Western European cultures. Members of a particular culture (5.8.2) take in these conventions through the process of socialization.

Networks and interrelationships of norms in shaping society. Norms for information behavior. Norms, as the name implies, are the expected behaviors in society and culture. There are norms for privacy (8.3.1), for courteous behavior, and for decency. of course, not everyone in a society agrees about or follows all norms. Thus, they are, roughly, the average attitude of the people who make up a society. Ultimately, some norms are formalized as rules and laws (8.5.1). Norms for culture. Norms and conversation (6.4.1). Norms provide expectations which help us understand situations.

Individual behavior is often the result of a balance between personal attitudes and social norms. Within any society, individuals exhibit varying degrees of deviance from the norms or conventions. While some individuals may deviate in small, and in many cases almost un-noticeable, ways from the average conventions of society, other individuals exhibit more extreme forms of deviation. Typically, these individuals attract the attention of the society or community at large, which then attempts to enforce its norms through social disapproval and/or sanctions.

Norms often provide simplified decision rules for complex situations. They can propagate a culture's values. Some norms are followed for communication interactions such as telephone calls and letters. In the same way, Email, a relatively new communication medium, is beginning to develop conventions that dictate its proper use. Netiquette describe the conventions of Internet use. And, though it is a new medium and its conventions are in flux, there is already discussion about what constitutes deviation from the norms of the internet community; what materials are allowed to be posted, and what actions constitute a crime. Over time, the conventions that develop will become more solidified and accepted, perhaps forming an amalgamation of different cultural norms from around the world. However, it is worth noting that not all traditions are constructive.

Norms and culture frequently change. Indeed, it's characteristic of human society that one generation creates a new culture for the next generation.

Deviance is straying from a cultural norm.

Norms in virtual worlds and with multi-agent systems.

5.3.2. Social Power

Force versus persuasion.

5.3.3. Disinformation

People often have very different explanations of an event. This may simply be because people have very different belief systems, because self-presentation and persuasion are very human activities, or perhaps even malicious obfuscation and distortion. Many people do not focus on obtaining accurate information.

Differing viewpoints versus intentional disinformation.

Argumentation can go beyond a person's considered opinion. The are situations where there are strong incentives to lie and cheat. Indeed, they often distort it. It may reflect an aggressive campaign of disinformation.

Managing public opinion (8.4.3). Out-right aggression.

There are many strategies for deceiving people beyond simply lying.

Information will often be manipulated and distorted to meet people's goals. Even if there isn't outright deception, people often accept simple narratives or those that are consistent with their prior beliefs (4.5.0). There are many examples of distortion. In synchronous interaction, there are many attributes which are difficult for a communicator to control. What's a lie anyway. Lies versus saving face.

Politicians often seem to induce confusion by over-simplification of a complex issue. Similarly, they may attempt to frame the debate – that is to emphasize particular issues and alternatives – with perspectives in their favor. Apply persuasion and attitude change techniques. People may have an incentive to use ambiguous categories. For instance, Robin Hood is viewed as either a hero or a criminal.

obfuscation example

Partial truths, Snow jobs. Inventing words or using common words with a non-standard meaning. Selecting presentation of information. Intentional distortion of information. Attitudinal change (4.5.2). Distortion of information in organizations. In a competitive situation, knowledge gamesmanship (8.13.3). Gaming the system. "Human beings are a political animal". Incentives for distortion. Such as by con-men (Fig. 5.16). At the extreme, this may include outright lying.

Figure 5.16: In a confidence game, the con-man attempts to gain the trust of the mark. *The Sting* portrays an example of a long con. That is a particularly involved con job. (check permission)

Several steps may help to minimize false persuasion. Holding people accountable for their actions. Separating opinion and persuasion from fact. Roles, such as journalism, which promote a neutral perspective. Compensate for distortions via information and media literacy (5.12.2).

Because of these tendencies, organizations can become badly distorted and mismanaged. They may not have effective internal check and balances. Reward structures in organizations can also alter the organizational culture, and organizational functions and economic considerations may affect the adoption of technology. "Who does the work and who gets the credit" is a common question regarding the introduction of anything, but particularly a new technology, which alters the status quo[52]. These factors will alter an individual's perception of how an organization works, or prevent them from actually conceiving a perception in the first place, and an unsuitable reward structure can change views of whether or not an organization is "fair". Employees who view an organization as unfair, and are skeptical about the rewards and punishments of sharing information, generally won't share that information.

Group and organizational gamesmanship. Corruption. Non-transparent. Meetings held in secret. Government contracts and agreements not made public.

Organizations are made up of individuals. Individual information behavior within compartmentalized organizations often leads to "information hoarding". This occurs when individuals in organizations have difficulties sharing information. These difficulties can be the result of organizational policy regarding such matters, but can also be an individual response to the overall organizational culture. Scientists sharing data (9.6.4).

Intentional distortion of information as gamesmanship. There are some common ways information is distorted such as with false rhetoric, invalid logic, and misleading statistics. Hoaxes.

5.3.4. Crime and Cyber-crime

There are many ways that information systems will facilitate criminal activity. Facilitate by mobility and remote interaction. Dark market for exchange of illicitly obtained information. Deviance.

Scams

These are often for financial gain or to facilitate other criminal activity. Attacks executed through the network or on information obtained through the network. Cybercrime and netwar are increasingly intertwined. Cybercrime and spam. Digital forensics (7.10.3). Money laundering.

419 scam. Identity theft. RealID. Advance-fee scam. Stolen credit cards.

Zombies.

Fraud and Fraud Detection

Banking and other financial transactions generate extensive records (4.4.4, 7.4.1). These records need to be managed accurately and efficiently, as mistakes will erode the trust of users. Baking records, combined with data mining techniques, can help to prevent fraud. These records may be mined (9.6.3) to determine, whether a credit card has been stolen and is being used by an unauthorized person. A database containing records of a consumer's purchase history may be analyzed to determine if their buying patterns have changed dramatically. Based on the suspicious pattern, a credit card company might contact the cardholder to inquire whether the purchases shown in Fig. 5.17 should be authorized. Such judgments would be enhanced by rich data about a person's past preferences, in effect creating models of customers; of course, raises privacy concerns (8.3.1). A real system would also consider the individual's history (4.10.2). Indeed, reality is a lot more complex and there may be legitimate but unexpected patterns of use. However, this can also be seen as algorithmic surveillance. Indeed, there are dangers of false accusations from purely automatic methods.

Date	Time	Purchase	Amount	Location
Jan. 1 2007	7 AM	automobile tire	$120	Jacksonville, FL
Jan. 1 2007	6 PM	gasoline	$24	Raleigh, NC
Jan. 1 2007	11 PM	17 hams	$267	Richmond, VA

Figure 5.17: Is this a suspicious pattern of credit card purchases which might indicate fraud? Could a general program be developed to detect such cases?

Figure 5.18: Fraudulent will.

Corruption

Corruption is violation of established organizational or government procedures. It is effectively an ad hoc tax on productivity. However, it is difficult to define as it is difficult to agree on what constitutes proper procedures. Cronyism. Strong institutions help to minimize corruption. Free press and a reliable records system (7.4.1), can help fight corruption.

Corruption ends up as a drag on effective functioning on society. It often results from the control of information. Ideally all government information such as budgets, taxes, and regulations would be fully and clearly available for public access. Beneficial effects of freedom of information and transparency in fighting corruption. ipaidbribe Web site.

5.4. Social Data and Computational Sociology

5.4.1. Characterizing the Behavior of People

Human mobility analysis.

Shopping cards.

5.4.2. Social Data and Social Predictions

Social network and social media data.

5.4.3. Social Simulations

Crowds. Individuals may show unpredictable behavior or but the average behavior of a crowd may show typical emergent behavior. There are increasing attempts to simulated the behavior of crowds and of individuals in crowds (Fig. 5.19). Artificial psychology (4.7.0). Agent-based models (-A.10.4).

Figure 5.19: Actual crowd behavior in a panic (left) and a simulation of a crowd (center), and battle scene from *Lord of the Rings* in which the individual characters are algorithmically controlled. (check permission)

5.4.4. Computational Sociology

Multi-agent systems (7.7.8) which explore issues of social organization and interaction. Alife (-A.10.4).

Community behavior modeling.

Figure 5.20: Agent societies.

5.5. Participation in Society

Social practices. Learning as social participation. Socialization.

5.5.1. Self, Roles, and Identity

Self

Individuals in society form a sense of self.“ Self emerges when a child understands that he or she is distinct from their environment. The “self” helps to mediate and internalize the social world[72]. Each of us has an identity that we call “I,” which is separate from the rest of the world. However, visions of the self are often primarily social; that is, we frequently understand ourselves by comparison to others: whereas that person is tall, I am short; whereas that person is selfish, I am generous. Regulation of affect leads to the developed of the self. Self as a narrative (6.3.6), Personal information management (4.11.0).

The self is also constructed and projected into a social environment. We may be concerned with the way others see us — “Do I appear enthusiastic?” or “Do I appear greedy?” — and we adapt ourselves accordingly. “Impression management” describe how we often manage social interactions so that we control people’s impressions of us. “Saving face” is an example of this; doing (or not doing) something that one does not want (or wants) to do simply because the action (or inaction) will help to preserve their image in the eyes of others[49].

People's self-reports are often inaccurate. Self-narratives are the stories people tell themselves. (6.3.6). These is some basis in neuroscience[108]. These stories may be distorted and inaccurate. Indeed, they are greatly affected by our social context. They are interrelated with the stories and impressions we have. Personal narratives.

Identity, space and time and culture. "home".

Roles, Role Playing, and Identity

Identity and roles. Role-playing games (11.7.0). A variety of types of roles. Brain science and identity [43]. Roles versus constraints. Self-presentation.

Virtual identities are personae a user may adopt in a virtual environment (Fig. 5.21); these roles can be adopted in much the same way that an actor adopts characters. In a sense, these non-task-oriented sessions may allow participants to role play; in many cases, an assumed identity may have nothing to do with a person's true identity[100]. This practice has been seen to have both positive and negative aspects. On the one hand, it allows people the freedom to experiment as different characters. Many people have advocated this as an opportunity for individuals to become comfortable with an identity in an anonymous environment before expressing it in the real world, or that once expressed in this "safe" environment, they may no longer feel a desire to act on that personality in the real world. However, critics have pointed out that no environment is truly "safe," and actions taken can have real-world implications. The adoption of various roles can be deceptive, and violates certain innately held social beliefs that we have regarding accountability for action. Spatial aspect of virtual worlds. Guided tours through virtual space.

Figure 5.21: Options for selecting characters for Second Life. (check permission)

Taller avatars and players reaction to them.

Constructing meaning. Culture as framing identity. Narrative and life story[71].

Extended sense of self to include attachment to a constellation of objects [?]. Evocative objects. Affect (4.6.2).

Actors mimicking the identity of the people they are portraying.

5.5.2. Social Perception and Social Impression Formation: Attribution of Intention and Responsibility

Social Categorization and Perception

Categorization (2.1.1). [28] Social categorization. Pros and cons. Making generalizations based on just a few attributes. Stereotypes. Traits. Affective input as groups. Emotion and attribution. Inevitable but many consequences. Many examples: Disciplines. Reclassification can be a way to redefine social practice. Boundary objects and communities of practice.

Difficulties of validity in applying any stereotypes.

Kinship (5.1.1).

Attribution

People are highly tuned to what other people are doing. We naturally make attributions about the causes and reasons for that other person's actions. Indeed, people are highly tuned to other people's behavior and are continually looking for the causes of that behavior. Empathy (5.5.3). What is a person doing and why are they doing it.

Stereotypes. Plan recognition (3.7.2). Theory of mind/behavior ((sec:theorymind)). Modeling attributions. Mental models applied to social interaction.

Expression recognition.

Earlier we considered perceived causation for physical objects (4.4.2). Analysis of "what is going on here". We are finely tuned to what people typically do in given situations. We have strong expectations about what is reasonable and we make judgments about them based on those expectations.

The causation of social activities is particularly complex. As highly social beings people almost continually evaluate what other people are doing. When we see another person, we tend to form an impression of what they are trying to do — their intention. Suppose we saw a person breaking into a car: is that person trying to steal the car or just getting at keys that are locked inside? There are many cues we may use. Our analysis of another person's intentions depends on our estimates of the probability of certain actions. These probabilities are affected by factors such as our understanding of social norms and how much is known about the person in question across a number of situations. Attributions and models of others. Attributions are often based on little evidence. This is part of what draws people into con-jobs.

Causation (4.4.2). Attribution and credit assignment. Self-attribution[77]. Cognitive factors in attribution. Is a payment reasonable for an activity? If not then the payment may not be perceived as an appropriate reward. Legal concept of proximate cause.

When we see unexpected behaviors, we look for explanations for them. Thus, if we see a person giving money to a shop keeper to pay for an item, we do not think much about it. However, we may be surprised if we see a person intentionally flinging money into the street. Such expectations help us determine whether a person is responsible for an action. Judgments of normative behavior is a type of plan recognition (3.7.2). Narrative explanations (6.3.6) and circumstantial evidence. One common type of attribution is judge responsibility.

5.5.3. Social Motivation: Binding and Cohesion

Earlier we considered motivation (4.6.0) but didn't focus on the social dimension. Of course, there are many types of social motivation:

Approval. Affection. Traditions, memorials. Breaking bread. Gossip. Malicious gossip. Information sharing. Nuanced information sharing. Selective disclosure of information to other people. Affect (4.6.2).

Empathy is feeling emotions similar to those felt by another person. Mirror neurons. Social brain (-A.12.2). Empathy from maternal care. Artificial empathy (Fig. 5.22). Horror movies. Empathy and a close community.

5.5.4. Social Learning and Imitation

When we interact with other people we learn about them and we also learn more about how to act in social situations – known as social learning (-A.12.2). A lot of social learning is simply watching to see how other people do things. Looking up because other people are looking up. In some cases, the learning seems to be more directly wired in. This may include important skills such as self-regulation, delay of gratification[73], arousal management (4.6.2), culture learning (5.8.2).

Social learning takes place in many ways; the experience we gain from interacting with others individ-

Figure 5.22: Instilling empathy. (check permission)

ually, as groups, observing others and the images, facts, and values that we are exposed to from the media and society as a whole all contribute to our social learning. We will discuss different aspects of social learning and how each may add to our individual understanding of our environment. Vicarious learning and imitation. One way we learn about how to behave in society is by observing and then imitating other people[26]. Children learn by imitating their parents. Imitation serves both learning and social bonding. By observation, individuals begin to understand what is allowed in society and what is deemed improper — imitation is the enactment of these understandings. Thus initiation contributes to fads, and hysterias.

Even adults may imitate what they see on TV, read about in magazines, or experience in media games. Indeed, people sometimes treat computers as though they were social actors. Modeling behavior.

Figure 5.23: Imitation and social learning. (check permission)

5.5.5. Social Navigation, and Social Filtering: Recommender Systems

A recommender system makes suggestions about content that may be of interest to a user.

Public Recommendations

Like button. Used in social search (10.11.1).

Information Referrals

One type of recommendation is interpersonal and is based on the knowledge of preferences or role of colleagues. A set of colleagues can be a type of social network. This is a type of collaborative information retrieval. [50] (Fig. 5.24). "Hey look at this." Re-tweets.

Figure 5.24: Collegial referral.

Anonymous Recommendations

The suggestions are often based on ratings and usage by others. Recommender systems may also be used to generate personalized advertisements targeted to specific individuals or groups. Relevance and recommendation system. People like you. How friendship networks behave. Usage information is now widely incorporated in many services.

In a second type of recommender system, the data is anonymous. Typically, these are ratings that other people make about it. Indeed, these rating are a type of representation. People's use of particular materials or particular types of materials is measured, and that measure is used to determine likely preferences for additional materials. In most cases, retrieval and filtering are based on matching attributes of the documents. By measuring the preferences for a particular class of documents (say movies, for example) of a large number of people across wide segments of a community, patterns of preference are able to be determined. If you and I consistently like the same kinds of movies, and I like a new movie, there is a good chance that you also will like that new movie. This approach work for multimedia documents from which it is difficult to extract matchable symbols. This is the most useful method for retrieving aesthetic content preferences in formats such as entertainment videos[56] and music[91]. There are also obvious applications for this technology in targeted advertising.

Predicting hidden interests.

Behavior modification through gamification.

This is a type of social medium for social metadata. To make accurate preference assessments, however, it is necessary to collect data from many people; unfortunately, the collection process may be intrusive. In the video example, individuals need to rate a large number of videos for the system to be effective. This type of data may be collected directly (explicitly) or indirectly (implicitly). Fig. 5.25 shows hypothetical preference ratings on seven items (columns) by four users (rows). In addition, three of the four users have rated the hypothetical target item. If we want to predict user 4's rating of the target item, we could look at which of the other user's ratings for the other items were most similar to user 4's. When we do this, we can see that the ratings of User 1 are similar; thus, we might expect that User 4's rating of the target item would also be comparable to that of User 1.

		Video						
		1	**2**	**3**	**4**	**5**	**6**	**Target**
Person	**1**	9	1	4	8	3	0	2
	2	3	0	9	2	3	8	1
	3	2	8	7	9	3	1	7
	4	8	3	3	7	8	2	?

Figure 5.25: Hypothetical ratings of seven items by four users. What is the prediction of the preferences of Person 4 on the target video?

Correlations are a particularly effective method for calculating recommendations across registered users. Fig. 5.26 shows the pair-wise correlations for all the users. Correlations range from −1.0 (perfectly uncorrelated) to +1.0 (perfectly correlated). We can confirm our impression about users 1 and 4 by noting that the correlation between their scores is +0.74.

		User			
		1	**2**	**3**	**4**
User	**1**	-			
	2	-0.14	-		
	3	+0.10	-0.40	-	
	4	+0.74	-0.49	-0.11	-

Figure 5.26: Correlations between the user ratings in Fig. 5.25. The large correlations suggest strong similarity (or dissimilarity) which can be useful for making preference predictions?

While the correlation between Users 1 and 4 is the strongest, some of the other correlations are also substantial, albeit negative. User 3 tends to predict the opposite of User 4 (correlation of -0.49). Thus, we might also expect that these two would also differ on the target. While User 3's rating for the target is high, we would expect User 4 to be low. However, the ratings of User 2 and User 4 were also negatively correlated, but User 2's rating of the target was low, which appears inconsistent with the predictions about the target obtained from Users 1 and 3. For much larger problems such as the Netflix prize; apply methods such as those used for text processing.

Although recommender systems focus on comparisons across people, they can also be used to examine comparisons across documents (such as books or videos) when linked by individual preference. Fig. 5.27 shows a map generated by individual selection of two books — "an individual who bought book 'X' also bought book 'Y.' The dots on the map represent book 'Y.' Notice that two clear groups of books emerge, representing a user (buyer) purchase pattern. Presumably, this reflects belief systems (4.5.0). More complex recommendations[12]. Filter bubble. Implications of recommendations for ecommerce.

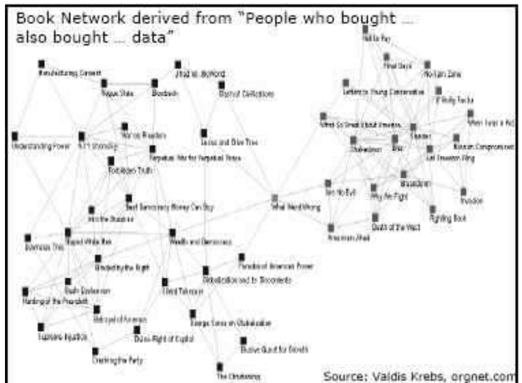


Figure 5.27: A 2-D visualization of book preferences based on co-purchases[64]. There is a clear separation of books by political orientation. (check permission)

Online ratings. Tend to be positive. Self-selecting population of raters. Product rating site.

Dimensionality reduction applied to preferences. Reference citation (10.10.2) networks can also be used as recommender systems; by charting the patterns of who cites whom, it is possible to determine areas of interest between different researchers. The same is true of Web sites.

Serendipity. Diversity of recommendations is desirable.

5.6. Small Groups and Computer-Supported Collaborative Work

People are social creatures — we bond, interact, and compete. From these interactions, we form groups, organizations, cultures, and societies. All of these shared endeavors involve the exchange of information in some form, often with other members of a group. People often form groups to complete tasks. Some groups, like military patrols, are highly organized and regimented. Others, like a group of friends who meet for lunch, are informal. Because some groups adopt formal structures, we can examine how well different structures affect the completion of different tasks, and we can look at the processes these groups adopt. Some social structures more suited to accomplishing certain types of tasks. Sometimes, groups are a part of larger social units such as organizations (5.7.0) or communities (5.8.2). This can also affect how a group is organized and how well it functions. Find levels of continuity in task-oriented group activities. Groups co-constructing knowledge. Shared resources. Computer-supported cooperative work (CSCW). Affective feeling of working with the group and separating affect from the groups needs. Individual approaches and group composition. Development of a group culture which includes ways of speaking and interacting. Ultimately, this leads to the development of communities of practice (5.8.2).

Conformity. Group-think.

$$\text{Meeting} > \text{Task} > \text{Project} > \text{Organization}$$

Figure 5.28: A flock of geese on land (left) are less structured but some groups have a clear structure like the geese in flight (right) (check permission)(get new photos).

5.6.1. Group Structure: Roles and Rules

When groups of people work together in teams they develop different roles. These are not unlike broader social roles but they are more focused on the activities at hand. These roles affect the communication and interaction patterns which are inter-related with the group structure. Fig. **??** displays two extremes of group structure. On the left, all the interaction is mediated by the person in the center. On the right there is no such centralized organization, and interaction is possible at all levels. Group communication structure helps to determine the information flow and decision processes. However, the composition of the group is also a factor. This is an example of structuration (5.1.2).

Structuration. Creating groups which can effectively solve problems.

Roles may be formal (explicit) or informal (implicit). Formal roles are generally well-established and are associated with specific responsibilities for supporting the organization's goals (5.7.2). There may also be informal roles in unstructured social interaction. Some people may be the "sounding-board" or the "clown". The leader, or in some cases the group as a whole, ensures that the desired goals are being accomplished. Managers are often leaders, but "leadership" is distinct from management. In a formal setting, this specialization is a clearly defined role. Groups often have a task leader who moves the group toward its goal, and a social leader who facilitates relationships within the group. We will revisit several of these issues later when considering organizations (5.7.2). However, in small informal groups, the roles are fluid. Role-playing games (11.7.0).

Group Processes and Decision Making

The group dynamics of juries are legendary. Jury deliberation is perhaps the most distilled and prototypical example of group decision making. This is one example of social decision making. In a jury room, a small group of people has a pool of shared knowledge, and they must analyze that knowledge and reach a consensus. Groups differ in the ease with which they reach consensus. Group opinions interact with group tasks. Building shared understanding among group members. Indeed, the procedures and artifacts of the group themselves channel effective outcomes. This is often referred to as distributed cognition. Interpersonal persuasion within the group.

When groups are engaged in a task, the members of the group bring different background but the group requires coordination to function effectively. like individuals they generally follow a *Look→Decide→Do* process. That process might be modified or expanded slightly to accommodate the group dynamic (Fig. 5.30). Problem solving (3.7.1). Following this model, the jury would analyze the task before them (to reach a decision), collect the information (the evidence presented to them), formulate resolutions (state their opinions and the reasons for them), and vote. This process may be more or less regimented for different groups and situations, but the process is very thorough and decisions made by small groups can be better than decisions made by individuals. This may be attributed to the mixing of decision-making processes (3.4.1) with social dynamics, which forces individuals to formulate their rationales in different ways, thus allowing them to more closely analyze their own position. Structured discussions can help a group to complete tasks (3.4.3) by helping the group to navigate effectively the steps of the

Figure 5.29: Group decision processes are evident in jury deliberations as has been illustrated by many movies. Here is a frame from the film classic *12 Angry Men*. In this movie, one juror gradually persuades the others to his point of view. (different picture) (check permission)

mental model. There has to be some commonality and overlap of concepts between members of the group. This allows individuals to better understand their own role within the group by understanding the roles of others. Collaborative information retrieval (10.3.2).

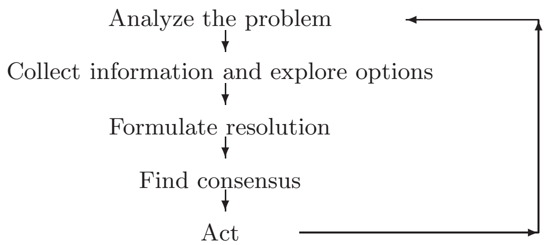


Figure 5.30: Stages in group problem solving. Note the similarity to the *Look→Decide→Do* process.

Changing Group Opinions

The opinions of the group evolve through interaction. Indeed, the tendency is for groups to shift their opinions over the course of discussion to more extreme positions compared to the original average of the group; this is known as the "risky shift" or "group polarization" phenomenon[97]. When an individual attempts to highlight the differences between their position and a different, perhaps competing position, they are likely to phrase their argument in an extreme, polarized way. Having committed to the argument, however, an individual is loath to modify it while a part of the group, even though individually they may think it is a little extreme. This overlaps with the models of attitude change we have discussed for individuals (4.5.2). This may make it difficult to develop a consensus within a group. There are developed techniques that may make it easier to do this, however. Taking an initial survey participant's positions helps to prevent the adoption of more extreme views, and fostering constructive, structured dialog helps to maintain group focus on the task at hand.

Shared Representations and Shared Knowledge

Shared knowledge also includes shared procedures. Distributed cognition. Instantiation of shared knowledge in artifacts with varying degrees of formality. Conceptual models (4.4.1)and shared conceptual models.

Individual with knowledge: One or more individuals know the answer to a question.
Interlocking knowledge: Different people in the group have different parts of the answer.
Group has effective processes: The group can find or derive the answer.

Suppose we ask a group or organization to answer a question. Even if no one person knows the entire answer, the group may be able to synthesize the answer, or the group may have procedures that allow it to develop an answer. Just because one person in the group has a good answer, it does not mean that the group as a whole will come up with the right answer. That is, there is shared knowledge across members of the group. Indeed, there are several senses in which knowledge can be shared. The group may develop common procedures for accomplishing tasks. Or, they may have common records.

5.6.2. CSCW, Collaborative Task Environments and Socialble Systems

Information systems can enhance group interaction. Small group interaction is supported by CSCW systems. Organizational interaction is, typically, supported by knowledge management systems (7.3.1). Using various information systems, collaboration between individuals can be distributed in both space and time[2]. Because the cost and effort of travel can be substantial, collaborative systems, sometimes called "groupware," can be extremely cost effective. Email can facilitate discussion between participants spread over the entire world at different times of the day. Other collaborative software aims to facilitate knowledge building by maintaining a record or log of conversations or work performed on an internet portal. This is termed computer-supported cooperative work (CSCW).

Collaborative information seeking.

Defining how work can be accomplished, especially distributed work. Articulation work[46]. Artifacts and environments. Group interaction can be nuanced and shift rapidly. Collaboration in science (9.2.3). Co-evolution from synergies among participants.

Work practices describe what people actually do to accomplish tasks. This is often rather different from the formal specification of the work (3.5.1). Generally should match work practice to computer support. Co-evolution of work practices and system capabilities. Moreover, the both the work and the system capabilities will change and the other components need to adapt.

Figure 5.31: Coordinating the activities of a medical team in a hospital emergency room is so complex and has so many exceptions that it is not yet able to be automated very well. (check permission)

Collaborative Information Behavior. Building shared understandings. Collaborative simulation.

CSCW (5.6.2). Collaboration. Remote collaboration and social interaction. The technology allows this, but is it a good idea?

Collaborative environments. Collaboration platform. This environment uses a desktop as a spatial metaphor for the interface; participants can collaborate, documents can be shared, and *ad hoc* work groups can be constructed. Sharing resources.

Sharepoint. Telework.

Creating awareness of co-workers. Collaborative operating picture.

Interfaces for collaborative design (5.6.2).

Collaborative information environments (10.3.2).

Design for group interaction is a natural extension of the issues here but before we return to this (7.9.6) we consider various models of social interaction in the next chapter. Designing social interaction patterns and roles while also designing the information system.

Participants need mental models of the tasks and of the other players. Versus office automation.

Information management for many types of collaboration.

Problem of groupthink.

Includes coordination among players.

Spontaneous distributed coordination for awareness of what other team members are doing.

Social interaction can be affected by the technologies mediating it. On one hand, technology can limit the richness of the interaction. On the other hand, the human activity will often adapt to constraints take advantages of opportunities.

Structuration and the organization of meetings.

Collaborative task analysis.

5.6.3. Supporting Face-to-Face Meetings and Co-located Collaboration

Information systems can facilitate many aspects of group interaction, including meetings. The purpose of meetings is to accomplish goals. Often, the goal of a meeting may be to determine a strategy to accomplish a larger goal. Managing a discussion and keeping a civil discourse. Nonetheless, information systems can help. Determining the tasks. Structured, possibly task-oriented, discussion A little later, we will consider distributed meetings (5.6.6).

Supporting the dynamics of face-to-face, small-group interaction can be invaluable in the articulation of the group's shared work objects, the accomplishment of its tasks, and in facilitating the group process itself. They allow people to sit together and collectively work to get something done. Face-to-face meetings, however, go beyond mere verbal communication. Body language and eye contact can be just as communicative as words, often unconsciously so. Observing eye gaze can be useful in judging an individual's interest during a meeting, especially as the thread of conversation shifts quickly across individuals and topics. Analyzing participant attention using information recording devices can help to determine what portions of a meeting are effective. One way to increase attention is to use wall-size displays or white-board displays around which people gather for demonstrations or collaboration (Fig. 5.32). Collaborative interfaces. Awareness of what other team members and what they are doing. Collaborative work spaces. Awareness of co-workers. Facilitating the cohesion and functioning of a group.

Meeting structure agendas, minutes, civil discourse. Verbal interaction (6.4.0).

Figure 5.32: Group interaction can be based around artifacts such as a computer.

5.6.4. Recording Meetings

Suppose that a complicated design problem is discussed at a meeting; later, one of the participants wants to review what was said. The records of individual meetings are called "meeting archives" or "meeting memories". This could be an entire multimedia recording or it could focus on the organizational business conducted at the meeting. Typically these are ad hoc and relate to organizational knowledge management (7.3.1) more than to formal archives (7.5.1). Continuum from personal information management (4.11.0). to larger and more organized groups and all of these access and create information resources. Much less than meeting minutes.

These tools provide continuity across sessions. More than just meeting support but part of broader activities. Recording decisions so that the issues don't have to be revisited and re-opened. These provide continuity across time. However, the minutes of a meeting are often brief and reflect more organizational politics than an accurate rendering of a discussion.

The discussion of the meeting could be covered by an argumentation systems (6.3.5) or for the records of a design group, there could be a design rationale (3.8.7). Having a recording of the meeting can be helpful for determining conversational dynamics; not just what was said, but how it was said. That it, indexing the meaning is crucial and can be very difficult. This can be important for meetings regarding policy issues, as a person's body language or tone might say more than their words. Meeting archives can also be useful for explaining the role of one domain within a large organization. Representation is a major consideration for records of meetings. The representation affects the ease with which information about the meeting can be retrieved later. A meeting archive system should facilitate finding events in the record of that meeting (e.g.,[48]). Difficulty with the representation of representational gestures which are used in the meeting.

5.6.5. Effects of Modalities for Remote Interaction and Developing Social Presence

A technology-mediated conversation will be different from a face-to-face conversation. Connectivity (5.1.5). Members of a group are often geographically dispersed, and this alters some of the fundamental aspects of interaction. In many distance communication environments, participants are unable to see one another, which limits the unspoken communication that normally takes place in conversation (6.4.0). When a group is interacting together through a technology-mediated interface, it can become difficult to realize different elements of the group dynamic, and people might not be able to grasp the roles that come naturally to them in an actual face-to-face meeting. Even text messaging can be considered as a medium. The more complex the message, the richer the communication medium needed. Deception.

Face-to-face interaction is the gold standard for communication[41]. It is the ideal to which all communication mediation technology aspires, and much effort has been, and will continue to be, spent developing different interfaces that not only reach that ideal, but augment it. It is frequently claimed that it is difficult to establish a relationship solely by electronic means; at this point in time, that does seem to be the case. However, it is often possible to produce productive electronic interaction once the dynamics of the group have been established face-to-face. Apparently, there is a greater tendency to lie by email than in other more direct communication modalities [?]. Artifact exchange for remote work.

Social Presence

Social presence is the awareness of other people[92]. Individuals increase their activity or improve their performance due to the presence of others. Social facilitation. Even avatars can create a sense of social presence in some situations[85]. In face-to-face interaction, gaze is one indication of social attention. Fig. 5.33 shows an automatic system to track gaze. It is an element used in the judging of emotion and in the attribution on intention; it is a clue used when watching others and when tracking the conversation. Mutual gaze, that is, eye contact between two people, is a sign that the other person is paying attention. Simulated gaze is a factor giving conversational agents natural interaction Curiously, while video does not provide significant additional information for completing most tasks over audio channels, it is often preferred. This is the case even though some tasks can actually be completed best with audio. From this, preference appears to be a function of the richness of the medium[35] Perhaps

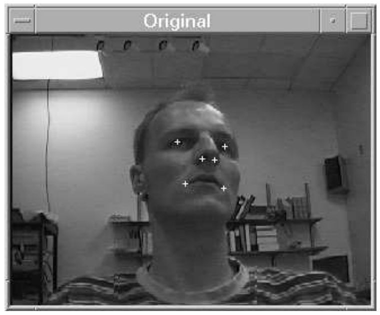


Figure 5.33: Gaze can indicate points of attention in a meeting. Gaze can be assessed by reference points on the face[96]. (check permission)

suprisingly, flattery by a computer agent can be very effective for motivating people [**?**].

Some effects of communication modalities are best explained by the salience of cues, or the obviousness of the interaction. When meeting with a group of people face-to-face, one cannot help but realize that there exists an interaction situation; when being spoken to, it is understood that the person speaking should be the focus of the listener's attention. Similarly, technology used to mediate communication, particularly communication between people in different locations, should not allow the modality itself to draw the participant's attention. We may listen more intently to an audio-only presentation than to a mixed-media interaction. This is because in a mixed-media interaction, a portion of our attention is diverted toward the images rather than the substance of what is being said.

New communications technologies and devices provide new modes of social interaction.

Social presence from interactive robots.P This could be helpful for autistic children.

Shared Artifacts and Augmented Spaces

Many meetings and discussions are based around documents, diagrams, or other artifacts, some of which may be electronic. In virtual meetings where not all the participants are located in the same place, conversational anchors allow for group interaction centered on particular objects.

Some allow for interactive sketching on a shared object, such as "live boards," which let participants interact directly with each other on shared writing spaces. A live board or an electronic marker board can also create a long-term record of the information that has appeared on it.

Other shared objects may include organization and/or meeting support documentation that structures the flow or agenda of the collaboration. And, just as in the real-world, coordination is necessary to manage people who may be involved at different stages of project development — notes of previous meetings can be part of the shared object collection.

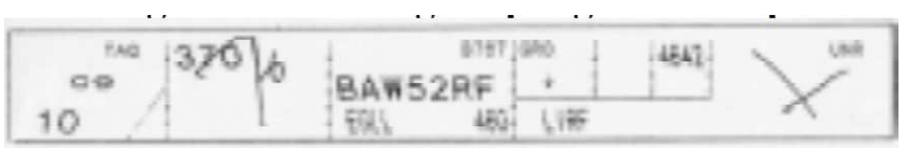


Figure 5.34: Shared information resources often provide support for distributed cognition. Here's a tracking slip user by air traffic controllers as a record for a flight. The highly structured slips provide a quick overview of the flight and can be easily transferred across shift changes. Recognizing how the are used can be helpful for developing computerized air traffic control tools. (check permission)

Shared artifacts for completing tasks. Shared understanding of the group activities by its members. Procedures affect human interaction. Fig. 5.35.

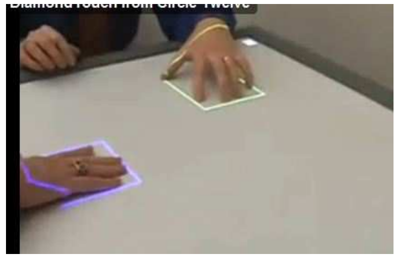


Figure 5.35: Multi-user touch surface (DiamondTouch). This could be used for local or remote manipulation of virtual objects. (check permission)

5.6.6. Shared Virtual Spaces and Media Spaces

Information systems can support virtual teams. Information systems can provide a portal between two physical spaces These portals are called "media spaces," and they become a part of the working environment. Remote perception

Media spaces can be social environments with a conceptual space for people and resources. Media spaces range from telephone calls to inter-office video links and video conferencing. A virtual media space is very similar to a real shared space, and common norms apply: there must be a mutual awareness that everybody is sharing the medium, and appropriate (5.3.1) behavior should be established to accommodate everyone's needs. Media spaces allow participants to meet and discuss common items as if they shared the same office.

When several people work together in virtual spaces, these spaces are called Collaborative Virtual Environments (CVEs). A CVE can provide a neutral, focused, and dedicated meeting ground for participants. CVEs aim to ensure that all participants are aware of the same things (11.10.3). In this environment, documents can be shared among the participants; video and audio communication channels can also be coordinated. Avatars and conversational agents.

Roles in a community of inquiry: initiator, facilitator, contributor, knowledge-elecitator, vicarious-acknowledger, complicator, closer, passive-learner. [103]

Socio-technical discussions. In other cases, a number of researchers may share research instruments such as a large telescope. Such shared resources and the social structure around them are called a "collaboratory" (5.6.6). These collaborations become part of a full-scale interaction environment that allows groups to pool resources, data, and knowledge. Simplicity is often with regard to CVEs. It is difficult to beat email as a flexible medium for collaboration over distance. While it may not provide all the bells and whistles of other technologically advanced collaborative environments, it is direct and easy to use. Conference review systems.

5.6.7. From Meetings to Teams and Projects

Teams are more stable than groups A team, especially a team engaged in highly technical activities, needs members who specialize. Moreover, to support complex collaborative tasks such as design, we need a collection of specialized, interlocking tools. Rather than developing generic environments for collaboration, it is better to consider collaboration on specific activities. To do so, we must ask what tools are required in particular collaborative environments, and then apply those considerations to design. Many technologies have evolved since conference calls were first introduced: virtual meetings (5.6.6), video conferencing, shared visual spaces (e.g., information spaces such as white boards), and shared window systems. There is, a need to information coordination in projects and, ultimately, organizations. New information environments are evolving quickly, like team rooms[18], threaded email discussions (10.3.2), distance education, group decision support systems (GDSS) (3.4.3), and software development environments (7.9.3).

Team formation.

Collective reasoning. Structured analysis system. Issue-based information system (IBIS).

Hybrid local-remote teams. Group and project records.

Team members sharing expertise. Intranets (7.3.6). From teams to task-oriented online communities such at the editing of Wikipedia (5.8.2).

Formal meetings and side channels.

Some teams never meet in person; they are virtual teams. Information technology allows work teams to be distributed. Get groups to work and learn together. These are notable in restricted modalities of interaction. Communication modalities and social presence (5.6.5). Collaboration in distance education. Virtual math teams[95]. CVEs. When the teams are part of a long term, for instance, when they are part of virtual organizations (5.7.3) there needs to be significant sharing and trust so that each member will make appropriate contributions.

5.7. Organizations

Organizations are social systems formed of individual units working together for a common goal; that is, they are task oriented and have a relatively formal structure. Organizations need to balance flexibility and efficient processing to adapt to change. Organizations face the additional challenge of balancing individual needs with organizational goals. In any event, information the glue that keeps the organization functioning. Knowledge management (7.3.1), Sharing information in organizations can be difficult. Organizations are dynamic and often have changes of personnel and mission. First, we consider organizational structure and then organizational processes. From mission, to goals, to structure. Information ties the organization together.

5.7.1. Organizational Structure

Organizational structure is formalized in the units in an organization and the lines of management for them. It also reflects the lines of formal information flow and control. Some organizations are structured, while others are adaptive and flexible. Control in a traditional organization is generally hierarchically structured (Fig. 5.36). General policies are articulated at the top level and they are implemented at the lower levels. Other organizational types are more loosely structured, with control and decision making spread out over a larger area. Organizations like this may include universities, or more broadly, a federation of states. The management structure of an organization depends on the level of control required for the tasks to be completed. Information exists at all levels of an organization, as does interaction. Even in traditional organizations, in addition to the formal lines of communication, there are usually many dynamic work relationships and informal channels of communication. This structure is particularly effective for traditional manufacturing organizations. However, it assumes different levels of information at different levels of the organization so it is less effective for information-intensive organizations. Organizational behavior. Hierarchies facilitate coordination, motivation, and training[34]. Organizations have clear boundaries. The organizational structure usually describes paths of both information flow and control.

5.7.2. Organizational Processes: Workflow and Control

Organizational structure is interwoven with workflow. Roles within an organization specify activities associated with completing tasks. Typically, these roles are formally specified. A university has roles such as Professor and Dean; each occupies a different level of authority and has different work to perform. In society at large, social organization is facilitated by the "division of labor"[42]; rather than having every individual do everything to complete an activity, individuals specialize, and become an expert at particular activities. UML (3.10.2) can be applied to the description of organizational information flow. Structure and roles are intertwined with processes. Organizational control has previously been described as the flow of resources (people and money). In a highly structured organization, individuals are often assigned roles. Roles are formed from groups of activities required by organizational tasks. These roles may include "foreman" or "programmer". Organizations are structured groups that have

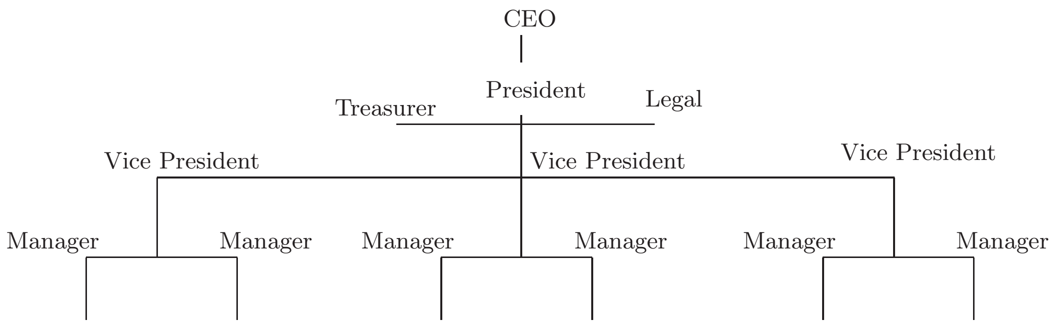


Figure 5.36: Traditional hierarchical management structure for an organization. Decision control flows from the top and information relevant to making those decisions flows up from the bottom.

cohesion and continuity. They generally work together toward a common goal within a framework. Though, of course, split loyal is often a major issue. Formal descriptions of processes.

Information is essential for the management of complex organizations. Control[27]. Not every organizational activity can be formalized. These are organizational practices rather than organizational rules. Office workers often spend more time handling exceptions rather than routine matters. Such tacit knowledge is particularly important in changing environments in which new paradigms are emerging [98]. Silos.

As we shall see in (8.11.2), this generally makes organizations smaller and the boundaries and interfaces between organizations more important.

Office work as practical action in which decision making and problem solving are critical.

Multitasking and interrupt-driven task activities.

Measuring productivity in office work.

Information Flow and Workflow in Organizations

Consistent with business process specification (8.11.2) and object-oriented design (3.9.3). Prescriptive work control systems. Workflow specification is a type of situated planning. Roles must be matched to the capabilities and the schedule of the individuals which fill them. Traditionally, those at the top of the organizational ladder determine for the organization to function smoothly. Organizational decisions should come as a result of an analysis of the desired goals and the existing procedures. The framing of organizational decision needs affect information needs and information seeking. In traditional organizations, there are usually formal processes. However, in real life, organizations don't always follow those processes. For instance, organizational activities may also include less formally defined procedures known as shadow functions. Worklfow leading to preservation (7.5.3). There can be too much emphasis on process.

Information may be viewed as the glue which holds an organization together. Control from one part of an organization to another. Parts of an organization must communicate to focus activities, such as scheduling meetings or designing new products. Thus, an organization is likely to have an information infrastructure that includes libraries, intranets, training, and databases. Some information systems control and track the flow of a product through manufacturing (production). Other systems control communication and information itself. These systems and roles are focused on the management of information within a group or organization. "Gatekeepers" are those members of a group or organization who mediate between the outside environment and the group[20]. They do a type of information filtering (3.2.3); that is, they systematically collect information from the external environment and forward it to individuals inside the organization. While this sounds nefarious, it often consists of identifying trends, marketplace indicators, or other beneficial information to those who can use it. In addition to the formal chain of command in an organization, there is also interaction in work teams and simply from friendships (5.1.0, -A.3.5).

Information may flow smoothly within an organization but introducing information systems may not always be successful. Like the theory of structuration and the socio-technical model, it is best for an organization to use an emergent model in the adoption of information systems and new technology (7.9.6). This allows the development of structures, processes and systems to fit the overall task.

Representing information flow in organizations. Managing incentives.

5.7.3. Individuals in Organizations

Organizations should be designed to effectively process information, as it is one of the most integral elements of an organization. Clearly, information is critical in an organization and there are specific positions within a company designed to manage it. We focus on social interaction within organizations and basic organizational structures and processes. Later, we will examine variations of these basic models. Stories and the organizational culture. Individuals often do not fully share the goals of an organization. Rather, those individuals' involvement may be based on other incentives.

Sociability and social networks in organizational environments. When does an individual decide to share information in an organization?

Individuals in organizations may ask the question of what is going on here? This is organizational "sense-making" [105] (3.1.1). This emphasizes the ambiguity of social constructs. A committee, cuts across functional areas. Organizations are made up of individuals so it is worth considering the organization from the perspective of the individual. We might ask how individuals react in the context of organizations[104]. Critical thinking as sense-making. Organizational narratives versus reality. Internal logic for organizational decision making.

Socio-technical interaction networks.

5.7.4. Politics and Power in Organizations

5.8. Institutions and Communities

5.8.1. Institutions

Institutions maintain society's values and, thus, the coherence of society. Some institutions, such as marriage, family and religion, are broad social conventions which are related to norms. Other institutions such as the judiciary are related to the government. Still other institutions such as universities, museums, and libraries. Establishing socially desirable behavior [40]. But, other institutions involves financial institutions are also information intensive.

Institutions have momentum and are difficult to change. Information is essential for most institutions but some are information institutions (7.1.0). Management in institutions. Institutions are, of course, social creations.

Institutions are often resistance to adapt to changing situations. At times, this can be of value. At other times it can be frustrating.

Mission creep.

5.8.2. Communities

A community, loosely defined, is a group of people with a sense of coherence and interdependence. This coherence can be the result of geography and government — the most traditional sense of community — or it can be the result of a shared identifying characteristic, interest, or profession. A community can usually be characterized as a particularly closely interconnected social network often with significant social capital between the members.

Unlike most organizations, communities rarely have a formal structure or roles. Members may act under shared values, which might lend cohesion to the group and lead to the development of a network of commitments, but communities generally do not have a defined structure such as is common in organizations. Community members can also offer each other mutual support and sometimes effective conflict resolution. Information is interwoven with communities. indeed, virtual communities are entirely mediated by information services. Beyond simple task completion, communities facilitate sociability (5.1.1). Scholarly community (9.0.0). Communities are often based around information and information exchange.

Traditionally, a community is composed of people who live near each other, and they generally have a common a government, economy, and ecology. Some characteristics of communities are shown in Fig. 5.38.

Type	Description
Proximity	Community by virtue of spatial proximity.
Practice	Share knowledge and responsibilities.
Interest	Shared non-task oriented activities.

Figure 5.37: Some types of communities. (merge into text)

Aspect	Description
Cohesion	The sense of there being a group identity.
Effectiveness	The community gets things done.
Help	The ability of members to ask for and receive help from other members.
Relationships	The likelihood that members will interact individually.
Language	The use of a specialized language.
Self-Regulation	The ability of the group to police itself.

Figure 5.38: Some attributes of communities (adapted from[87]).

Figure 5.39: Communities may form clusters in social networks.

Community Dynamics

Legitimacy of community membership and respect for opinions. Regulating behavior or members. Common bonds and empathy with other community members. Becoming parts of a group. Socialization.

Community Information Practice

Members of a community share many information needs. Newspapers (8.13.7). Radio stations. Citizen journalism. Wikdelphia. Geographic factors in topic models. Communities maintain knowledge. Community archive. Community Repositories.

Digital inclusion.

As communities develop, recording their interactions and history becomes more important, and various types of information systems may be developed for the purpose. In towns, for example, information systems such as a newspaper or radio station may inform people of community activities, and keep them abreast of news, events, and history. These records can become a "community memory," which documents important events or just tracks the development of the community and its progress. In the area of information systems and community memory, communities of practice are the most developed and contribute the most to our understanding of the relationship between information science and systems and varying ideas of community. Community informatics. Making information available for a community. This could be a government information service or it could be related to records.

Community Models

Can include data about infrastructure.

Communities of Practice

People who work together because there are synergies in their skills and knowledge. Membership provides a type of social capital. Facilitates information sharing among members. Discussing work practices. Situated learning such as apprenticeships. Practice leads to action. Communities of practice often support knowledge collection and dissemination related to their field. Peripheral learning of tacit information by observation of the group. Professional practice (5.12.4). In-group and out-group.

Professions and Professional Communities

Professions have a specialized body of expertise. They generally involve extensive training and upholding professional values. Professions and institutions (5.8.1).

Groups of professional in a given area may form professional associations. There is also a down-side in that they can also exclude outsiders. Guilds. Professional association.

Members of professions as law, journalism, and medicine as well as craftspeople such as plumbers and electricians, form communities of practice. Sharing knowledge with stories. Communities and social networks.

Professional associations. These are learned societies (9.1.1). usually set ethical standards and disseminate technical information of relevance to their members. Craftspeople and their information needs. The activities of a community of practice include some explicit procedures and some which are tacit and almost impossible to articulate. However, like all organizations these can also be reactionary and membership may be excluded. Jargon. A professional association is different from a trade association which is generally composed of companies which produce similar products.

Apprentices. We will discus communities of practice in the context of knowledge management (7.3.1).

Jargon.

Discourse and Document Communities

One example of discourse communities is scholarly literature (9.1.1).

They use language to create boundaries. Discourse communities own genres. Sets of organizational documents can reinforce the organizational boundaries. Print culture (8.13.6)and bibliophiles (8.13.6).

Online Groups and Communities

Differences in being remotely located as affected by communication modality (5.6.5). Member-mediated online communities such as wikis (10.3.2). Game communities. Clubs. Fan communities. Motivating contributions by (a) emphasizing uniqueness of goals and (b) given challenging goals [?]. Sociability and friendship in these online communities. Social presence can strengthen commitments to an online community. Online communities as an information resource for instance by learning what other people in a similar situation have encountered. Community structure and norms.

Increasingly, there are ad hoc online groups to which individuals contribute. Managing online groups and other services.

Designing online communities. Typically, communities should provide both information and emotional support.

Games (11.7.2). Massively multiplayer games (MMOGs) and massively multiplayer role-playing games

(MMORPGs). Opposing factions. Different types of play. Data collection from the game players. Game-centered face-to-face social interaction.

5.9. Culture

5.9.1. What is Culture

Culture is the amalgam of the norms, beliefs, rules, traditions, art, history, and myths of a society. Culture as what peoples actually do. They can also be interpreted as providing a shared meaning. culture is based on shared assumptions. Culture is a set of beliefs which maintain the values and cohesion of a social group as it is learned and transmitted across generations. Presumably, successful cultures have a survival advantage for the group.

Culture depends on information transmission and it is greatly affected by communication media and records. Translating words is a fairly simple matter; it is more difficult to make clear the cultural meaning they may carry. Information artifacts, such as books, stories, and sculptures can provide a record of a culture, and hence can help to preserve it (7.5.4). Information systems are artifacts of our culture. Their organization and structures reflect different values, preferences, and abilities that a group may display. While the relationship between culture and information science and systems may seem tenuous, it can be quite important, particularly when designing a system for use by people of another culture.

Figure 5.40: Balinese water temples and the rituals associated with them support an elaborate system for managing irrigation[66]. (check permission)

Fragmented culture. Culture in modern society. Culture and family size.

Culture and the tribal level of social organization. Cultural niches. Kinship (5.1.1). Modern society includes many cross currents, counter culture. Education and culture. Culture and information behavior. Willingness to ask questions. Culture and dangerous knowledge. Ritual. Culture as an adapted set of constraints for meeting a human group's needs in a given environment. Other cultures might have developed to meet those constraints and some of those solutions may be more effective than others and some may be more adaptable if the environment changes.

Dimensions of culture. Homogeneity of culture. Power distance, individualism. National culture [?]. Oral cultures. Cultural assumptions and indexing.

Culture helps to structure human activities[68]. Culture helps to define norms (5.3.1). Culture helps to shape belief systems (4.5.0). Ecology of norms. Tradition. Ritual and creating meaning. Establishing a shared narrative.

Cultures are not monolithic. Sub-cultures. Fandom as a sub-culture. This is often associated with social-network.

Cultural learning. Cultural tradition as a learned representation. Culture often helps a social group cohere and survive. Though, in many cases the reasons the cultural traditions are not apparent. In some cases, the traditions help the culture manage resources (Fig. 5.40). Other traditions such as those surrounding weddings and funerals provide stability and continuity of the culture itself. Culture and narratives (6.3.6). Cultural modeling.

Culture in relation to modern society.

Participatory culture.

Cultural Management of Knowledge. Traditions about treating knowledge. Cultural traditions about culture. Applying cultural dimensions. Cultural property as a form of intellectual property.

Among the differences in cultures are the differences in category systems across cultures. Culture and categorization[68]. Ethno-classification.

Culture and language (6.1.2). (Fig. 5.41) Patterns in search terms (10.11.2).

Months	J
Example	x

Figure 5.41: The frequency of postings about a given topic are a function of two factors.

Cultural models[36]. Cultural traditions need continuity. Cultures are adaptations to one set of conditions and are not necessarily well adapted when those conditions change. Indeed, cultures can sometimes be harmful and out of sync with their environment.

5.9.2. Cross-Cultural Communications and Interaction

The ambiguity of language can be amplified as people different cultures try to communicate.

Effect of disruptive media on culture.

Challenges of moving across cultures.

Ability to interact across cultures. "intercultural competence".

Cultural Change

On one hand culture is continually evolving across people. On the other hand, for a given person, culture can be difficult to change since it deals with solutions for basic human needs and generally has social reinforcement for beliefs.

Culture versus technology[3] and external forces for change.

Cultural change and adaptation.

Mixed Cultures and Cultural Transitions

In the modern world, culture is continually changing.

Change is an issue for archival description (7.5.4).

5.9.3. Cultural Heritage and Memory Institutions

The relationship between these institutions and political constraints. In our complex, industrialized society culture is maintained in part by large institutions such as libraries and museums. A slightly different view of institutions frameworks for social interaction. Relationship between cultural institutions and educational institutions. These "public spaces" exist distinct from commercial organizations [54]. Community memories. Libraries (7.2.1) are cultural institutions. Traditional libraries have served an important social and community role; they provide stability and a standard of open knowledge for the community. Role of small town libraries [**?**]. This is a major benefit of community information services (5.8.2) and supporting collaborations. In many towns and universities, libraries are places where students can gather, have a quiet place to work, and socialize. It is apt that libraries are a place to socialize, as information is inherently social: it is passed from one person to another through books, conversation, painting, and innumerable other modes, and now through electronic information systems as well. These organizations serve broader educational and knowledge-creation roles as well.

Elgin marbles.

Indigenous Control of Culture

Who owns cultural traditions? Could be related to intellectual property; however, the logic seems to have to do more with respect than with legal control. Perpetual rights to cultural, especially, sacred content.

Respect versus rights. Of course, it is difficult to legislate respect.

5.9.4. Media and Culture

Media dissemination of culture. We cover media more generally in (8.13.7). How should cultural institutions handle complex objects such as mashups.

Does Media Violence Cause Individual Violence?

Does watching violent movie or playing a violent video game make that person more likely to act violently themselves. There is some evidence that media violence causes individual violence. However, there are usually many levels of social constraints on a person. While violent games can sometimes cause a short term physiological arousal, they are generally not as strong as social norms. Mass culture. Catharsis.

There is a vigorous debate about the relationship between viewing violence in the media and the occurrence of violence in society. One view suggests that people imitate violence such as that on television, movies, music, or video games, and that these negative images contribute to the violence that occurs in society. Other theories suggest that these media merely reflect the violence that is already inherent in society, and that the violence itself is primarily due to other social factors. In addition, they may be harmful to young people with mental health problems [?].

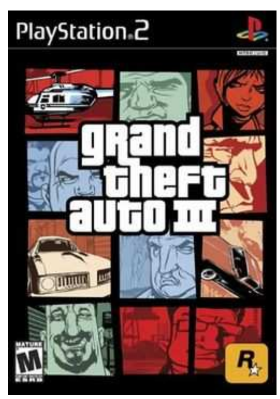


Figure 5.42: Do violent video games increase violence in the players of those games? (check permission)

[22] Does viewing smoking cause an increase in smoking? Generally attitudes and habits are slow to change, but there are situations where that happens. Social roles are those identities that are found throughout society, such as man, woman, parent, child, boss, and employee. Beyond violence within a society, individuals may also infer norms of behavior for social roles from media input and social learning. For example, media may present extreme characterization of social roles.

5.9.5. Institutions and Organizational Culture

Globalization and cultural transitions.

Information Culture

Cultural factors in information behavior [?].

5.10. Living Analytics

5.10.1. Everyday Life and Living Analytics

Data sets about everyday behavior.

How do people actually live? How much television, etc. How do people spend leisure time. Patterns of consumption.

Behavioral economics and everyday decision making.

5.10.2. Technologies and Social Interaction

Big data.

Transportation tracking . optimizing travel based on where people want to go

5.11. Education

Education involves both social and cognitive processes. Education and information are intertwined. Education may mean learning a complex interlocking information structure rather than individual facts, and should focus on acquisition of complex new skills or new points of view. Education, knowledge, and information are rarely used in a vacuum. Education has it has both cognitive and social dimensions[88]. It is one thing to learn a new skill set, but it is another to know or learn how to apply it in the world or to communicate it to others. Also, the process of learning itself is often interactive: discussions, explanations, persuasion. Education helps to make individuals effective members of a society or culture. It also helps to perpetuate that culture. The ultimate goal of learning is changing an individual's behavior; for instance, the student can speak to someone else in a foreign language whereas before they would have been silent. However, because changes in cognition seem to be necessary for changes in behavior, learning sometimes focuses on cognitive changes. This highlights the natural connection between education and information resources. The balance between them recalls the discussion at the beginning of this chapter about the relationship between society and individuals. Ultimately, we would like to determine the conditions for the most effective learning.

Learning sciences.

5.11.1. Instructional Objectives

Education is an essential function of society. Schools and universities are social institutions which are important for transmitting social conduct; but in a complex and diverse society, this often means there are many different goals often contradictory, of what those goals are. Among these are the importance of socialization, of care-giving, of learning independence and creativity, and of abstract thinking skills. Are some more important than others? Is it important to learn how to do arithmetic? What is the role of the parent versus educational institutions. Systematic education for young people for making them productive members of society. Education of young people also depends on physiological and social maturation.

Providing both content and processes (5.12.2). People are adaptive, but not infinitely so. Forming habits and providing a base of knowledge for future effective action. Most would agree that a worthy goal is the mastery of a skill required to complete a job; this would allow the individual to be a productive member of society. But what job? Some people value home schooling, while others point to the benefits of "living learning" (e.g., how to get along in a dormitory). Ultimately, the point of education is to change behavior and not just provide information. Presumable, the same skills that a student learns when studying arithmetic are used in their career.

Avoiding commercial and political influence in education.

5.11.2. Theories for Learning and Education

A wide variety of learning theories have been proposed over the years. Rather than trying to compare them, we can examine them from the perspective of the two main approaches to education that we have adopted: cognition and social interaction. We have briefly discussed detailed cognitive learning phenomena (4.3.5), and later we will consider machine learning (-A.11.0). As we noted at the beginning of this chapter, in education, as in all of human activities, there is a mix of social and cognitive perspectives. Evaluation of educational widgets.

Cognitive Perspective on Education

Cognitive theories of education focus on the development and modification of cognitive representations (4.3.0, -A.11.0). Education may be viewed as a process of re-structuring a student's concepts. Here we consider two types of cognitive theories: information processing theories and constructivist learning theories. When presented with a new experience or piece of information, we contextualize it based on many factors: the experience of acquiring the piece of information, the expectations we have for it, and previous related information or experiences, to name a few. It is then incorporated into our understanding or mental model using a grouping strategy. Thus, information processing theories of education focus on the external presentation of facts, figures, and theories in a way that allows students to easily include them in their pre-existing mental model. This is the classical model of education; teachers present information and students memorize it.

By comparison, "constructivist" focuses on the construction of meaning from fragments of information. This is related to sense-making. It includes discursive, adaptive, interactive, and reflective components. In essence, students build, or "construct" their own meaning of data, events, or observations. After the learning exercise, students need time to reflect on the educational experience and to consolidate their interpretation of it. Learning about processes rather than facts [29]. Gleaning information from the world. Web of concepts. Developing conceptual models. Learning by Doing: Dewey.

Social Perspective on Education

Learning is social in many senses (e.g.,[88]). Cognitive aspects are often dominated by the social lives of the students, their peers, their families, and the broader social context. In a narrow viewpoint, students often learn procedures by talking with other students. We have already noted imitation (5.5.4). Even constructivist approaches to learning often emphasize the importance of social interaction [102]. Even the content and concepts of learning may be viewed from a social perspective; for instance, we can say that learning happens as one negotiates or pulls meaning from the output of external sources [67][106]. The social is internalized to the cognitive through time [102].

Training versus education. Credentialing.

5.11.3. Instructional Strategies

A teacher needs to decide how to implement an instructional strategies. Pedagogy is the approach selected for teaching. The pedagogical model is a description of how that pedagogical approach works. Pedagogic models, domain models, student models.

Pedagogical Models and Instructional System Design (ISD)

Fig. 5.43 illustrates the typical stages for developing a strategy for instruction. Developing critical thinking by comparing information resources [76]. Inquiry-based learning. Reflection. Instructional system design (ISD). Critical thinking [45].

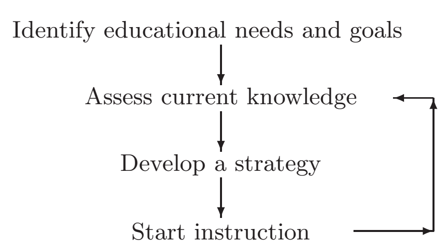


Figure 5.43: Outcome-based learning. Stages in planning for instruction (adapted from [65]). As the instruction proceeds, there may be additional assessment and refinement of the instructional strategy.

The "pedagogical model" is the strategy for teaching; it may be used to provide heuristics of when to intervene in a student activity. Teachers need to tailor content to the capabilities and interests of a group of students. The strategy must go beyond single applications to enable the development of an integrated curriculum. This is an authoring task; educational objectives need to be integrated with available content. A number of learning strategies have been proposed (Fig. 5.44). These go beyond lecturing in traditional classrooms.

Instructional Strategy	**Description or Example**
Rote	Learning by memorization.
Resource-based	Learning by using information resources
Problem-based	Learning by working on (and solving) a problem.
Project-based	Learning by working on a project. This is related to problem-based learning.
Experience-based	Learning byu doing, Apprenticeship, Field trips.
Inquiry-based	Learning by exploring complex questions.

Figure 5.44: Several common pedagogical strategies.

Inquiry-based learning is one way to implement constructive learning. This approach suggests that learning is best supported by questions that students generate themselves. A student might collect evidence and then make generalizations from it. These processes are best implemented by a five-stage learning model[15] that is similar to the stages of information for developers of scientific theories.

Projects can help a student understand the interaction of aspects of a complex task. Project-based learning can be done, in part, with simulations and reasoning support. Reasoning support can help to illustrate patterns or relationships that it is necessary for a student to understand for the completion of a project. Simulations can allow students to control an environment; a model of physical effects can be used for teaching the laws of physics. A simulation might be used by a student to learn the equations necessary for launching a satellite into space. Simulations approximate behavior, but often with less-than-realistic displays; they may include virtual reality. Simulations can be particularly useful for allowing students to experience environments that are inaccessible or conditions that occur very infrequently, such as the ocean floor or outer space. More general implementation of simulations will be considered later (9.5.0). Training simulators. Medicine.

"OK, here's the deal." The gruff inspector snarled as he spoke to your team of detectives. "For a long time people have been blamin' things on the moon! People claim to be crazy because of it, lovers claim to be under its spell, and even hospitals blame the full moon for loaded emergency rooms." "Yeah!", one of the newer members of your team replied flippantly, "So what's new?" The rest of your team let out a low sigh. Now the whole team was in for it! "I'll tell you what's new, Mr. Smartypants," the inspector glowered at each of you slowly, "Now some nutcase has brought charges against the moon for causing the tides! And, its your job to bring me proof one way or another!" The inspector turned back toward his desk and we thought he was through. He wasn't! He turned back to your team, pointed his finger at you and said, "And you only have two weeks to solve the case. Now get started!"

Questions: Can you find a pattern that will convince the jury that the moon is responsible for the tides? If the moon is guilty, does it have an accomplice which contributes to causing the tides?

Figure 5.45: Web Quests challenge students to use Web pages for resource-based learning. (check permission)

Learning requires not only cognitive processing but also motivation. Student engagement — that is attention to the task — is essential to learning by getting the student to synthesize and reflect. It is helpful to engage the student as opposed to using passive listening or reading, and to use "learner-centered design"[93]. Other examples and techniques of constructivist-like learning include: experience-based learning[39], such as field trips and experiments; allowing students to put something into their own words rather than memorizing the words of another; encouraging the deep processing of concepts by forcing students to build their own knowledge while working on a complex and hopefully motivating question.

Scaffolding provides a framework to help students to learn. Scaffolding may be seen as setting the experience level so students can make their own discoveries. The scaffold can be gradually removed or faded as the student's learning improves. These techniques supports constructivist learning[102] which suggests that students construct knowledge for themselves. A related approach attempts to find the teachable moment.

Teaching and Tutoring

Teaching is a transfer of skills from on person to another. Teachers apply strategies for meeting educational objectives. A teacher creates an environment for learning, usually by developing a curriculum and assembling materials. Teaching in a classroom may be contrasted with one-on-one tutoring. In traditional schools, it may also involve talking with parents and, of course, working directly with students.

Feedback is an integral part of teaching and tutoring. Sometimes, the feedback can be minimal — just showing the student what he/she has done. At other times, the feedback may be tailored. Indeed, there are effective feedback languages to guide students without excessive use of criticism.

Figure 5.46: Tutoring.

Tutoring is personalized adaptive instruction. The tutor determines what pedagogical strategy to apply for a particular student: how and when to intervene, either to explain material or to redirect the student's attention, and when to encourage reflection. Language, of course, is essential for this. To understand what makes for effective human tutoring we can examine transcripts of tutoring sessions (Fig. 5.47).

Tutoring discourse such as explanations (6.3.2). Fig. 5.47. Dialog management for tutoring (6.4.0). Note that in the example the teacher does not contradict the student, but poses a question which may help the student identify an inconsistency. This is an example of the "Socratic method" which is based on challenging students with questions and discussion. This is a type of discourse specific to education (6.3.2). Tutoring and question answering (10.12.0). Accountable talk gets students to articulate complex concepts.

Actor	**Statement**
Tutor	Do you know why it rains a lot in Oregon and Washington?
Student	There is a warm current passing over cool land.
Tutor	Do the Cascade Mountains there affect the amount of rainfall?
Student	No, no, no.
Tutor	How can the Andes affect the amount of rain in the Amazon and the Cascades not affect the rain in Oregon?

Figure 5.47: A tutoring dialog[51]: Note how the tutor highlights the conflicting answers of the student to have the student better understand the underlying processes.

Intelligent Tutoring Systems (ITS) can adapt to individual students. Even if the entire process of tutoring cannot be automated, perhaps some aspects of it can be. For instance, agents might simply coach students, rather than attempt to manage complex interaction[99]. "A teacher for every student." Tutoring vs learning Logo. It is a small step from tutoring systems to serious games. Training with games (11.7.2). Gamification.

Student-to-student computer-supported peer review.

Educational Assessment

Assessment determines progress toward an objective. Presumably, for education we are concerned with functioning in real-world tasks The knowledge of students needs to be assessed at different stages in the educational process. There are two functions of student assessment: assessment for the purpose of evaluating the student and assessment for understand the impact of the supporting information system. Assessment ascertains what a student knows and can help determine what should, or needs, to be taught. For skills training, a "skill gap analysis" could be conducted to determine what the difference is between the skills a person has and the skills they need to complete a task. Validate assessment tool against outcomes. Outcome-based assessment. Criteria for assessment tools.

Embedded assessment can be part of the interaction such as part of an online tutoring session

Typical quizzes ask for a single factual answer to questions. This is known as "item-response testing". This method may be contrasted with testing that involves more complex responses, such as answering essay questions. It is important to find the set of test questions for systematic assessment; educators must be aware that the interpretation of questions on a test may be subjective. In traditional testing, the same questions are given to all students. However, with interactive systems it is possible to tailor questions to a student's knowledge. Moreover, adaptive testing adjusts the questions to the level of knowledge of the student. Data collection about what works in the curriculum [**?**]. Modeling affective state of students.

Representing Student Knowledge with Student Models

If we have a model of the learning process and of the student's knowledge, we should be able to be more effective at tutoring. There are several aspects of a student's knowledge that can be modeled and several ways to represent these concepts. Developing a model of a student's knowledge within a particular domain is a useful step in developing a learning system. Models of for how a task should be solved. Models of the student's general knowledge and state.

A tutoring system may employ a student model, which is similar to a user model but a student model attempts to capture the level of the student's knowledge. Interaction between students and teachers is a specialized type of discourse (6.3.2). Modeling a student's knowledge from just a few observations is treacherous. Suppose a student was trying to do a fractions problem, such as Eq. 5.2. What would you conclude if the student gave the answers in Eq. 5.3 or Eq. 5.4? Rather than treating the symptoms of knowledge deficiency, such as an incorrect answer, it is helpful to identify the "root cause" of any problems, such as the process by which a student arrives at an incorrect answer. However, this can be difficult to sort out especially if the student has multiple sources of confusion. The behavior event stream in very limited is understanding the detail of what the student is thinking. A more subtle representation would show student goals and activities. Indeed, student performance can be predicted with data about the student's activities at the university. Knowledge representation (2.2.2)for the user model.

$$\frac{1}{2}+\frac{1}{2} = \frac{2}{2}=1 \tag{5.2}$$

$$\frac{1}{2}+\frac{1}{2} = \frac{1}{4} \quad (incorrect) \tag{5.3}$$

$$\frac{1}{3}+\frac{1}{3} = \frac{1}{6} \quad (incorrect) \tag{5.4}$$

Implementing Computer-Based Tutoring

Behavior graph. Conversational agents. Providing feedback.

5.11.4. Instructional Design

Many educational technologies have failed by teaching skills outside of a broader curriculum. Effective instruction needs to be built on more than learning isolated, individual concepts. Design (3.8.0). Rather, a coherent set of concepts needs to be woven together to form lessons, courses, and ultimately an entire curriculum. Instructional planning should specify desired outcomes (Fig. 5.49). That is, educational goals can be identified and components could be designed to contribute to those goals. At a second level, however, we can identify underlying concepts that cut across several content areas. These underlying concepts can be applied to many areas of education and not, say, just arithmetic.

Dimension	Description or Example
Domain knowledge	Knowing about a specific content area.
Knowledge of the learning environment	Knowing what aids are available and how to use them.
Self-management	Monitoring oneself while learning.

Figure 5.48: In addition to domain knowledge, a student in a learning environment needs knowledge of the learning environment and self-management skills.

Knowledge Skill	Example
Remember	Have heard of SQL.
Understand	Know what SQL is good for.
Apply	Could decide when SQL should be used.
Analyze	Can determine what might be wrong with an SQL statement.
Evaluate	Could decide whether an SQL statement is doing what needs to be done.
Create	Could create new SQL statements.

Figure 5.49: Hierarchy of knowledge skills[23] for a domain and an example using the Structured Query Language (SQL). Instructional system design might specify the level of knowledge expected of students.

These are both cognitive factors and affective factors.

Incentives are a way to implement a design for a social activity. Creating habits with incentive structures [9].

Learning involves much more than simply acquiring facts about a particular domain (Fig. 5.48). A student should learn not only the content of the domain, but also the process of learning. Understanding the process of learning involves “meta-cognition,” which is the awareness of one’s own thought processes. Help-seeking. This is related to information seeking. Being trained in this awareness can help a student to self-manage the learning process in all other educational domains. Several factors determine the selection of teaching methods from the real world: Theory, cost, and social priorities must all be balanced.

There are several different levels of knowledge skills (Fig. 5.49); they reflects the depth of understanding and the degree to which that understanding can be applied. Remembering knowledge is viewed as more basic than being able to evaluate that knowledge or to create it. It is one thing for a student to memorize facts, but it is quite another to relate facts to each other and absorb their unified significance. Simple memory is, of course, essential to learning. But, this broader perspective suggests that learning that consists of a range of techniques, from memorization to concept integration to application. Language and education (5.11.5).

5.11.5. Educational Informatics

Technology is most effective when it is woven into an educational plan; that is, there should be an emphasis on education rather than technology. As noted earlier, this is a mixed blessing. Pros and cons of technology in the classroom [81]. Evaluation of information technology for education. such as the value of cellphones for classroom use. Supporting collaborative learning and learning communities. Supporting task interaction with shared artifacts. Information environments should be able to stimulate learning. How the use of information resources affects learning.

Serious games (11.7.2) for education. Fun can increase motivation and engagement. Multimedia interactivity may increase attention. However, immediacy of games may reduce reflection. Measuring the pedagogical value of games. Assessment via learning games. Pointification.

Teaching social skills.

Science, Math, and Computing Education

Many concepts is science and math are abstract; however, they can be illustrated with models. Virtual manipulatives (Fig. 5.50). Visual and/or conceptual demonstrations, like those provided by simulations and reasoning support, generally help a learner to develop a greater, and deeper, understanding of a topic than a simple recitation of definitions or facts[30] (Fig. 5.51).

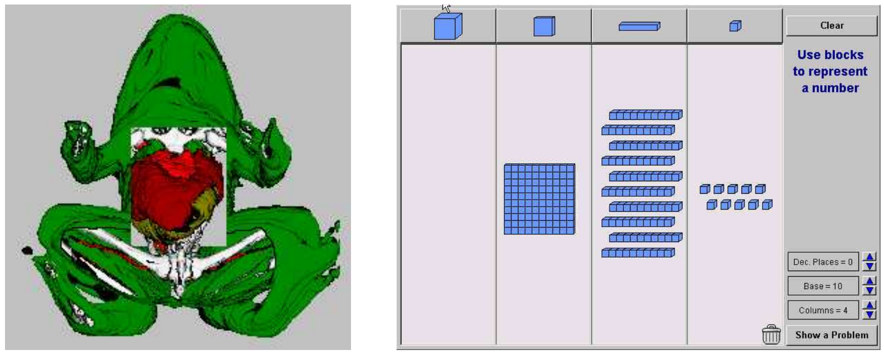


Figure 5.50: Virtual manipulatives allow students to explore principles. [101]. Here are two examples: A virtual frog (left) can help students learn anatomy and a math manipulative (right) teaches the concept of multiples of 10. (check permission)

> The concept of prime numbers appears to be readily grasped when the child, through construction, discovers that certain handfuls of beans cannot be laid out in completed rows and columns. Such quantities have either to be laid out in a single file or in an incomplete row-column design in which there is always one extra or one too few to fill the pattern. These quantities, the child learns, happen to be called prime numbers.

Figure 5.51: Visualization can be useful to help young students understand prime numbers[30].

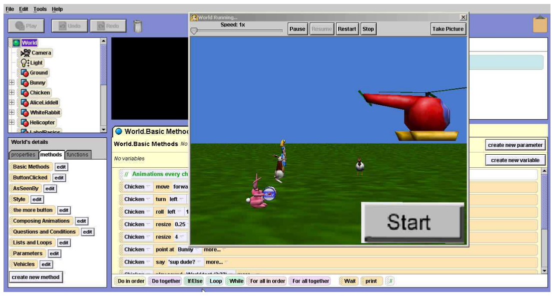
Personalization of math problems with natural language technology. Collaborative problem solving. Mixed-initiative dialogs for collaborative problem solving.

Learning to solve complex science problems. Medical simulations for training (9.9.1).

Constructionist Learning Technologies Computer programs specify processes (6.5.2). programming, or instructing a computer to perform a series of commands. It is helpful to be able to visualize, the effect different programming actions have on the output of a computer. Logo, for example, is a simple programming language that is suited to this purpose [79]. Using it, a student can explore the effect different commands on a graphical display. It makes the student articulate the assumptions behind the graphical procedures. It also introduces programming basics to the students.

Algorithmic thinking. There have been claims that learning to program leads to better problem solving [79]. However, the empirical evidence does not support this[82]. Alice is an object-oriented programming language (3.9.3) which manipulates graphical objects (Fig. 5.52) [59]. Object-oriented programming is a good way to implement businesses processes. Scaffolding can help transitions among programming languages[53]. Another view is that programming languages should be easy to acquire. Alice for telling stories. Everyone a programmer. Scratch. Squeak. Difficulties of thinking about classes and objects.

Science education and explanations (6.3.4). Scientific inference and reasoning can be supported with argumentation systems (6.3.5). Learning about argumentation. Discourse (6.3.2).



bunny.move(up, 0.15)
bunny.drum.move(up, 0.15)

Figure 5.52: Alice world and Alice program. In the first lines, the whole bunny moves. In the second line, the drum moves. (new photo)

Learning to Read and Write

We examine cognitive issues in reading later, but here we consider technologies for the support of reading. Human language technologies can help to develop tutors for reading. We will examine cognitive processes and social implications of reading later (10.2.0). Reading without formal instruction.

There are many skills involved in reading[75], ranging from correct pronunciation of words to understanding the meaning of words in a given context. One information system strategy presents sentences on a screen; the student reads them aloud, and a speech recognition system processes what the student has said and provides feedback (Fig. 5.53). A student's cognition in reading, literacy, and writing is the result of several factors, several of which include: (a) that they use reading to obtain meaning from print; (b) have frequent and intensive opportunities to read; (c) be exposed to frequent, regular spelling-sound relationships; (d) learn about the nature of the alphabetic writing system; and (e) understand the structure of spoken words. A lack of any of these experiences can lead to difficulty in reading and writing[14]. Children's literature.

Computer assisted language learning us speech recognition technologies (Fig. 5.53). Computer assisted language learning (CALL). Summary Street project.

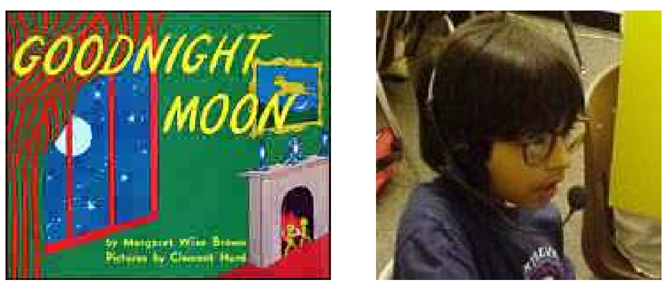


Figure 5.53: Learning to read is facilitated with a multimodal presentation. Illustration in a children's book *Goodnight Moon* (left). Bedtime stories provide parental bonding. Perhaps students can be taught to read by using speech recognition technology to listen to them reading out loud[74] (right). (check permission)

Phonics is a system of teaching reading by identifying constituent sounds of words and the letters that compose them, thereby allowing students to work out and construct the meaning and sound of written words by themselves, rather than memorizing lists of words and their spellings (10.2.4). This is a constructivist approach to teaching reading.

When teaching a foreign language, it is particularly important to engage the student's active participation, as opposed to using passive listening or reading techniques. This can be accomplished with networked distribution and multimedia immersion and is another area where information systems are revolutionizing education. Information systems have made a much wider array of foreign language materials available to schools and individuals than had previously been the case. Moreover, automatic speech recognition means that the student can be given interactive exercises.

Spontaneous reading with OLPC.

Educational discourse. Feedback on student essays can be provided by text-analysis (10.4.0). A text summarization tool may be used to provide feedback on a student's writing by determining how closely a student's composition corresponds with a pre-determined level of topic coverage[62]. Similarly, collaboration can be used when learning to write.

Information Resources and Education

Many of the systems we have described are active and try to anticipate students' needs, using information system technology to supplement traditional learning techniques. Another educational approach, however, is to have students seek to discover answers (education) for themselves. This system encourages students to investigate questions by accessing rich content. Libraries — can be viewed as complex information systems — play a key role in this aspect of education. Generally, information systems allow students to explore and acquire information. Understanding and using structured information[58].

Libraries (7.2.1). Resource-based learning allows students to build their own knowledge and meaning from various artifacts, or resources (5.11.3). Although it is difficult for some readers to integrate and synthesize information from several different perspectives presented in various resources, extracting significant concepts from an information resource is a skill that students can learn.

5.11.6. Effectively Presenting Information

Managing attention with multimedia.

Learning Objects and Educational Metadata A library provides a range of facts and viewpoints. These facts and viewpoints, scattered among such disparate items as books, microfilm, computer programs, and artwork, support "resource-based learning" by providing "learning objects". A learning object, as discussed above, is simply a resource that supports learning. Within any teaching system — be it an individual classroom or an entire university — the selection and presentation of learning objects are clearly vital to successful education. However, it is unrealistic for an individual teacher to search through and evaluate every possible learning object on a particular topic without having some knowledge of what the objects contain; in this regard, educational metadata becomes very important. One possible solution to this problem is the Dublin Core Metadata Initiative (2.4.4) which has been extended to include educational resources (Fig. 5.54). Open-access educational materials.

Attribute	**Description**
Audience	For whom is the material intended?
Duration	How long does the material play?
Standards	What educational standards does it support?
Quality	Quality ratings.

Figure 5.54: Elements added to the Dublin Core standard for describing educational materials[8].

Learning objects need to be interoperable with other educational environments. Object-oriented design (3.9.3) facilitates the re-use of modules (7.9.3). It is possible that educational learning objects can be re-used much the way that software modules are reused[4]. Synchronous versus asynchronous delivery.

Learning management systems can facilitate many aspects of education beyond simple content. They can help teachers to understand each individual student's performance, and note signs of grade improvement or degradation. These systems can also help to assess what teaching methods are producing the effects, both individually and collectively. Learning Management Systems (LMS) use databases to keep track of student activities. These activities may include class registration, grades, quiz results, and digital library use. Certain elements of student information need to be secured, but with simple measures this is not difficult.

Figure 5.55: Sakai Collaboration is an open-source learning management system. LMSs typically incorporate resources and assessment modules. (check permission)

5.11.7. Learning Environments and Learning Communities

A learning environment is the entire context in which the learning occurs. Traditionally, the context of education is a quiet classroom; teachers often lecture, but lectures do not facilitate constructivist learning. Alternatively, teachers can be the "guide on the side," allowing students to develop their individual intellectual abilities. Information resources can support different learning environments. School libraries can support inquiry-based learning.

There are modality effects in different learning environments. For instance, traditional classrooms do not encourage collaborative discussions. Intelligent tutoring systems (5.11.3).

Communities (5.8.2).

Educational System, Classrooms, and Schools

In the apprenticeship system, education was in is in the context where it is applied. However, much education has moved to classrooms. Lesson plans are goals and strategies for coordinating class presentation and interaction. A classroom teacher should facilitate effective interaction. Supporting classroom discourse. Feedback languages. Instructor facilitates discussions.

Traditional classrooms are sometimes described as being like a factory; students are treated all the same – almost as if on an assembly line. Teachers generally pace their presentations in the classroom and engage the majority of the students. However, lectures are often presented orally and unless a student kept very good notes there was no way for her to reclaim that information. However, classroom presentations could be videotaped and those tapes could be digitized, as meeting archives often are (5.6.4).

Multimedia instruction can be seamlessly applied to a traditional classroom setting. Different images, figures, or videos can illustrate how to parse the material presented in a lecture (Fig. 5.56). Information from many sources can be combined to demonstrate cross-disciplinary techniques such as gesture recognition (11.4.1) that might be helpful in processing the content.

There are many ways to learn. Learning in a studio or a master class is often vicarious learning (5.5.4) (Fig. 5.57). Apprenticeship model of learning. Innovative classrooms.

Groups of students, like other groups learn by working together. A small group of students working on a project is a community within the larger community of the school, which exists within the larger community of society. The community brings social interaction to education at all levels, and provides tools to support that interaction [57]. This in turn gives students a supportive group that facilitates their exploration and development. They can then build further on the social foundations of learning. Individuals may play several different within a learning community.

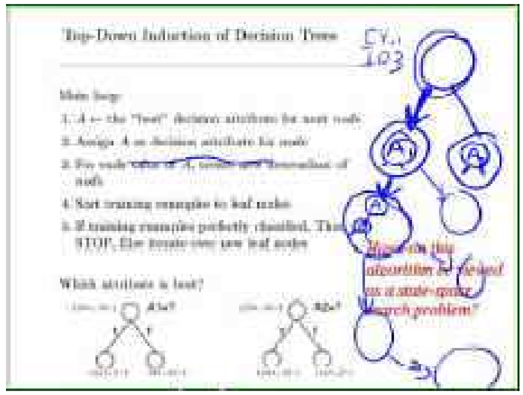


Figure 5.56: Annotations and highlights on the presentation by an instructor during a lecture[24]. (check permission)

Figure 5.57: Learning in a studio may include viewing the work of other students and listening to feedback given to them about their work[17]. (check permission)

Computer supported collaborative-learning.

Distributed and Distance Education

Increasingly, information systems are being used to facilitate distance learning. It is not always practical for teachers and students to get together at the same place at the same time; for example, working students may find it difficult to schedule classes due to the demands of their jobs, or rural students may not have the time and/or means to travel to a university campus several times a week. Information systems are helping to create situations in which the teacher and students are able to be separated from each other, across both space and time.

Distance education may simply involve students using audio or video to attend classes from remote locations, however, new technologies allow multiple means of communication including discussion forums, video-conferencing, online access to lecture transcripts, and online study groups. Modalities of interaction (5.6.5). This is sometimes called “distributed education”. Technologies developed for distributed education can also provide support for people with disabilities, for whom it may be difficult to physically attend a class or to keep up with its pace. Teaching presence.

Pros and cons of distance education. Distance education and threaded discussions. It is very convenient. However, social presence and engagement with other students sometimes stimulates involvement. Engagement seems to be essential for learning (5.6.5).

There are many forms that distributed education may take. It could include interaction through the Web for the entire educational experience, as in a typical lecture experience, or an interactive web portal could just be used for discussion forums, while the bulk of a student’s time is spent in individual study. A compromise, which could perhaps retain the benefits of both distance and face-to-face education is blended education. Increasingly, distance education is provided by integrated systems such as Instruction Management Systems (IMS).

Effective practices for distance education.

Mass-course ware. MOOCs. Massive online courses. Learning management systems. Several variations. Quality control. Generally works best for courses where little discussion is required. The difficulty of online credentialing across different universities.

Learning Beyond the Classroom

While some types of learning may be facilitated by the quiet and orderly experience of classrooms, a lot of learning occurs outside of classrooms. Indeed, learning is often most effective if it occurs in the environment and context when it is to be applied[38]. Pervasive and context-aware environments. Learning by doing and learning in everyday situations may be more effective than more traditional classroom-oriented approaches[5].

When using inquiry-based learning students may be thought of as "personal scientists"[60]. That is, students actively construct theories about their world based on their observations of it. The process of manipulating and organizing information modifies students' conceptual structures. Education involves more than just subject-oriented learning; it also includes a social dimension, such as making friends and living with fellow students. There are important aspects of student life, and should not be taken lightly. In this regard, distance or distributed education may never fully replace traditional in-class, on-campus learning environments, but it does provide options for students and teachers to take advantage of educational opportunities and to more fluidly incorporate them into their lives. There is also a lot of learning outside of schools and universities. Some that is supported by public knowledge and cultural institutions such as libraries and museums (Fig. **??**). Because of their educational missions, museum exhibits are sometimes designed to present an interpretation[25]. Docents.

Learning Communities

Because education is often a social activity involving discussion, interpretation, and negotiation, we use — and even attempt to design — effective social environments for learning. Learning often occurs in the context of collaborative problem solving[63]; groups of individuals working together to answer a question, or seek information. Such groups are often called learning communities though, in some cases, the group may be more transient than what we would think of as a community. People generally like to work with other people; those other people can provide both feedback and motivation.

Information systems are well-suited to facilitate these tasks. Commonplace systems, such as Email, allow learners to communicate ideas with ease. More advanced systems are designed to facilitate collaborative discussion and knowledge building using text strings, voting systems, and communal perspectives. These technologies allow students to find a community of interest despite their actual location, enabling them to seek out and find a venue for the discussion of their ideas.

The measure of educational outcome in collaborative activities is determined by the performance of a group as a whole and not the individual members. Group discussions support the development of a shared understanding among the members of the group, as do group learning objects or artifacts. Sharing and discussing an object, such as a document or a simulation, in the group environment can allow knowledge spaces to open so that there is expertise in at least some elements of the group.

Because learning is often social action, communities are an integral part of education. A learning community is any community that supports and facilitates learning. They exist on a continuum of size, ranging from large, diverse, integrated societies to small, distinct groups of learners. Fig. 5.58 illustrates two levels of a learning community. The math forum itself is a relatively small, distinct group of learners, while the submitted post points to the fact that this student is situated within a much larger, more diverse community composed of family, school, and peers [**?**, **?**]. This can also be supported with a type of virtual reference (3.3.2). Computer-supported collaborative learning (CSCL).

> My father says that a radius is not what i think it is... I think that in a circle half of it is the radius. (Like center to edge) My father says that it has to do with the curve of the circle... I was looking over my pretest for Math and i seemed to have gotten a similar question wrong.. My 13yr old sister says itz right though... My teacher obviously believes that the radius is the diameter... Am I the one who is right?

Figure 5.58: Question submitted to "Dr. Math" in Math Forum, an online math help service. Note the apparent family involvement. (check permission)

This example emphasizes the social aspects of education and how the small group level of interaction exists as an integrated part of a larger community. The act of group formation itself is an act of social learning, in that an individual must not only learn what it is that they are seeking in a group, but also whom else among the larger community shares that idea.

5.12. Everyday Information Skills and Critical Thinking

Many situations are complex and not necessarily what they seem. This can be particularly for some social and information-related activities. Thus, people need a frame of expectations for how to interpret claims. This is often framed as a need to have literacy about those activities.

The ability to prioritize observations is essential to addressing complex problems. This is essentially the same as the goal of supporting unbiased decisions for organizational information systems (3.4.2).

Minimize emotional and attentional bias. Degrees of critical thinking. Due process in legal proceedings (8.5.4) minimizes the effect of emotion.

We have seen many instances including decision support systems (3.4.2). Critical thinking depends on more than just understanding the observations, but understanding the ways such observations may be biased. Argumentation (6.3.5). People also need to detect obfuscation and deception.

Minimize emotional and attentional bias. Degrees of critical thinking. Due process in legal proceedings (8.5.4) minimizes the effect of emotion.

5.12.1. Getting and Evaluating Useful Information

Being an informed citizen. Critical thinking involves weighting the evidence before making a decision. Specific examples include: everyday inference (4.3.4), everyday information seeking ((sec:everdayinformation)), interaction in the social milieu (5.1.1), and making social decisions (8.4.3).

Information resources are not always what they seem. Students should learn about interacting with information systems. They should learn responsibility and caution in handling information. Two related ideas and sets of skills: information literacy and media literacy. Although the skills are necessary for all decision making, Information literacy and media literacy are often considered as training for students. There are many activities which are not well characterized as tasks.

Nonsense detectors. Realizing that people are likely to be biased in their answers. This often violates conversational norms. However, they convey some information. Dubious advertising and freedom of information.

Personal information management (4.11.0).

Learning how to organize and access information. This includes, learning about information structures such as book indexes and library catalogs. Information finding is often difficult. The ability to use indexes needs to be taught. As does the ability to find trustworthy experts when that expertise is needed.

5.12.2. Literacies

Members of our complex society need basic skills to function effectively. These skills are often termed literacies.

Knowing how to find and access information as well as how to evaluate information. There is an expectation in our society that people generally accept responsibility for their own actions. Reading literacy (10.2.2). These skills include economic literacy (e.g., "let the buyer beware"), consumer education, health literacy, media literacies. "Archival intelligence". game literacy, science literacies (9.4.3). Data-analysis literacy. Expectations on information literacy in developing economies. Visual literacies.

While we think of these are the necessities of good citizenship, they can also be seen as cultural expectations.

Information Literacy

Information literacy in an era when ever more of the information is opinion based. Information literacy is needed at many levels such as in the ways that Wikipedia might be biased. Causes of information il-literacy.

Here, we focus on information literacy which teaches people to interact efficiently with information.

Here we consider aspects information literacy. From literacies to expert knowledge. Just as reading is considered an essential skill (10.2.2).

Deception intentionally creates false impressions. Deception may create incorrect beliefs. Deception is common in human endeavors (5.3.3). Truth bias. Intentional misuse of categories. Cues for deception. Cross-cultural dimensions of deception. Levels of distortion in organizations[21]. Impostor. While almost everyone has an instict for self-preservation, there's is a great variety in the degree to which people will take advantage of situations for personal gain versus being altruistic and cooperative. However, it's always the case the eventually somebody come along to turn a situation to peronsal advantage. It may fulfill an economic or political agenda. This is rather the opposite of the conversational norms (6.3.1) or the standards of information professionals ((sec:infoprofessionals)).

Pervasive, consistent and systematic distortion of information.

Internet Literacy

The broad connectivity of the Internet creates many challenges. Awareness of attempts to obtain personal information. Phishing. Privacy literacy. For instance, people should be aware how broadly personal information they post on the Internet may be seen. Students also need to be aware of the nature of information resources. These skills are often termed information literacy and "media literacy".

Judging the Quality of Information

Perceptions of quality versus actual quality. Given the vast amounts of dubious information on the Web, it is essential for users to assess the quality of information. There may be clues about the quality embedded in the information resource. Information finding (3.0.0). Trust (5.2.3). Publishers provide reviews and branding. In other words, they give authority. A user can learn to pay attention to clues that indicate the quality of information. Need to have background knowledge about a resource. Crap detection.

People are frequently uncritical of the reliability of information from sources such as the Web (4.5.1). It is often helpful to focus on materials from reliable sources such as experts and high-quality publishers. Nonetheless, we then have the question of how to identify those reliable sources. Cross comparing information across several sources. See what other people are saying about a claim. Awareness by the reader of the motives behind writing. This can be due to one-sided information or outright deception (5.3.3). More subtly, can we trust Wikipedia articles (10.3.2)? The nature of scholarly authority.

Being able to judge the credibility of an information resource is[10]. More systematically, both information literacy and media literacy encourage students to be aware of the social context of information and media content. A number of factors such as internally consistent, discussion of contrary opinions, and organizational affiliation of the author are clues to information quality.

Figure 5.59: Propaganda posters[11]. Media literacy suggests that the students should be aware of how attitudes can be manipulated.

Beyond analyzing individual information resources, we can also consider entire collections. There are clues which suggest, though certainly don't guarantee accuracy. These include not having any broken links.

An agent provocateur is intentionally disruptive.

Teaching and Learning Search

Teaching young people how to use search engines effectively. Ability to extract and integrate information for several different search pages. Reading (10.2.0).

Judging the Motivation Behind a Communication

Many communications are not trustworthy. This is applied to the influence the television commercials have on children. Media literacy is the ability to judge the intention behind a message. Some presentations take care to present a variety of viewpoints; others may give only one.

As notes above, we expect citizens to be literate about advertising. This is reflected in the statement "Let the buyer beware."

Motivation of advertising. Persuasion gamesmanship. (4.5.2). Media and advertising. Aware of the biases due to attentional processing. Sometimes these assumptions are built into the culture. Recognizing that news reporting might be biased.

Clues about what we can trust in communication. News (8.13.7) (Fig. **??**). Political persuasiveness of content. Gaming the system.

Recognizing that processes association with communication also controls people.

Weighing evidence. Detecting persuasion.

Social Mechanisms for Ensuring the Quality of Information

Due process. Civil debate. Neutral white papers and pundits. Knowledge institutions. Reference. Furthermore, due process should be transparent to encourage people to believe in the system and should build trust. Information professionals (5.12.4). Consent, privacy, and forgetting.

5.12.3. Information Ethics

Ethics analyzes situations in a way that encourages moral actions[33]; thus, critical thinking is essential to ethics. Ethics in the use and management of information. Many organizations have ethical standards. Professional ethics concerning information. Journalistic ethics (8.13.7). Scholarly ethics (9.1.1).

Photo journalism and the difficulty of selecting a single image to show.

Ethical issues in mining large public data sets.

Collective benefits versus individual harm. and some people may be hurt by making information public. It may be legal but could still be harmful.

Individuals should give credit and cite the sources of material they use. Not doing so is known as plagiarism. Plagiarism is related to the violation of copyright but is not the same. Copyright is a law concerning the use of information, while plagiarism in based on social norms. "Plagiarism" is the use of someone else's works without giving attribution of their source. Failure to do so is unethical, and can lead to claims of plagiarism. In some cases, authors re-use their own writing. This is known as self-plagiarism" [89]. This is related to academic honesty (9.1.1).

There are several applications of technology for detecting intellectual fraud. Copy-detection software (8.2.5) can also be used to detect plagiarism.

5.12.4. Information Professionals

Professional are parts of information institutions. Minimize specific agendas. Professions (5.8.2). Codes of conduct. Professional integrity. Information professions depend on a high level of professional integrity. For instance, we expect journalists, archivists, and notaries to be trustworth in handling information.

This is not to say that human information professionals always follow their responsibilities. Journalists and distorted information. Another example is the Heiner case in Australia which involved the destruction of archival records. Police may lie to secure an arrest or conviction.

5.13. History

We have noted that human behavior even in contemporary society are difficult to decipher. This is even more true of history. Informal explanations and the narrative of history. Like lessons learned from organizational reflection, history can provide a reflection of society's decisions. History as collective memory.

Local history.

Social uses of history.

It is very difficult to trace historical evidence.

History data sets civic records, newspapers, archives. (Fig. **??**). Memory studies.

Figure 5.60: Digital history

5.13.1. What is History?

History tries to systematize explanations of past human activities (6.3.4). History as change through time. However, history doesn't directly capture the past. History as description of events (chronologies) versus history are interpretation causes. History as interpretation and narrative (6.3.6).

Generalization about history.

Popular history may represent an idealized version of cultural values. Historiography Causation is interpreted. This is inlike science, where the constraints on inference come from physical processes, In history the interesting effects are often the decisions made by people. Because it is difficult to interpret people's motives, the key constraints for history are provided by memories and records. The saying "History belongs to the winner" has considerable truth to it, but at least rigorous historical investigation needs to contend with some evidence.

Types of history. Intellectual history. History of technology. Social history. History of art. Public history explores public interaction with history. This can be simplified as idealized versions of history.

History and events. Writing history. Historical argumentation (6.3.5). Historical explanations as distinct from scientific explanations (9.2.2). History is not grounded in replicability as science is. Difficulty of reasoning about counterfactuals.

How people learn about the past. On one hand, the past is a foreign country, but some conception of the past is essential. Another viewpoint is that while cultures and time perids differ those differences may not be so great that they can't be covered understood back on the commonality of human experience and basic empaty.

From history to sociology.

Digital history.

Doing history as a process of conceptualization. Can have accurate facts but still not convey and valid historical account.

5.13.2. Evidence about Historical Events and Social Memory

Event Streams and Historical Concepts

History as a way of organizing knowledge. Notions of historical periods and historial figures. Colligatory concepts.

Social history, economic history.

Historical Evidence

There is a tendency to revise history. Difficulty of history is that there are many possible explanations and too little evidence.

Adequate evidence for claims about history. Historical explanations.

Documents as providing evidence (2.3.1), records (7.4.1), and archival materials (7.5.1). Also, other sources such as architecture and archeology. There is a real chance of fraud with digital objects. Evaluating the legitimacy of records. Some kept in archives has some level of confidence but what to make of records that gave not been in a systematic archive.

Primary sources. Archaeological evidence is often based on the context from which an artifact was obtained. Physical evidence from museums.

Figure 5.61: Political cartoons can be useful as primary sources as evidence of perspectives on social issues.

Oral histories (Fig. 5.62).

The presentation of history in movies is often controversial. Oliver Stone. Docudrama. Immersive historical games.

Figure 5.62: One of the video oral histories from the HistoryMakers collection. (check permission)

During a court trial, the jury may be presented with a reconstruction of an accident or a crime. If a video of the events were available, the jury would want to see it. While such a video is usually not available, an animation of the events can be made. Note, however, that there are many ways to shade the veracity of an animation, and so it might give a distorted impression to a jury. Fig. 5.63 shows animation from two perspectives. By comparison, interactive animation allows for a full view of actions; hence, interactive animations can facilitate better exploration of all perspectives on an event. Digital evidence.

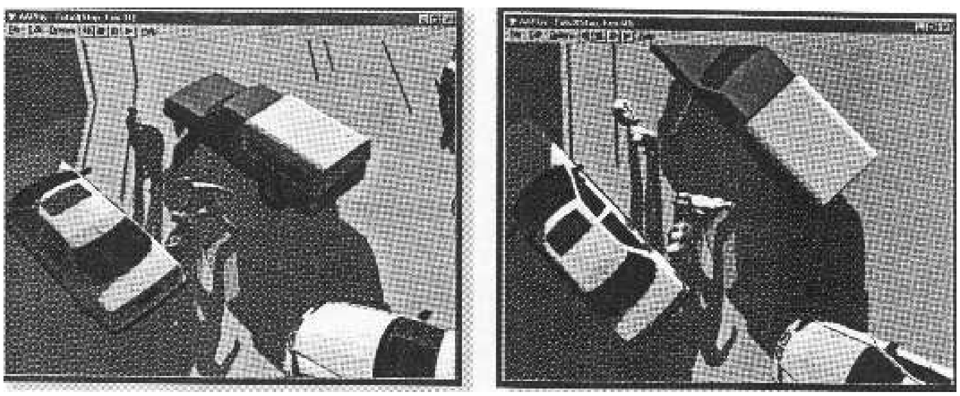


Figure 5.63: Two perspectives on an event may lead to different interpretations. In the view on the left, the person in the center appears to be striking a victim. However in the view on the right, the same person is seen to be running past the victim[1]. (redraw-K) (check permission)

Systematic Attacks on History

Swaying popular opinion by creating an alternative historical narrative. Changing the language to eliminate collective memories. In many cases, this is relatively easy because the institutions which provide evidence are relatively weak. Corrupting historical evidence for instance by creating inauthentic records.

Representations of History

Civic data sets (8.1.1).

Figure 5.64: Historicans workstation.

Mass digitization (10.1.6), massive amounts of data (9.6.0), and understanding history. Analysis of historical texts. Automated text analysis. History serious games.

Figure 5.65: Historical reenactors.

5.13.3. Social and Personal Memory

Cultural memory institutions (5.9.3). History (5.13.0). Biography, Biopic, Autobiography. Theory of biography. Digital lives (10.3.1). Expectations (4.4.3). Archival appraisal (7.5.3) and forensics. Personal information management (4.11.0).

Figure 5.66: Personal letter. (check permission)

Eye-witness testimony in a trial may sometimes be doubted, especially if it is based on leading questions or other concept map-like preparations. There are many errors in convictions for serious crimes based on eyewitness testimony. Many types of memory biases (4.3.2).

We can find similar efforts in eye-witness testimony [6]. This is also sometimes called "gist memory" since the person tends to remember the main points – the gist – but not the details. The inaccuracy and susceptibility of human memory can create biases in eyewitness testimony. People recall of events was able to be manipulated [70] to create false memories. Certainty is based on many factors. Face recognition.

Exercises

Short Definitions:

Action research
Assessment
Attribution
Co-browsing
Cooperation
Constructivist learning
Coordination
Culture
Distributed cognition
Division of labor
Domain model
Early adopter
Information literacy
Intelligent tutoring systems (ITS)
Instructional system design
Knowledge skill
Learning community
Learning management system
Learning object
Learning outcome
Manipulative
Media literacy
Media space
Meta-cognition
Norm
Pedagogy
Phonics
Plagiarism
Professional development(teachers)
Recommender system
Reputation
Role (group)
Scaffolding (learning)
Shadow function
Social brain
Social capital
Social contract
Social network analysis
Social presence
Sociability
Structuration
Student model
Task group

Review Questions:

1. Develop a simple fraud detection model you might apply to credit card purchase data. (5.3.4)

2. Describe some of the examples of social learning. How is it similar to or different from other types of learning? (5.5.4)
3. What are the different types of systematic information flow through an organization? (5.7.0)
4. Describe examples of three types of communities. Explain how they meet the definition of communities. (5.8.2)
5. How might information systems decrease the sense of community? How might information systems increase the sense of community? (5.8.2)
6. Identify the level of knowledge skills required for: (a) Determining that a car is broken, (b) Explaining to a mechanic what is wrong, and (c) Fixing the car. (5.11.4)

Short-Essays and Hand-Worked Problems:

1. Explain how online tools could support the development of social capital. (5.2.1)
2. Why do you trust your bank to take good care of your money? (5.2.1, 8.7.3)
3. What is the likely target value for user 4 in the table? Justify your answer. (5.5.5).

		Video						
		1	**2**	**3**	**4**	**5**	**6**	**Target**
User	**1**	4	8	2	7	1	9	2
	2	3	0	9	2	3	8	1
	3	2	8	7	9	3	1	7
	4	2	6	1	9	4	7	?

4. Listen to a meeting and characterize the types of social interaction that takes place. How might that social interaction be modified with additional information systems? (5.6.3)
5. Observe a meeting and, if possible, videotape it. Describe how you would annotate the events in the meeting to make it accessible for use later. (5.6.3)
6. What are some of the barriers to communications for organizational components in remote locations? (5.6.6)
7. What are some of the difficulties of virtual organizations compared to organizations in which there is face-to-face interaction among the participants. (5.7.1, 5.7.3)
8. How does information technology amplify the division of labor? (5.7.2)
9. Briefly describe an electronic community to which you belong. If you do not belong to any electronic communities, describe one you have heard about. Why you do you consider it an electronic community? In what way could the community interaction be strengthened? (5.8.2)
10. Give examples of the way a community is defined by language. (5.8.2)
11. A community creates coherence among its members but such coherence in an organization can result in silos. Do communities develop silos? (5.8.2, 7.3.6)
12. Describe the design for an electronic book interface which would support reflective thinking. (5.11.2)
13. What is the difficulty of building student models for activities such as writing an essay? (5.11.3)
14. Propose how you might develop a curriculum for a high-school information science class. (5.11.3)
15. Describe how the hierarchy of knowledge skills (Fig. 5.49) would be applied by a student learning about (a) chemistry, (b) history. (5.11.4)
16. Describe some ways in which non-traditional information systems could be used by students in pre-schools and kindergartens to improve learning. (4.9.2, 5.11.5)
17. At one extreme, libraries may be seen as passive repositories where people can search for information. At the other extreme, education attempts to be proactive and give people an understanding of basic principles before the students need them. In the future, will libraries and educational computing completely merge? Explain. (4.10.2, 5.11.5)
18. What education model do you think is best used to teach science education. (5.11.5)
19. Describe the online materials you should collect for a digital library designed for fifth graders. (5.11.5, 7.1.2)
20. Compared to Eq. 5.2, what cause would you infer for each of the following *incorrect* answers? What are some possible alternate explanations? (5.11.7)

$$\frac{1}{2}+\frac{1}{2} = \frac{2}{4} \tag{5.5}$$

$$\frac{1}{2}+\frac{1}{4}=\frac{2}{6} = \frac{1}{3} \tag{5.6}$$

$$\frac{1}{2}+\frac{1}{2} = \frac{1}{17} \tag{5.7}$$

21. Project what you think the mix of technology will be in the classroom in 20 years. Will there be classrooms? (5.11.7)

22. How might you teach students to evaluate the accuracy and truthfulness of information resources? (5.12.0)

Practicum:

1. Evaluate the information needs of an organization. Describe the ways that organization deals with these information needs. (5.7.0)

Going Beyond:

1. Is there always wisdom of crowds? (5.0.0)
2. We have emphasized the synergy of social forces but other sociological theories focus on "power" and "class". What are the advantages and disadvantages of employing those notions. (5.0.0)
3. Do television and Internet access provide the same level of social isolation? (5.1.1)
4. How might we quantify social capital is there in an organization? (5.2.1, 5.5.5)
5. How does information technology affect the optimal structure for task groups? (5.6.1)
6. Give some examples of how family life was or will be changed because of information technology.
7. Create a taxonomy of types of organizations. (2.2.2, 5.7.0)
8. Describe information flow in an organization with which you are familiar. (5.7.0)
9. What is the relationship between culture and technology? How easy is it for technology to change culture? (5.8.2)
10. Does a complex industrial society have culture? (5.8.2)
11. Describe the information systems available to members of your community in public schools, in libraries, and in community centers, such as the YMCA. (5.8.2)
12. How important is access to information to reduce poverty? What are some specific steps that you feel could be effective? (5.8.2)
13. List some ideas of how to encourage people to participate online communities. (5.8.2)
14. Give examples and discuss best practices for each dimension of S.O.A.P. (5.11.0)
15. What is the role of entertainment in education? (1.6.1, 5.11.0)
16. It is possible to synthesize both cognitive and social perspectives on education into a framework? (5.11.2)
17. How important is the acquisition of facts for students versus learning analytical skills? (5.11.2)
18. Compare the similarities of use-case analysis and instructional system design? (3.10.2, 5.11.3)
19. How should cognitive processing models impact to instructional system design? (4.3.0, 5.11.3)
20. Develop a model of the rules students need to learn to do fractions problems. (5.11.3)
21. What kind of knowledge does a multiple-choice question test evaluate as compared to an open-ended question test? (5.11.3)
22. Explain how an adaptive testing program would be implemented. (5.11.3)
23. Collect a tutoring dialog. Annotate the dialog with notes about the state of understanding of the student and the strategies of the tutor. (5.11.3)
24. How can a tutor increase student engagement in a dialog? (4.2.2, 4.6.0, 5.11.4)
25. Develop a lesson plan for (a) a fifth grade science teacher and (b) a tenth grade history teacher using digital resources. (5.11.5)
26. In what sense are public schools learning communities? How could the community aspects be enhanced? (5.11.7)
27. How important is face-to-face interaction for education? (5.11.7, 6.1.2)
28. To what extent should an information science course teach values about the use of information? (5.12.3)
29. Do you agree with the statement: "The winner writes history"? (5.13.0)

Teaching Notes

Objectives and Skills: Group dynamics, Instructional system design.

Instructor Strategies: This chapter introduces fundamental principles of social processes. It then combines these social approaches with cognitive issues for education. The two main sections, social issues and education, could be considered separately.

Related Books

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- National Research Council. *How People Learn: Brain, Mind, Experience, and School.* National Academy Press, Washington DC, 1999.
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Chapter 6.
Language and Communication

Figure 6.1: Example of American Sign Language for the word "cat" (left). The fingers are drawn away from the upper lip in a way that suggests stroking the whiskers of a cat. Finger spelling for "cat" (right). (check permission)

Formally, languages are systems for creating especially complex and novel representations. Functionally, natural languages facilitate human communication and social interaction (6.5.1) are those in which meanings can be specified unambiguously.

6.1. Natural Language

Natural language is much more ambiguous than formal languages such as computer programming languages. Context and metaphor can completely alter the semantics of a natural language sentence. Indeed, there is ambiguity at many levels. It is unclear in the sentence "The woman saw the man with the binoculars," exactly who has the binoculars. The context in which these sentences are spoken or used help us to understand these cases. Even when the syntax of a sentence is very simple, the semantics of language may be subtle. Consider the use of metaphor in the sentence "The old man drank in the scenery"; people must possess a very nuanced understanding of language to understand usage such as this. Unlike a formal language, where usage rules are delimited at the outset, natural language is a social artifact (6.4.0); it is active and dynamic. Words can change their meaning over time as prior uses become outdated, and different structures and styles are dropped or adopted. Understanding natural language has as much to do with context, as with learning or memorizing usage rules. Some techniques of natural language processing are described in (10.4.0).

Natural language processing is a frontier of information science. Thus far, only limited progress has been made in creating computers that understand and can interpret natural language. Obviously, the ability to communicate with computers in this way would offer great benefits. However, natural language is used in various forms including text (10.1.0), visual language (11.2.4), and speech (11.3.3), and each modality has its own idiosyncrasies. We will examine topics concerning natural language and its components. Later, we will look at techniques for processing natural language (10.4.0).

Language allows the communication of complex ideas. Utilizing language is a means of interaction. Language games[63]. This should be compared to the mathematical definition of languages.

Symbolic representations versus distributed representations. As we have seen, human language is often a tool for persuasion and it is heavily context dependent.

6.1.1. Characteristics of Natural Language

Not only is natural language ambiguous, it is also often highly redundant. This helps to ensure the transmission of the message, and makes language robust in the face of distortion, such as with accented speakers or noisy environments. It is often easy to guess a missing or garbled word. That is, the semantics are intertwined with context. Coherence of meaning.

6.1.2. Varieties of Natural Language

Human language is amazingly diverse. Beyond the obvious differences between langauges there are differences within languages in jargon and culture The differences among languages create a huge human cost through blocked communication. Not only are there different languages but even for a given language the are great differences across speakers. Even for a individual speaker, there are differences across social settings.

Human Languages

Differences among Natural Languages There are more than 3000 human languages. Human languages differ from each other in many ways: structures, semantics, alphabets (10.1.1), word segmentation (10.1.5), and word sense (6.2.3); for example. This is apparent in areas related to sensory perception, such as the definition of colors. In Russian, for instance, there is no single word for "blue"; it is necessary to define that color in terms of its being either light blue (*goluboy*) or dark blue (*siniy*). As another example, the English word "fly" exists in approximately 40 different senses when translated into in German in addition to its multiple meanings in English.

Languages also vary in structure. Languages vary in "case order". Grammars versus inflection. The structure of words and of phrases also differ across languages. Typically, English is Subject-Verb-Object (SVO) – John went home. Other languages are different. Object-Subject-Verb (OSV) – Home Yoda went.

Evolution of languages.

There can also substantial differences within what is widely considered to be a single language. Of course there many variants of English and even regional differences with the U.S. (Fig. 6.2) [**?**]. Indeed, there are strong regional differences in language in Tweets. Geographic topic models.

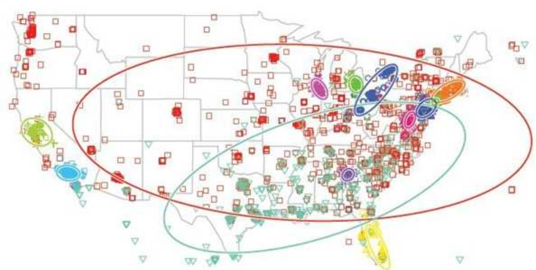


Figure 6.2: Regional differences in Tweets[3]. (check permission).

Cultural Differences and Language While they may seem separate, a people's culture and language are related to one another in complex ways. Culture is inextricably intertwined with language; this important intersection is studied extensively in "sociolinguistics" (6.4.4). Language helps to define and even perpetuate cultural differnces. Linguo-cultural differences may be so pronounced that translation from one language to another is essentially impossible without extensive explanation (6.1.2). For example, many Polynesian cultures have a fundamental different approach to directions than in Western societies. In Japan and Korea, great care must be taken to use the proper honorifics in conversation to express respect for the person with whom one is speaking. Use of language by gender. Use of by young people.

Evolution of Natural Languages Cognitive factors and cultural factors such as assimilation.

Speakers of a language tend to prefer simple statements and expressions. Language adapts to complexity. The "principle of least effort" suggests that common expressions tend to be shortened over time [65]. For instance, nicknames are usually much shorter than full names. This is another example of individuals managing cognitive effort (4.3.3)

Semantic drift as changes in the meanings of words.

Endangered languages (Fig. 6.4).

Modalities of Natural Language

Natural language also crosses sensory modalities. It includes written text, speech (11.3.3) or verbal

Figure 6.3: Spread of human language.

Figure 6.4: Ishi, The last Yahi Indian and the last native speaker of the Yahi language. (check permission)

communication, and sign language. Moreover, face-to-face communication usually includes gestures (11.4.1) and references to objects in the environment, which are, technically speaking, not part of the language itself, but are nonetheless well understood. Sign language, though seemingly limited, possesses all the subtleties of spoken language. In fact, there are two common forms of sign language: one in which concepts are represented with gestures, and the other in which words are spelled out. Fig. 6.1 shows examples of each: a sign-language gesture (left) and finger spelling (right). Continuum of increasingly complex gestures (11.4.1) and, finally, sign language. Sign language grammars.

6.1.3. Human Cognition and Language

Natural language is a human process and is susceptible to the biases of cognitive processing. Relationship of natural language and cognition. Natural language is integral to being human. Categories and lexical differences [**?**]. Interplay between language cognition. Categories and lexical semantics. Reading and writing (10.2.0). Human language processing picks first relevant match it finds [**?**]. Brain science, brain development, and language (-A.12.2). Reading (10.2.0) and writing (sec:writing).

Linguistic relativity (6.4.4). Concept maps (4.4.1) and semantic fields. This implements the notion of compositionality which is a combination of concepts which goes beyond the meaning of the individual components.

How do people learn and produce natural language? Is it simply a function of learning the rules and vocabulary? There is some evidence that language acquisition is rule-based in this way [46]. One supporting example is the over-application of a rule in language use: a child might say *I go-ed to the store* rather than *I went to the store*. Presumably, the child has acquired the rule of adding "-ed" for creating past tense, but has not acquired an understanding of irregular verbs. Cognition (4.3.0). Moreover, the ability of the human brain to develop new representations seems to change across growth Fig. 6.5. The effort to find a universal grammar has largely failed. Language chunking.

Translation. Bilingualism.

Lingua Franca

Common language with pidgin dialects.

Quasi-Natural Constructed Languages

Esperanto.

Figure 6.5: Photos of a child at several points in the first years of life.

Relationship to concept development. Some speculate that humans have a fundamental capability for language. That is, our brains have evolved to produce linguistic ability, and that there are "linguistic universals" common to all people. One of these linguistic universals was a hypothetical "universal grammar," This universal grammar theoretically provides a general template for the acquisition of language, particularly grammar. The particular syntax of any given natural language fits on top of this larger, innate schema. Anecdotal evidence for the innate propensity for language in humans is that it is easier for a child to learn a language than it is for a child to learn to play the piano. Computational language learning entirely from samples of language would provide counter-evidence.

Role of imitation in language learning (5.5.4).

Children learn language remarkably quickly. LSA and Plato's paradox for vocabulary learning[35].

6.2. The Structure of Natural Language

Natural language is highly structured. As we shall see, there are several approaches to describing this structure but by far the most common proposes that there are several levels: Lexicon, Syntax, Semantics, and Pragmatics.

6.2.1. Words: The Natural Language Lexicon

Exactly what constitutes a word is open to debate. The *Oxford English Dictionary* contains approximately 290,000 word entries, but over 615,000 word senses. Should compound words be considered two words, or one? Most estimates put the total number of English words at over 1 million if technical terms are considered. Apart from that, as we will see, specific words are themselves no simple matter. How words are created, how we define them, and how we use them are all questions that we will consider in this section, though it must be noted that answers to these questions may be elusive. One interpretation is that word senses may be implemented as frames as suggested in the FrameNet project (6.2.3).

Stems, morphemes, words. Words are composed of different parts, and those parts, when combined, are what indicate the meaning of the word. "Morphology" is the word structure and the most basic elements of words are called "morphemes". Generally, there are considered to be three morphemes: roots, prefixes, and suffixes. These are the central or main portion of the word, letter combination placed before the root, and letter combination placed after the root, respectively.

Morphology helps to trace the origins of a word or language. Because many words may originate from the same root, finding and identifying the history of that root form facilitates the understanding derivative words. The process of identifying a root is known as "morphological analysis". Whether in written or spoken speech. Lexical semantics (6.2.3).

6.2.2. Phrases, Clauses, and Sentences

Natural Language Syntax, Parts of Speech, and Grammars. Natural language incorporates many types of structure. Probably the most obvious structure is the syntax which is often modeling with grammars. Indeed, this has received the most attention.

Parts of Speech

In language, words are combined to form phrases and sentences. Generally, phrases are combination or groups of words that are functionally similar to individual parts of speech — they may identify an object (noun phrase) or an action (verb phrase), or describe an object (adjectival phrase) or an action (adverbial phrase).

Words are typically classified into groups based on the way they are used. This practice of identifying "parts of speech" (e.g., nouns, verbs, etc.) was probably a familiar assignment in grammar school. These parts of speech match grammatical structures. Indeed, we can call them "grammatical categories". Adjectives as modifiers. Predicates. Analytic versus systemic languages.

A sentence combines phrases into higher-level conceptual units; it organizes them into a whole unit that identifies or describe a concept. Through this process, symbols — words — are composed in ways that communicate information (1.1.3). As we have seen, words are complex — meanings and uses vary with time, geography, and context. Designing and information system to understand words and how they are used is a long-term process. Phrases and sentences, however, provide another way of accomplishing this task. Collocations and co-occurrences are statistical measures of what words appear together when communicating certain concepts. In this way, it may be possible to chart the semantics of a particular grouping of words, instead of the semantics of individual words.

Grammars as Models for Natural Language Syntax

Grammars are a logical formalism which describe the sequence in a string, especially in a string of words which form a sentence. We will examine the way grammars are used in constructing formal languages at the end of this chapter (6.5.1). But, of course, grammars are also associated with natural human language. Formal models versus probabilistic models.

While grammars provide an effective formalism, there is a lot of debate about the psychological validity of grammars. One view holds that the grammar of a natural language is based on fixed rules, which maintain its structure and consistency across time. Any deviation from those rules results in an incorrect usage, in a technical sense — the misuse of language for literary or poetic effect is quite common — though it is still, technically, incorrect. The opposing view holds that, in a sense, language is the medium of the people, and its rules are determined by those who use it. In this view, there are general part-of-speech categories that describe how words function within a sentence, but these cannot be conclusively assigned to every word. These are applied to natural language in describing the structure of parts of speech. Phrase-structure grammars. Fig. 6.7. Such a relatively simple grammar can be modeled with a state machine. Indeed, a state machine can be applied as a parser (-A.5.4).

Rewrite Rules		**Description**
LHS	**RHS**	
S	NP + VP	Sentences (S) are composed of Noun Phrases (NP) and Verb Phrases (VP)
NP	N, D + N	Noun Phrases (NP) can be composed of a Noun (N) or a Determiner (D) (i.e., 'the') and a Noun (N)
VP	V, V + NP	Verb Phrases (VP) can be composed of a Verb (V) or a Verb and a Verb Phrase (VP)

Figure 6.6: Fragment of a phrase-structure grammar. These are recursively expanded as in parse tree shown below.

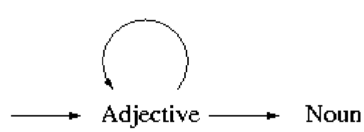


Figure 6.7: Grammars are closely related to state machines. Here a recursive state machine link shows that one or more adjectives can be repeated before a noun.

String grammars (6.5.2) such as the ones we have been describing thus far often describe the structure of natural language statements. A "constituent grammar" is one that can be understood by breaking

Grammatical Categories	Lexicon
D Determiner	the
N Noun	dog, boy
V Verb	bit

Figure 6.8: Here is a simple lexicon for the example grammar; any real lexicon and grammar would have many more parts.

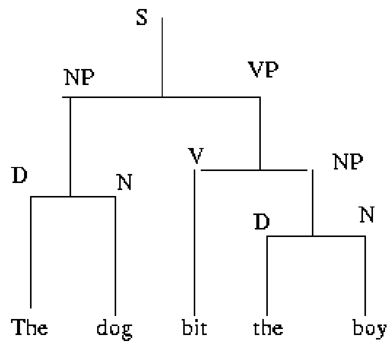


Figure 6.9: Parse tree for "The dog bit the boy". (check permissions)

it down into its constituent parts. The traditional grammar that is taught in most grade schools is an example of a constituent grammar; more specifically, it is a "phrase-structure grammar". In this framework, a sentence (or an entire grammar) can be seen as being composed of ever more discreet units, such as noun phrases and verb phrases at the phrase level, and nouns, verbs, adjectives, etc. at the word level. Simple grammars such as those which approximate state machine are easy to develop but natural language is so complex that they do not handle all cases.

Constituent grammars are generative models of languages; that is, they provide a framework for describing how language could be generated. Natural language grammars are a type of knowledge representation for subjects and predicates. To a large extent, natural languages are well modeled by context-free formal languages.

Grammars and Language Production Grammars and Language Production. Psycholinguistics. From deep structure to surface structure, for instance, there are regular patterns for making a question from a statement. These patterns can be described with "transformational grammars" (Fig. 6.10). This is the basis for the deep structure.

Declarative	Interrogative (Question)
Today is Friday.	Is today Friday?
Jill went to the store.	Did Jill go to the store?

Figure 6.10: Questions are created from declarative sentences with a regular pattern. This change of structure can be accomplished with a "transformation grammar".

Wh-questions and question answering.

Beyond Phrase Structure Grammars Natural language is subtle and there are many aspects of natural language which are not well captured by simple grammars. These include: Agreement and tense as aspect. Language coordination. Stochastic grammars.

6.2.3. Natural Language Semantics

By comparison to formal languages, natural language is ambiguous. One of the hallmarks of natural language is its redundancy. Although the following two sentences have different vocabulary structure, they have approximately the same meaning. Semantics, in this sense, can often be paraphrased — the same ideas can be expressed in several different ways. Words as distinct lexical units (6.2.3).

The pedestrian was struck by the automobile.
The car hit the person who was walking.

Semantics is the literal definition as derived from the dictionary. rather than the subjective meaning. Rather, subjective meaning is covered as pragmatics (6.3.1).

Lexicography. Semantic analysis of words.

The semantics of natural language differs from formal semantics (6.5.2). The semantics of formal language are specific, and can be defined within that formal system; however, the semantics of natural language are not specific, and may depend on the listener. Meaning can be subjective — ultimately, understanding natural language communication is an act of interpretation on the part of the listener (or reader).

Semantics may be defined by an absolute standard, such as dictionary definitions, but it may also be defined by use.

Lexical Semantics and Definitions

We start with "lexical semantics" which focuses on the meaning of words. In natural languages, as opposed to formal languages. This builds on several issues we have already discussed such as categorization (2.1.1) and semantic networks. there is generally much redundancy at the word level; many words can mean the same thing. This highlights the fact that words themselves (what they sound or look like) are only indirectly related to the concepts they represent. Generally, meaning is not inherent to the word or sound of the word itself, with the obvious exception of onomatopoeic words such as "hiss," or "bang". Meaning is attached to words in an abstract way. Another model for the relationship among words describe the relationships among the words as semantic fields. Semantic relationships (2.1.4).

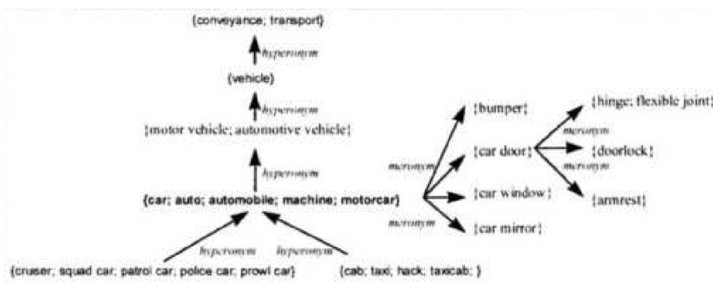


Figure 6.11: Wordnet. (redraw)

Words as signs in the semiotics sense (1.1.4).

Word spaces and search engines.

Definitions

Definitions as declarations versus definitions as reporting actual usage. Ideally, a language would identify each concept with a different word or word sense. A "word sense" is a particular formation or meaning of a word; "fly" vs. "flying," for example, or the different definitions of the word "bank". Following Aristotle, definitions should be based on determining underlying concepts and their attributes. This often works well, but as we noted in (2.1.1) there are other approaches to describing entities than Aristotle's. A single word, however, may be used to describe several different concepts; *Webster's New Collegiate Dictionary* lists 63 different senses for the word "set." Some words even completely change their meaning through time, and in some cases, both senses may continue to be used: "sanction" can mean both to approve and to disapprove. Clearly, it can be difficult to pin down word senses. Indeed, definitions also reflect social usage. Fig. 6.12 contrasts definitions of "music" from two dictionaries. Word senses are often domain specific. Differences of definitions and discourse communities. Moreover, word definitions and usage are fluid. Frames as capturing word senses (6.2.3).

music	
1.	The art of arranging sounds in time so as to produce a continuous, unified, and evocative composition, as through melody, harmony, rhythm, and timbre.
2.	Vocal or instrumental sounds possessing a degree of melody, harmony, and rhythm.
3.a.	A musical composition.
b.	The written or printed score for such a composition.
c.	Such scores considered as a group: We keep our music in a stack near the piano.
4.	A musical accompaniment.
5.	A particular category or kind of music.
6.	An aesthetically pleasing or harmonious sound or combination of sounds: the music of the wind.

music	
1a:	the science or art of incorporating intelligible combinations of tones into a composition having structure and continuity
b:	vocal or instrumental sounds having rhythm, melody, or harmony
2:	an agreeable sound: EUPHONY
3:	punishment for a misdeed
4:	a musical accompaniment
5:	a musical ensemble
6:	the score of a musical composition set down on paper.

Figure 6.12: Entries for "music" from two dictionaries: (upper[1]) and (lower[6]). Why aren't the word definitions and senses exactly the same?

The subtleties of word distinctions suggest the difficulties of creating hierarchical lexical categories such as those in (2.1.2). Organizing natural language for the purposes of computer interaction is further complicated by the evolution of language. Language is not static (Fig. 6.13); the changes in words over time is a problem for controlled vocabularies (2.5.3) such as those used in natural language processing systems.

Language games.

The word *suede* originates in the phrase *Suede gloves*, from the French phrase *gants de Suede*, literally "gloves from Sweden".

Figure 6.13: The meaning of words often evolve from other terms. The word "suede" comes from "Sweden"[21].

We have already seen several techniques for representing semantics such as ontologies (2.2.2). An ontology be used to create a working vocabulary and then build outward, with each new term or usage being labeled to fit into the overall categorization. This is similar to a semantic network in that the meaning of any word is determined by its position relative to other words, but ontologies are usually more limited, seeking to allow communication and understanding based on a predetermined, context-independent vocabulary. Ontology extraction (10.5.3).

Verbs Verbs link nouns or noun phrases together much the way relationships in ER models link entities. Verb hierarchies establish conceptual dependency between different words (frames). Verb forms and tenses enrich and coordinate conceptual dependencies with ontologies (2.2.2). However, such approaches are often difficult to apply because of the ambiguity of context. Verb type affects syntactic structure (e.g.,[37]). Tense-aspect-mood.

Semantic network (Fig. 6.14).

Denotation and Connotation We may distinguish between "denotation," which is the exact dictionary definition of a word or term, and "connotation," which is the informal meaning it carries. Prescriptive and descriptive definitions.

The discrepancy between literal and intended meaning is often expressed through the use of literary

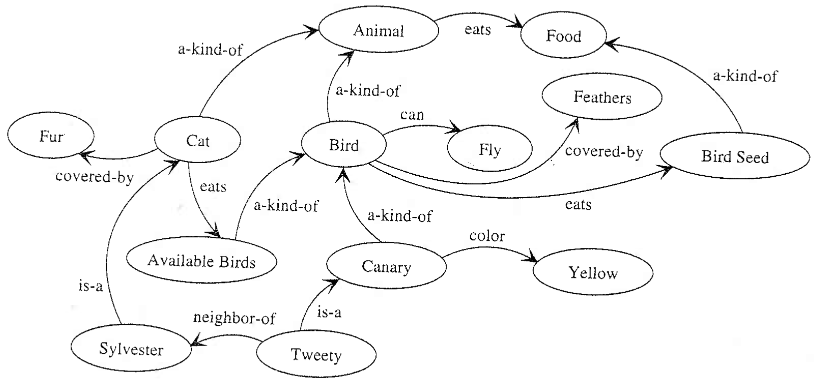


Figure 6.14: Semantic network. (redraw)

devices, such as metaphors. This is when a word or phrase is used to describe something when that word or phrase literally means something else. Metaphors are not meant to be taken literally but to set up a comparison between two things for the purpose of expressing an abstract concept.

Evolving Word Senses and Definitions

The human environment changes. Natural language needs to be malleable. "Ruthless," means to actually be without "ruth," which was a common Middle English word for pity or compassion. That word slowly lost favor and fell out of use; however, "ruthless" remains common today. Languages interact with one another to form new languages, and new words and word senses are constantly coming into being. Some words are introduced from other languages, and are termed cognates; an example would be the word "menu," which was adopted in English from French, where the word means the same. Other words are created. These are termed "neologisms," and frequently arise due to technological or social change. The word "spam" is a good example of a neologism; originally coined as a brand name for a type of canned meat, it now exists as a word in its own right, meaning unsolicited email. The need for a word to describe unsolicited email (or even "email," for that matter) simply did not exist until the 1990s.

Words which have evolved to have multiple meanings are said to have "polysemy," or to be "polysemous". A "chair," which is a piece of furniture, preceded the concept of a "chair" as a person who leads a meeting. The meanings of polysemous words are generally related to one another through abstraction and derivation.

Representing Natural Language Semantics

The meaning is not reflected by parts of speech. Rather, the meaning is defined by the combination of entities. Indeed, a whole other model for representing word meaning is based on words distributed in a space (10.9.2). Using frames of various sorts. Related actions and descriptions.

From knowledge representation to knowledge representation languages. Only symbolic representations are considered con in this section. Semantic representations have several useful applications such as summarization and machine translation. A detailed semantic analysis can provide an interlingua (6.2.3). A semantic representation that is language-neutral and can be useful in translation between two or more languages (Fig. 6.15) (10.13.1). Formal knowledge representation languages often employ ontologies (2.2.2). More complex reasoning and logic (-A.7.0). Encapsulating contexts.

[$_{Event}$ GO$_{Ident}$([$_{Thing}$SNOWMAN],
[$_{Path}$TO$_{Ident}$
($_{Position}$AT$_{Ident}$([$_{Thing}$SNOWMAN],[$_{Thing}$PUDDLE],)])],
[BY <MELT>])]

Figure 6.15: Possible semantic representation for the sentence "The snowman melted into a puddle"[20].

Case and Semantic Frames Semantic relationships have been important throughout this discussion. Frames are templates of related attributes (6.2.3). Frames can be constructed around verbs. A frame is a group of schemas, or generalized descriptions of an action or event, that form a consistent unit (Fig. 6.16). Frames are used as a means to anchor the potential meaning of language. They provide a context within which to interpret the relationships and can be useful in information extraction (10.5.0). Extends verbs. This is a type of semantic role (2.1.4). Thematic roles.

> An Agent performs a Response_action on a Victim as a punishment for an earlier action, the Injury, that was inflicted on an Injured_party. The Agent need not be identical to the Injured_party but needs to consider the prior action of the Victim a wrong. Importantly, the punishment of the Victim by the Agent is seen as justified by individual or group opinion rather than by law.

Figure 6.16: Frame for the concept of "revenge"[15]. Note the expected Frame Elements: Injury, Agent, Victim, and Response.

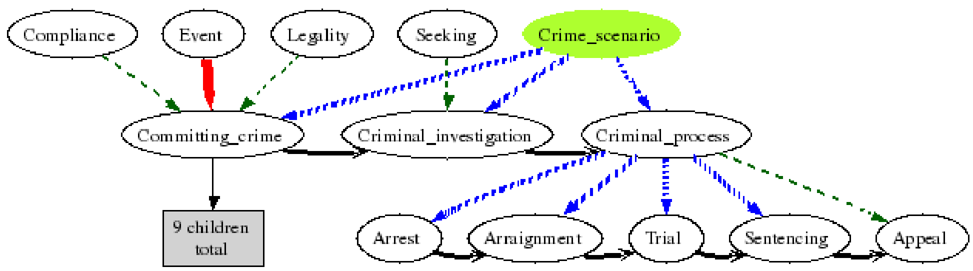


Figure 6.17: FrameNet composite frame for a crime scene. Several frames are joined to create an overall scenario. (redraw) (check permission)

Propositions and Semantic Grammars The roles the words play in creating the meaning of the sentence. This may be related to parts of speech but is not necessarily the same. What is "case"? SVO[23]. Sometimes semantic networks will employ "case frames" to help determine context. Case frames are assumptions about common word meaning when used in particular contexts. These seek to disambiguate different possible word meanings by identifying common semantic relationships between words in a given usage. Case grammars are used to facilitate this process. Because the semantics of a particular contextually situated sentence or phrase are often determined by the syntactical relationship between, primarily, the noun and verb phrases, this syntactical relationship can help to determine the semantics of a sentence. Word senses depend largely on context.

Semantic Cohesion

Reasoning about semantic properties helps people understand how statements hold together. The meaning is ultimately defined by a person hearing or reading the language. The relationship of the components is the semantic cohesion. Semantic cohesion develops from an understanding of the relationship among concepts (Fig. 6.18). This cohesion is based on our knowledge of what would be logical in a given context. Attention management in language and conversation.

> Margie was holding tightly to the string of her beautiful new balloon. Suddenly a gust of wind caught it. The wind carried it into a tree. The balloon hit a branch and burst. Margie cried and cried.

> Margie cried and cried. The balloon hit a branch and burst. The wind carried it into a tree. Suddenly a gust of wind caught it. Margie was holding tightly to the string of her beautiful new balloon.

Figure 6.18: The first story is more satisfying because it has semantic coherence and follows our expectations for the logical development of events. (redirect)

Semantic cohesion includes reference which refers to timing, sequence, or indicate cause and effect.

"Anaphora" is the technique of using a word (often a pronoun) to refer to something described earlier. Similarly, a metaphor has a scope of applicability.

These referents are generally based on the unique characteristics of the human experience in the physical world; notions of time, location, mass, movement, and causality are so intuitively used by humans that day-to-day language allows short cuts. This would be confusing to anything not indoctrinated into this system; consider this pronoun reference example, using anaphora: "The table hit the chair and it fell". Most listeners would expect that it was the chair that fell, as it is lighter than a table, but it is also possible to interpret the sentence as saying that the table fell.

This understanding of the physical referents of language help to socially mediate communication and construct a joint understanding of language. This can be termed "groundedness". In situations dealing with non-physical things, people use physical-world referents as metaphors to describe abstract concepts.

Cohesion in text is somewhat subjective. The writer's goal is the management of the listener's attention [29]. Consideration of higher-level units in the text leads us to the possibility of examining the structure of those intentions.

6.2.4. Semantics and Domain Structures

There are many niche applications of language and knowledge of these niches turns out to be crtical in dealing with them.

6.3. Language and Interaction: "Doing things with Language"

Semantics focuses on the literal definitions of terms but natural language goes well beyond the literal meanings. Function rather than structure. Natural language use is very context dependent. This can be viewed as layered interaction which can go beyond natural language. Relationship between language and action and behavior. Semantics and Wikipedia [**?**]. Linking instances with semantics.

6.3.1. Pragmatics

Pragmatics considers the effects of the social context on the meaning of statements. Thus,y it is essential for communication because the social context and cultural assumptions are often significant factors in determining meaning. Context can often clarify ambiguity.

referential	conveys information about some real phenomenon
expressive	describe feelings of the speaker
conative (instrumental)	attempts to elicit some behavior from the addressee
phatic	builds a relationship between both parties in a conversation
metalingual	self-reference
poetic	focuses on the text independent of reference

Figure 6.19: One taxonomy of pragmatic categories[31].

There are many types of context, such as the context of the communication task being performed, the expected audience, and knowledge that is implicit or shared between the communicators, which may be manifested as assumptions, social conventions or expectations. A sentence may have a literal meaning in one context and an entirely different meaning in another context.

Signs. Semiotics. Indexical signs.

Layers of interaction in education (5.11.4). Communicative practice.

Grounded natural language processing. Reference (Fig. 6.20). Artifacts in computer-mediated communication (5.6.5).

Most conversation has a topical focus that lends it coherence. This focus contributes to attention management[29].

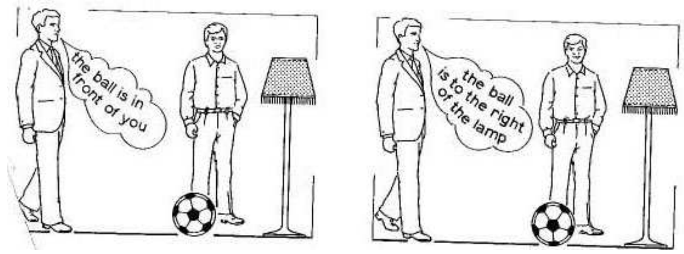


Figure 6.20: Conversations include reference to the physical world. (redraw)(check permission)

Emphasis on the social aspects of language suggests that a focus on social interaction leads readily to a functional analysis of language rather than to a structuralist approach. That is, the focus is on the effect of the language rather than the syntax. Languages have large cultural and political implications. Moreover, language is highly dependent on the task or domain to which is applied. Recognizing the task can help the language understanding.

The context, tone, or history of the speaker may be used to modify the literal meaning of words (11.3.3). Statements such as "It's cold in here" may be intended as a request to close a window. One distinction is between statements that commit a speaker and those that are intended to change the state of the listener (perlocutionary acts).

Speech Acts

We can also try to understand how people "do things" with language[13]. Performatives. Thus, the focus is not on the structure of the language but the functionality. These are speech acts (Fig. 6.21). The approach is based on a model of intentional action.

Earlier, we mapped a negotiation by the transactions and commitments that were made rather than the ways those were expressed (3.4.4). Tutoring dialog may be characterized by speech acts which emphasize the educational purpose behind each statement (5.11.3)(Fig. 6.22). This is for the ideal situation which does not include persuasive speech or gamesmanship. (illocutionary acts)

Speech Act	**Explanation**	**Example**
Assertives	To instill a belief	Today is Tuesday. Not Wednesday.
Directive	To get the addressee to do something	Put it over there.
Commissives	To commit to something	I'll fix it after dinner.
Expressives	To express a feeling to somebody	I'm so excited, I could burst!
Declarations	To state a position	I'm in favor of building it!

Figure 6.21: One system speech acts (adapted from[53]).

Speech Acts	**Example**
Pump priming	Gives some basic data and examples from which a student could generalize.
Splicing	Suggests how to unify ideas that have been expressed separately.
Correct and amplify	Gives corrections and further information.

Figure 6.22: Some speech acts which have been proposed for tutoring dialogs[26].

Multi-sentence speech acts [**?**]. Macro-speech acts.

6.3.2. Discourse

The term discourse is yet another that is used in a number of different senses. It may refer to any sort of conversational exchange or to a stylized way of speaking or it many simply refer to units of the exchange.

Discourse in science (9.2.3). The author needs to provide context for the reader by managing coherence and attention.

Discourse fulfills social goals as a part of social action. For instance, discourse is essential for tutors (5.11.3). It also helps us better understand "gamesmanship" (5.3.3). However, discourse can often be subjective. To the extent it matches a group's perspectives, it may reflect political opinions.

Discourse as "how things are said". Discourse is often associated with constructing passages that accomplish certain purposes or tasks. Discourse is an interaction sequence which intends a transfer of information. Four types of discourse are commonly identified: Exposition, Description, Argumentation, and Narrative.

Discourse versus genres (6.3.7). Discourse macros. Academic discourse[30]. Moves in discourse shift focus from one level of understanding to the next[17]. Discourse helps disambiguation based on social factors. Discourse types of sentences: declarative, question, imperative, exclamatory.

One example of the style of presentation such as "hedging" – that is allowing for some possibility of error. Discourse management in tutoring and classroom (5.11.3).

Normative ethics[14].

Critical Discourse

How people use language to accomplish their goals. Attitude change. The way people present things when speaking may reveal cultural assumptions and logic. Either explicit or implicit. Passive voice.

Discourse Processes: Elements, Acts, and Moves

Affects processing, understanding, and memory.

Discourse also creates structure of meaning beyond the sentence level. The elements of a discourse are related to the structure of a task (3.5.4). In this sense, the given part of the discourse is based on a task model or user model. For some tasks, the components are clear and the accomplishment of those tasks can be clearly indicated. Discourse elements generally are not useful by themselves. Rather sets of them are needed to complete tasks. There are many ways of classifying discourse. Sets of discourse elements. Functional task analysis.

The transitions within a discourse are called "discourse moves". These are initiated with specific structures. This include discourse pairs such as Topic-Comment, Theme/rheme, and Given-new. It is common in communication to establish a "given" and then to use that as the basis for comparison with a change (Fig. 6.23). This forms the classic "given-new" pairing "Bill went to the store." tells us that somebody we know (Bill) changed to a new state. He went to the store. While given-new is very common, it is not very precise.

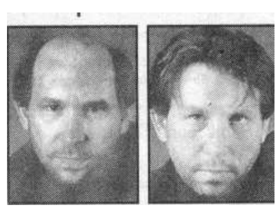


Figure 6.23: Before-after pictures are a form of the "given-new" principle. (new picture-K) (check permission)

Automatic Extraction of Discourse Structure. Generating models of what is going on in a discussion.

Discourse macros versus discourse plans.

Discourse Plans

Planning (3.7.2) is a part of a text generation system. Planning as a goal-oriented activity.

Statistical models for speech act detection. For instance, with HMMs.

Discourse and verbs (6.2.3). Verb semantics. Semantic cohesion versus discourse frameworks.

Many of these models are hierarchical. That is, they form discourse tree[47].

When discourse is part of a complex activity intended to have specific effect, it may need to be planned (3.7.2). Determining and filling constraints[41].

Discourse Processing and Comprehension There is a great deal of research about how people understand discourse. That is considered as part of the study of reading (10.2.0). Story understanding as being able to answer questions about a story.

6.3.3. Types of Discourse: Description, Exposition

Here, we use a relatively simple set: Description, Exposition, Explanation, Argumentation, and Narrative.

Scoping communicative acts is a fundamental activity. However, this can get quite complex. For instance, a narrative can be interwoven with an explanation. These can have implications for the design of effective texts. Generally qualitative (4.1.1).

Conveying factual information. Descriptions of information resources (2.4.3).

There are many styles of authoring. From speech generation to design. Language can be styled to express myriad meanings, from the simplest statement to high art. Poetry, for example, combines sounds and sense to give the reader an emotional, aesthetic experience. Other language devices include allusion, alliteration, and rhetoric.

Exposition lays out the facts of a case. High-level expository styles. Problem-solution. Cause-Effect. Analogy.

Expository content lays out an issue or presents a description of a process or situation. It can also illustrate causal relationships among concepts. Complex texts use elements that enhance their coherence, including time, entailment, implication, and causality.

6.3.4. Types of Discourse: Explanation

Explanations go beyond descriptions to provide context and causation. They describe a model. We have discussed many types of question answering systems in this text, answering those questions often results in providing explanations. An explanation helps a person comprehend a situation or event. Describing content to others. This should emphasize the use of mental models and is similar to tutoring and teaching (5.11.3). Build on the basic elements. We have already discussed many types of explanations such as those used in question answering and tutoring. Another type of super-structure is explanations. The goal is to convey a description of a process as clearly as possible.

There can be several approaches to explanations. Explanations based on theories and causation (4.4.2) and conceptual models (4.4.1). Scientific explanations (9.2.3). History explanations ((sec:historyexplanations)).

Wittgensten and language games.

Adding interactivity to explanation approaches a tutoring system (5.11.3).a Tutoring models with discourse-based explanations [**?**].

Two aspects: what is the explanatory model versus how best to present it.

Explanations and expert systems and case-based reasoning – explaining why a certain decision was reached. Explanations often include appeals to logic but also includes some background. Evaluating explanations[36]. Explanation includes an aspect of presentation of effective conceptual models. Explanations are typically either causes or sub-processes[48].

History attempts to describe and provide explanations for specific events. Fig. 6.24. Science (9.2.2) explanations for general cases.

Explanatory target

Why does a *patient* get *atherosclerosis* with associated symptoms such as chest pain?

Explanatory pattern

The *patient* has inherited various *genes* that encourage the development of risk factors such as hyperlipidemia, hypertension, and diabetes.

The *patient* is subject to various *environmental factors*, such as a high fat diet.

The *genes* and the *environmental factors* interact to produce the disease.

Figure 6.24: Atherosclerosis explanation schema[60].

Explanation is, of course, useful in education where it often in intertwined with the presentation of conceptual models, Models are essential for explanations. of expository writing[32]. Mathematical models such as those in DSS systems are known as influence diagrams. Explaining causes versus identifying actual causes. Explanations are often based on dubious constructs and poor logic. Schemas are similar to frames in providing templates for possible answers (Fig. 6.28).

Explanatory coherence[60].

6.3.5. Types of Discourse: Argumentation and Rhetoric

Arguments makes claims and support them with evidence. It's purpose is to persuade; however some of the argumentation systems we describe below simply lay out an argument. We find formal approaches to argumentation in law (8.5.4), history (5.13.0), and science (2.6.2).

The Structure of Arguments

Issue-based analysis lays out considerations in reaching a decision. It is a type of argumentation system. Claim-support-argument structure (Fig. 6.25)[18]. Argumentation and trustworthiness of information (5.2.3). Design rationale (3.8.7).

1) Jones would make a good president.
2) He has a lot of experience.
3) He's been on the city board for 10 years.
4) And he's very honest.
5) He refused bribes while on the force.

1) Jones would make a good president.
2) He has a lot of experience.
3) He's been on the board for 10 years.
4) And he's refused bribes.
5) So he's honest.

1) The city is a mess.
2) The parks are a mess.
3) The park benches are broken.
4) The grassy areas and parched.
5) Returning to the city problems, the highways are bad too.

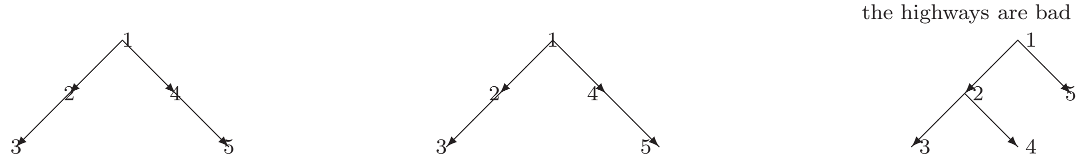


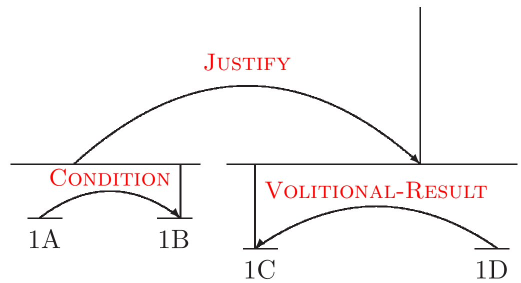
Figure 6.25: A variety of Claim-Support-Argument structures[18]. (different example)(check permission)

Claims and hedging.

Rhetoric and Rhetorical Structure

Rhetoric is sometimes defined as any sort of public speech and sometimes the goal may just be to present information clearly. In a stronger sense, sometimes rhetoric is "persuasive speech," or "effective discourse". One of Aristotle's most famous works was his "Rhetoric"[12] that attempts to instruct people how to be persuasive. For instance, Aristotle emphasized syllogism which is a simple logical device. Teaching effective (persuasive) writing and oratory. Rhetorical devices. Disputation and affect. Procedural rhetoric.

Rhetoric is how a position is presented. Rhetorical structure theory (RST)[40] is probably the best known approach for discourse tagging. Rhetorical Structure Theory (RST) is composed of discourse sets and relationships among them[40] (Fig. 6.26). Nucleus/Satellite. One block of text may "justify" or add "conditions" about another block of text. Genres (6.3.7).



[And if the truck driver's just don't want to stick to the speed limits,]^{1A} [noise and resentments are guaranteed.]^{1B} [It is therefore legitimate to ask for proper roads and speed checks.]^{1C} [And the city officials have signaled to support local citizens.]^{1D} (maz$_{5007e}$)

Figure 6.26: The rhetorical units in a discussion based on an analysis with RST. A specific set of Elements is proposed but also, proposes that thread which connects them follows a specific structure.

Focus on larger elements of the argument. One model's elements include: Claim, warrant, data, backing, rebuttal, qualifier (Fig. 6.27)[61].

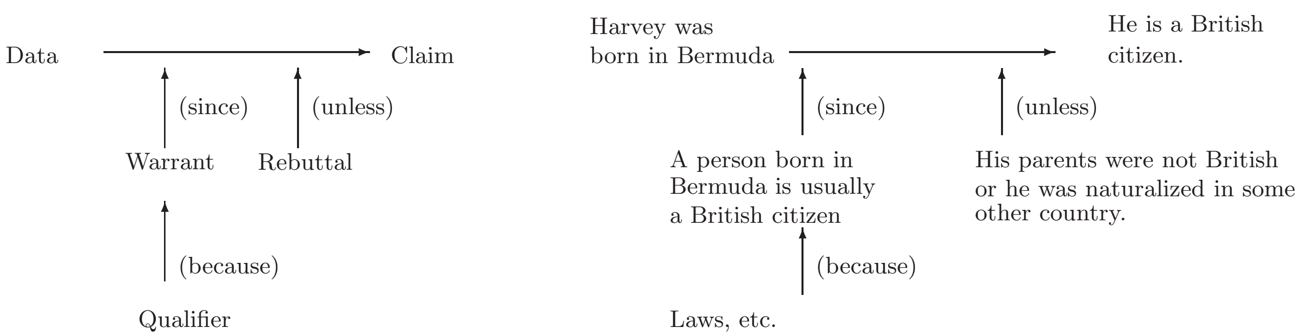


Figure 6.27: The reasoning of an argument can be illustrated graphically. A framework for the components of an argumentation (left) and an example (right) (adapted from[61]).

Science as argumentation (2.6.2). Actual arguments are often more complex than can be handled by Toulmin[42].

Varieties of argumentation systems. Representation of argument elements. Interfaces for browsing the arguments. Overview of most important themes and zoom in. Collabortive and community argumentation. Argumentation systems can be useful for claify arguments and for teaching argumentation.

6.3.6. Types of Discourse: Narrative

Narratives deal with a specific situation rather than general principles. Narratives typically do not emphasize logical explanations but usually emphasize human experience. Typically, a story states a problem or challenge describe how it is resolved. Stories include narrative, plot, and character. Narrative as a trajectory through a story space. Some games. Collaborative story telling. Narrative as revealing cultural gist.

From narrative to drama to cyber-drama. Drama provides a focused context around actions. Theater (11.5.0). Cyber-drama (11.5.3). More theory in (11.5.4). Structure of a story with drama. Character development. Building emotion, affect, and empathy. Yet, in current systems there are restrictions on the possible complexity of the narrative pathways.

The king died. Then the queen died.

The king died. Then the queen died of grief.

Ubiquity of Narratives

We have encountered stories repeatedly as a way that people create coherence of their world. Narratives are similar to explanations but they include additional features such as titles to support emotion and attention management. Having a story understanding the practical constraints can be effective for some management decision making. When there are several possible stories, find the story that is most consistent. There are many ways in which casual models affect perception. Stories and attribution (5.5.2). A strong sense of causality in memory. Episodic memory. Topic-organization content. Narratives and games. However, maintaining the coherence of the narrative in the interactivity can be challenging (4.4.3). Oral histories and cultural heritage.

1. The defendant was speeding and sleepy so the defendant caused the accident.
2. The defendant was speeding and sleepy but another person's car lost its brakes hit him.

Figure 6.28: A narrative based on a plausible causal chain (top) can be persuasive even another statement is more accurate.

Combining events into a larger conceptual whole. Multimedia programming and management of attention.

Narrative as a foundation for cognition (4.3.0). Inferring causation with narrative (6.3.6).

Narrative is the retelling of a sequence of events. Drama (11.5.4). Dimensions of drama from [16] are listed below:

Diachronicity describe the idea that there must be a sense of action taking place over time.
Hermeneutic composability refers to the idea that narratives can be interpreted as a story composed of events.
Canonicity and breach is the principle that stories require the breaking of a normal state of events.
Referentiality is the principle that a story somehow refers to real world states, though this may be tangential.
Genericness means that the story belongs to one or more families of story types.
Normativeness is the idea that narrative depicts norms of behavior.
Context sensitivity and *negotiability* suggest that narrative requires the negotiation of roles between author and text.
Narrative accrual describe the principle that new stories directly follow from older ones.

Narrative Components

We usually enter into a story with expectations that we assume will be fulfilled. A story must reach "closure," that is, the resolution of an initial conflict.

The story has a progression. A dramatic arc describes the evolution of a character across a story. (Fig. 6.29). The arc can also reflect the dramatic tension and presumably, the emotional response of the audience.

Point of view which is also found in video games.

Combining logic and the perception of plausibility. It can often be improved by critical analysis. Combine logic and perception of plausibility. If there is any causal story, people tend to accept it. Stories have many roles in a culture. Myth and canonical structures. Road movie.

Components of narrative. Plot, character, theme. Narrative design. Story planning.

Story episodes.

Systagmatic. Specific time, place, characters.

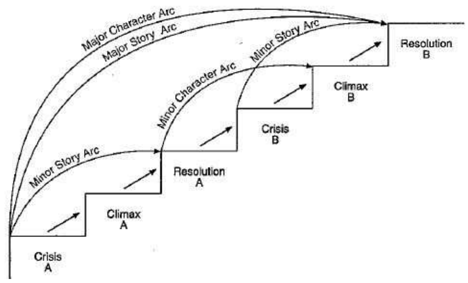


Figure 6.29: Story arc with major and minor characters. (check permission)

Motifs and themes.

Narrative Structure

Many stories follow regular patterns so it seems natural to develop representations. Some aspects of narrative are highly stylized. Indeed, Russian fairy tales (Fig. 6.30) are so stylized[50] that grammars have been proposed describing these. Story lines, story graphs. grammars, and dynamic agents. Agency in narrative[22].

> In one village there lived three brothers. The two elder brothers were successful merchants, but the youngest brother was a fool named Emelya who slept on the stove all day long. Once it happened that when he went to the ice-hole for water and he caught a magic pike. The pike asked him to let her go free and promised him to grant any of his wishes. “Just say these magic words: ’By the pike’s wish, at my command,’ and everything will be done” the pike said. Emelya agreed.
>
> He ordered his water-pails to go home by itself, which they did, much to the surprise of his sisters-in-law. Then he ordered the sledge to go by itself to the nearest forest where his ax felled wood for the fire. The Tsar of the land heard about that wonder and ordered his officer to bring Emelya to the palace. When Emelya came to the Tsar’s courtyard he saw the Tsar’s daughter and used the pike’s magic to make her fall in love with him.
>
> Then the Tsar gave orders to place the princess and Emelya in a barrel and throw them into the sea. But Emelya again used the magic words and the waves rolled the barrel onto the shore of a beautiful island. With the pike’s help Emelya “built” a big marble palace. Then the princess asked him to become handsome and smart, and he turned himself into a fine young prince. They started to live peacefully in the palace.
>
> One day the Tsar visited the island and, oh! What a wonder!, he recognized his own daughter and Emelya who was changed into a fine prince. The Tsar wept and asked their forgiveness. They celebrated the family’s reunion and lived happily after that.

Figure 6.30: “The Pikes Story” is a Russian fairy tale. Such tales are highly structured and it has been proposed that a grammar could describe the structure. (Translated Richardson). (Check permission).

The fabula is the sequence of behavior in the story world and syujhet.

Markup for narrative[11].

Story grammars. Rewrite rules for narrative [**?**]. Planning and story generation.

Narrative comprehension. Forming mental models.

Stories, Character, and Capturing the Human Experience

Stories have a structure, but they also reveal human experience. Describe such common human experiences as birth, death, and family. Managing affect. Developing empathy (5.5.3)with the characters. A story’s closure gives it an emotional satisfaction. The moral of a children’s story transmits a lesson as in *Aesop’s Fables*. Tracks human life. Social role of narrative. Taxonomies for folktales and folklore. Managing emotional affect (4.6.2). Are the characters believable? Do we develop empathy with them? We need models of the users in order to develop empathy with them. Representing character goals and psychology.

Standard character: Heroes, victims, villains (antagonist), sidekicks[55].

Affect in stories and generating affect. Effective story-telling[5]. Narratives and games (11.7.0).

There are many common patterns of in human lives and , of course, these are reflected in human stories. Universal themes and story templates. Moral. Allusion, Symbolism. Myth. A "failed quest" is one of what is claimed to be 12 basic story forms[4]. An example is the story of the Holy Grail. Stories often follow predictable patterns; one type of story tells of a "failed quest". Plot and character development can also follow patterns. Archetypes.

Figure 6.31: Lancelot and the failed quest for the Holy Grail. (check permission)

The coherence and fidelity of a story can be more important to our beliefs than support from direct evidence[24]. Expectations (4.4.3).

Describing the goals of the characters and the goal conflicts[22].

Interactive Stories: Story Interfaces and Narrative Engines

Beyond books and movies, Computers lend themselves to interactive fiction. Interactive stories. The simplest of these are branching stories and serious games (11.7.3).

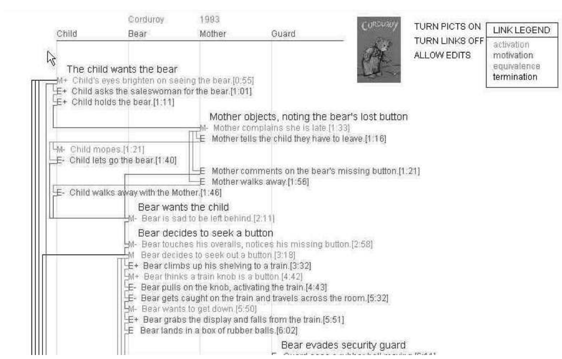


Figure 6.32: A notation for browsing the events which form the plot of a story[11]. (check permission)

Automated story telling. Narratives in games. Planning and narrative. Story re-planning as needed. Believability.

Narrative theory (11.5.4).

Combining Discourse Types

Story interpretation and cultural context[49]. Some types of works are composed entirely one type of discourse. An explanation may be only that. However, some other types of material may interweave several of the types. A news story or a biography have explanation, narrative, and argumentation all mixed together LDM[49] a different approach to discourse units. In other cases, this we see more structure for organizing content. Simple example: explanation within a story. Trajectory of a discourse. Many types of knowledge are required for understanding language.

6.3.7. Content Genres and Literary Forms

There are trends and styles in information resources. They often reflect technological changes in media presentations or events in society. For a while Western movies were particularly popular and then the interest in that style faded. These emergent patterns often not stable enough to be systematically classified. These are reified as complex objects (7.8.4).

The use of genre can be viewed as social action. They may be relatively stable (e.g., business letters) or ephemeral. They are related to trends in both technology and culture. Genres provide expectations about a resource for the members of a given community.

A literary form is more defined than a genre. XML DTDs as genres (2.3.3). Genre Template.

Genres are found in systems of media. Complex works include books, movies, and songs. Typically, genres are composed of sets of related entities and they often result from a nexus of technology and culture. There are many examples of genres.

Trope.

Media exists in a milieu of technology. Broader units than discourse (6.3.2). Genres can provide expectations about discourse and help build expectations. They can be thought of as a prototype (2.1.3). Genres can are also defined by reference to cultural trends and other works. This latter is known as intertextuality. Genre analysis[58] and genre classification are tricky because genres themselves are often poorly defined and are highly dynamic.

Genre ecologies[56] describe interlocking sets of document and forms in an organization.

Examples of Genres

There are many examples: Graphic novels. Documents as a genre (2.3.1). Music genres. Hip-hop. Genre detection Genres in science writing (9.2.3) are sometimes explicitly defined.

Genres, hypertexts, and interactive video games (11.5.4).

Literary Genres Books are a highly developed and generally very effective genre. Aids for readers and clarity for use. The development of books, printing, printing, libraries, and universities are all inter-twined. Ecologies of genres in organizations. Also, to an extent in businesses and the Web.

Printing and publishing (8.13.4). Print culture (8.13.6).

However, it is a specific style that evolved over time. Novels are a story told in prose.

Figure 6.33: *Kiss of Death*[33] is an example of the 1930s genre known as Film Noir. (redraw) (check permission)

Items from a given genre show shared communicative purpose. Genres are hard to capture. Genres on style, theme, mode. From literary styles to genres. Affected by the culture and technologies. Genre of media forms such as a novel. Content genres such as Film Noir (Fig. 6.33) which was a style of movie which was popular in the 1940s and 1950s (Fig. 6.33). Building shared expectations about style, symbols, and structures. Emotion, society, content. Social processes and genres. Game types (11.7.0).

Genres in organizational communication. Indeed, [44] argue that communication genres help to define the structure of the organization and may even control members of the organization. Social genres. Genre ecologies[2]. Genres often defines a sub-culture. Genre classification can be tricky because genres are by their nature fuzzy and ephemeral.

6.4. Conversation and Dialog

Language is primarily social. Here, we consider the social component. Conversation is the most direct form of verbal interaction. Social interaction through language.

Modalities (5.6.5). Dialog systems (5.11.3)[27]. As with other types of multi-agent communication, protocols for the interaction. Language is, of course, fundamental to social interaction. Social interaction is highly varied. From simply getting acquainted to communicating shared goals of a group. Communicating the scope of an interaction. Orality and oral traditions (11.3.3). Multimodal social interaction (4.2.4). Gestures (11.4.1). Multi-person conversation and speech analysis (11.3.3).

We may distinguish among different types oral interaction. Debate. Gossip. Genres. Meetings (5.6.3).

Task-based and activity-structured discussions Meetings. Routine activities.

Providing tools for supporting reference in computer-mediated interaction (5.6.2).

6.4.1. Social Interaction through Language

Conversation is social interaction by natural language. It is a model for other kinds of interaction such as, increasingly, the interaction between a person and a computer. Conversation is often instrumental, that is it helps people to accomplish their goals (Fig. 6.34). Development of conversational ability. Types of social coordination (3.5.3).

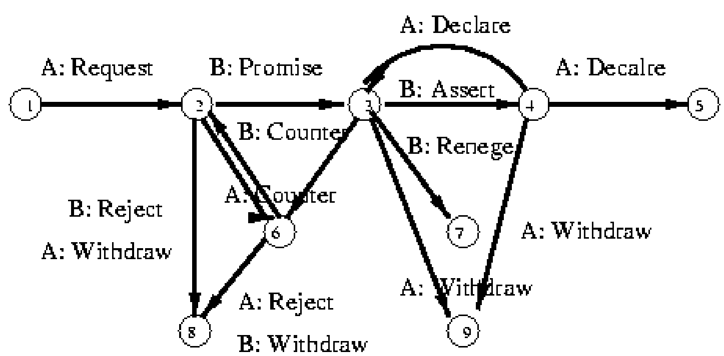


Figure 6.34: Stages of interaction between two people (A and B) during a negotiation (adapted from[62]). (redraw) (check permission)

Conversation and work.

Adjacency-pairs. Question/answer Greeting/Greeting.

Pragmatics is a significant factor in conversation. Indeed, many conversational statements violate syntax but are understood perfectly well because of their context.

Fig. 6.35 during design discussion. Task-oriented discourse.

Chat-room conversation transcript.

While discourse is “public speech”, conversation is often an informal discussion between a small number of people. Conversation incorporates linguistics with social interaction. Most conversation is about

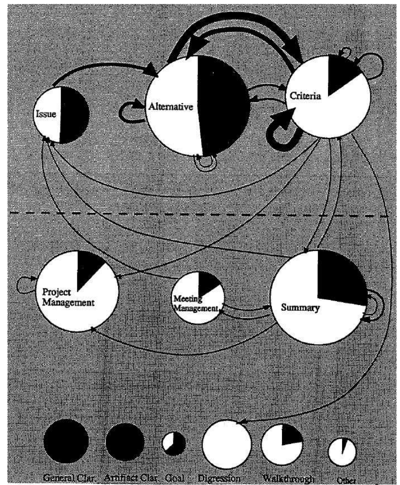


Figure 6.35: Transitions observed discussions during design interaction.[43]. (check permission) (redraw)

narrow topics, is between people who know each other very well, and is heavily context laden. When the participants in a conversation know each other and have a long history, the conversation may appear erratic to an outside observer. Several types of conversational interaction can be identified. Task-oriented interaction versus information interaction (3.4.3). Conversation conveys information and that often creates social bonds (5.2.1).

Rather than focusing on the words which are exchanged, we can also consider conversation?s role in developing affective bonds. Physical aspects of conversation such as gaze and body language. Gestures and facial expression (11.4.1) are an integral part of face-to-face conversation. Social engagement in conversation.

Conversation as developing shard understandings. Conversation and tasks. Conversation for problem solving. Bridging across sessions, illustrates a type of team meta-cognition.

The participants have to identify which object in the environment are being described. Most conversation is oral (11.3.3) and social (1.2.1). Conversation across many different types of social interaction. Dialog management (6.4.2). Recall the basic social interaction model (Fig. 6.36). Judgments about another person in conversation goes beyond judging what the person is saying but also their emotional state.

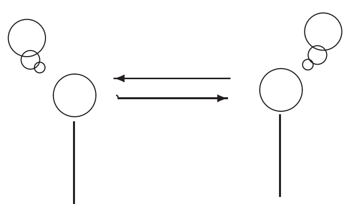


Figure 6.36: User models in conversation; each person tries to determine what is the other person thinking or feeling.

In one view, the meaning of language comes from the extent to which it mediates social action [**?**]. Conversation does not result in literal transfer of information between people. Repairs negotiating shared meaning.

Subjective sense of the context. Typically, conversation is heavily context laden. There are often abrupt changes in topic when the participants have a long familiarity.

A conversation is language-based interaction between two or more people or organizations. It is generally spoken language (11.3.3) but we can also have asynchronous email conversations. Person-machine interaction can even be thought of as conversation. Fig. 6.37 shows a fragment of conversation between a consultant and a supervisor at a company help desk. The words within slashes are spoken simultaneously by the two participants. Presumably, this is accompanied with other shared ideas. Face-to-face conversation includes physical interaction and signaling as well. Moreover, there may be subtle clues that participants pick up on[45].

Some electronic text interaction is like oral interaction. Tweeting as a type of conversation. Gossip (6.4.4).

Speaker	Transcript of Conversation
Consultant	... Then escalate it to the benefits. EVA is asking for this information on this (indistinguishable). We show it as having such-and-such. That way /we\
Supervisor	\Okay./ Okay,/I\
Consultant	\can/ tell them... what EVA is looking for.
Supervisor	I can tell the employee it's showing there's not, shouldn't be a problem, so ...
Consultant	... we're trying to fix it.
Supervisor	I'm trying to get a feel for it. Thanks, Nik.

Figure 6.37: Fragment of conversation between a consultant and a supervisor at a company help desk. The words marked by slashes overlap between the users (adapted from[8]).

Following the principle of least effort (6.1.2) and the reduction of cognitive load (4.3.3), the speaker prefers simple messages however, a listener generally prefers unambiguous messages.

Obtaining clarifications and making repairs in a discussion. Conversation often does not proceed in a straight line.

Affect in conversation and social interaction. Social bonding from face-to-face interaction (6.1.2).

Norms for Effective Conversations

We expect a conversation to be cooperative. This is a type of pragmatics. Four norms (5.3.1) or "maxims" of conversation have been proposed[28] as the implicit principles for constructive conversation (Fig. 6.38). If someone asks you for directions, you should answer accurately (quality) and concisely (quantity). There are also the principles an instructor might expect for students answering questions on an examination. Those answers should, of course, be accurate, succinct, relevant, and clear. These are frequently violated. There are many exceptions to these maxims. For instance, "shaggy-dog stories," which never seem to reach a conclusion, violate the principle of "quantity," while deception violates the principle of "quality". We expect statements to show relation. However, the maxims are violated in persuasive speech (4.5.2) and even more so in deceptive speech (5.3.3). Relevance as a cognitive phenomenon. Deception requires inferences about other people with a type of empathy. Multi-person conversations and small group discussions have additional norms (6.4.0).

Norm	Statements should...
Accurate	be genuine and not spurious.
Succinct	give neither more nor less information than is required.
Relevant	be relevant to immediate needs.
Clear	make clear what the contribution is.

Figure 6.38: Proposed norms (maxims) for effective conversation (adapted from[28]). These are frequently ignored.

6.4.2. Conversation Management

Conversation is a social activity so it involves not only natural language but also social skills. Like other types of the social interaction, it needs to be coordinated across participants. Conversations are structured by norms (5.3.1) which provide openings, closings, and turn-taking. Handling restarts, repairs, and silences. Some of these are social skills for smoothly facilitating conversation. These skill can be supported with a type of scaffolding [**?**]. [52]. Other activities include: Checking, repairs, changing topics.

Opening	"How are you today"?
Closing	"OK, I'll see you around",

Figure 6.39: Openings and closings serve as bookends on a conversation.

Conversation Body

Effective conversation requires that the participants share implicit knowledge about their interaction, as opposed to trying simply to make workable inferences about each other. There should be robust tracking of expectations and a means to allow the participants to back out from misunderstandings and confusion. Structured conversation (10.3.2).

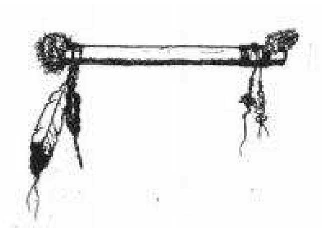


Figure 6.40: The "talking stick" was used by Native Americans to control who was allowed to speak during a council meeting. (redraw-K) (check permission)

Linguistic markers which allow speakers to emphasize what they wish to communicate.

Negotiating meaning in a conversation. Each person makes sure the other person understands. Structured conversations such as threaded chat (10.3.2).

Techniques for conversation analysis[59]: Question-answer pairs. Sequences.

Dialog Goals Some conversations have specific goals. Dialog is tied up with goals for a discourse. Bids for macrogame. A dialog game is composed of three goals: the goal of the initiator, the goal of the recipient, and a joint goal. A information offering game is a specific type of game (Fig. 6.41)[39]. Other types of discourse management games. These are useful approaches for conversational planning (3.7.2).

Goal of initiator	Provide particular information to recipient.
Goal of recipient	To identify and receive the particular information offered.
Joint goal	The responder comes to possess the particular information.

Figure 6.41: Information offering game from the viewpoint of several participants[39].

Initiator	Can I give you directions to help you find something?
Recipient	Yes. How do I get to the Liberty Bell?
Initiator	Go down Arch Street and take a right at 5^{th} Street.

Figure 6.42: Example of an information offering "game"[39].

Group Verbal Interaction

When groups interact at a distance, many of the cues that guide face-to-face interaction are missing. Different methods may have to be established to coordinate such elements as turn-taking and floor control (6.4.2). Back-channels. Toward broader activities such as tutoring, giving directions, negotiation, or teaching a skill.

Conversation Beyond Verbal Interaction

Social interaction beyond words. Non-verbal cues for control on conversation. Eye movements. Attentional gestures. Conversation can also be seen a part of a continuum of communication modalities.

As part of non-linguistic interaction, speakers may use hand movements and other gestures (11.4.1) to emphasize points, and listeners may respond silently with nods, smiles, or other facial expressions. Modalities such as gestures, eye contact, and gaze (5.6.5) can be non-verbal signs of interest. Modalities of interaction in meetings (5.6.3). Coordinating gestures in a conversation (11.4.1).

6.4.3. Sub-Languages and Institutional Dialogs

Language use is also affected by social context. It may be better not to think of natural language as a single entity. There are restricted languages for specific tasks. Languages for special situations or social groups are termed "sub-languages". Institutional dialogs are similar to sub-languages. The discourse is often determined by the roles of the individuals involved. Examples of institutional dialogs between doctor and patient. The dialogs are affected by the relative status of the participants. The relative status is also associated with the beliefs and the information available to the participants. This could be captured with a meeting archiving system (5.6.4) and then used as part of a medical decision support system (9.9.2). Whether intentional or not, jargon acts a barrier to interaction. Jargon.

Inter-generational discourse. Similarly, parents speak in a distinctive way to their children. These may be helpful for the child to learn language. These are known as "care-giver" languages or sometime, "Motherese". For example: "Yes, Mommy will pick baby up". Or, "Would baby like to go night, night".

"Meeting talk".

Figure 6.43: Institutional dialog cartoon.

6.4.4. Synergy of Language with Culture

Language and categories are inter-woven with culture (5.8.2). Language weaves together communities, culture and individuals. Sociolinguistics is concerned with the language and social interaction. Language both unifies and divides groups of people. We noted earlier the importance of language for communities and cultures (5.8.2). Communities of practice develop their own thesauri. One of the ways that communities regulate their membership is via their use of language and they are defined in part by their language. Language needs to be appropriate to the setting or reference group (Fig. 6.44). [64]. Common cultural assumptions allows us to disambiguate language. Kinship relationships (5.1.1).

Dialects to support group identity.

Culture and discourse expectations. For instance, topic-comment vs comment-topic.

Interrelatedness of Concepts and Cultural World View

Language and culture.

QUOTE "Russian speakers, who have more words for light and dark blues, are better able to visually discriminate shades of blue.

"Some indigenous tribes say north, south, east and west, rather than left and right, and as a consequence have great spatial orientation.

"The Piraha, whose language eschews number words in favor of terms like few and many, are not able to keep track of exact quantities.

"In one study, Spanish and Japanese speakers couldn't remember the agents of accidental events as adeptly as English speakers could. Why? In Spanish and Japanese, the agent of causality is dropped:

"The vase broke itself," rather than "John broke the vase." ENDQUOTE

Cultural interpretation. Insults, and cursing. Slang is often a way of marking a social group.

It is not surprising that language reinforces social conventions, as in the use of honorifics to show respect. Social courtesy and politeness. Crudity. "Honorifics" are expressions in language that show respect. In French, "tu" is the singular form of "you," and "vous" the plural. But the two words have another connotation — "vous" is the more formal or respectful mode of address to an individual, while "tu" is more familiar or intimate.

> Most members of the Arizona Tewa speech community regard their language as their unique and self-defining possession. Many older speakers claim that their language cannot be learned by non-Tewas and cite as evidence for this claim the fact that no Hopi, their neighbors for almost 300 years, speaks fluent Tewa. The Tewa help perpetrate this situation by ridiculing any Hopi who attempts to utter even an isolated word or phrase of Arizona Tewa.

Figure 6.44: Language and communities[34].

There are many such examples. Dewey classification and religion. Nonetheless, communities do change definitions and category systems do change across time.

Even gossip has a social function – it helps to elaborate our models of the social world. In other words, it is a type of information exchange. Malicious gossip.

Language is also a clue as to social status. Social chat for understanding the layout of the social world.

Niche use of language in specific domains.

Spread specific information (5.1.0, -A.3.5).

Government control of the language itself. This can be a way to steer culture or even to detach a people from their cultural heritage. German "language reform" by the Nazis.

6.5. Models for Language

6.5.1. Discrete Models for Language Structure

In this chapter, we have focused on natural languages; these are highly dependent on context nonetheless, natural languages all generally share a structure which can be characterized basic formalisms. We end this chapter with a discussion of those formalisms. Transition networks and by grammars provide formalisms which have been widely used to model natural language syntax. These approaches have proven especially useful for formal languages such as computer programming languages. We end this chapter with a discussion of formalisms such as transition networks and grammars which are useful to formal languages. Petri nets (3.10.2). Sequences of words and sequences of phonemes modeled with a state language.

Transition Networks: ATNs and RTNs

Basic transitions networks (TN) are similar to state machines (3.10.1) but they don't cover some essential features of language. They have been extended as Augmented Transition Networks (ATN) which add registers and a stack. Augmented Transition Networks (ATN) variables set at one point in the network and tested in other parts of the network. ATNs are much more general than simple state machines because they hold context. Fig. 6.45 shows a very simple example of how an ATN might be used to manage a game. The states in an ATN might reflect rooms in a dungeon-like game, programmed so that the player would encounter a dragon the second time he or she entered the room. The value "c" is set to 1 in State C, this is the only circumstance under which the dragon will appear in State D. As a model of natural language generation, markers in an ATN could be set to signal a plural subject so the verb could be made to agree with it. Later, we will see how an ATN can be used for parsing (-A.5.4).

Recursion allows statements embedded within other statements. Recursion in language. Recurrent

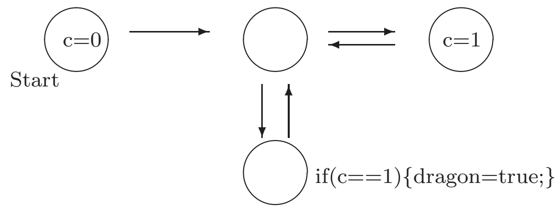


Figure 6.45: A simple Augmented Transition Network (ATN). The Dragon will appear at node D only if node C has been visited and the variable "c" has been set to 1.

Transition Networks (RTNs) are an extension of ATNs which allow ATN networks to be nested one inside of another. These are particularly useful when applying ATNs to natural language processing.

Figure 6.46: An Recursive Transition Network (RTN) for generating a regular expression can recursively embed another RTN. (revise/redraw)

Grammars

Grammars model syntax. State machines and transition networks describe sequences, but a more powerful technique for describing sequences such as those in languages. Specifically, grammars implement recursive productions or re-write rules. These sequences are a sequence of states and could be represented as a state machine, but the grammar allows the repetition of states to be simplified into a more concise statement. While most grammars are deterministic, statistical models can to provide structures similar to grammars (-A.5.5).

Formal grammars are expressed by productions containing symbols on the left-hand side, symbols on the right-hand side, and a right-pointing arrow separating them. When stings are "generated," the components of the equation interact in ways that are dictated by the production rules. In general, the production rules described the ways that non-terminal symbols may be replaced with terminal ones; the end result of the process, in which only terminal symbols remain, is known as a "sentence". All the possible sentences that can be constructed (often an infinite number) constitute that grammar's "language". Any language that is described by a formal grammar is a formal language, and vice versa. Formal grammars are defined by very specific orders of operations and rules for expression, and are practically used only for computer programming, though some are also used as models of natural languages.

Formal grammars can be approached in two ways: one way is to use the rules of the grammar to generate strings of symbols, and the other way is to utilize the rules of the grammar to determine whether or not a given string is consistent with a particular grammar (grammatically correct). While this difference may seem negligible, some grammars are created only for analysis and not for generation. There are two types of formal grammars: "generative grammars" (those that generate symbol strings) and "analytic grammars" (those that analyze symbol strings). The most notable type is Context-Free Grammars (Fig. 6.47).

Rewrite	**Expansions**
S:	A, AB
A:	x, xy, xyz
B:	y, yz

Figure 6.47: A simple context-free grammar. Using this grammar the strings "x" and "xyzy" are legal while the strings "yx" and "yzx" are not legal.

Parsing Parsing is the identification of grammatical and lexical components of a sequence. A parser is a part of a "compiler" for computer programs. It validates content (often a computer program) to make sure it is syntactically correct [9]. Compilers determine whether the syntax of a computer program is valid, and therefore compatible with the operating system. Parsing can be thought of as a search problem in which the user tries to match the particular case within all possible constructions of the grammar. Natural language parsing in (10.4.2). Rule-based parsing versus parsing as constraint satisfaction (3.7.2). Parsing candidates. Parse trees (-A.5.4).

There are other applications of grammar parsing. Formal grammars form the basis of many types of computer programming languages. Many techniques developed to apply to formal grammars in theory have been able to be applied to computer programs and languages in actuality. There are many possible Document Type Definitions (DTDs) (2.3.3) that an XML document might use; given a document of an unknown source, using a parser-like program it is possible to figure out what DTD generated it [54].

6.5.2. Corpus Linguistics

FrameNet, WordNet. Domain models. Linking to knowledge-bases ((sec:knowledgebase)).

Formal Languages

Formal languages such as programming languages are very different from natural languages. A formal language may be defined as the entire set of complex sequences that can be formed by combining a finite set of symbols (the lexicon) according to rules (i.e., the grammar). A language's "words" make up that language's "lexicon". The two letters are individual symbols that have been combined in a certain way. The particular pattern of symbols and the way in which they are combined would generally be used to convey meaning between two or more entities in a predetermined manner. Even with an alphabet as simple as two symbols, the potential extent of the language can be large. Mathematics (9.7.0) and music (11.3.2) share aspects of natural language.

Theory of language. Expressiveness. Model theory.

Types of programming languages: Procedural, declarative. Rule-based.

$$\text{Formal Language} = \text{Rules} \ \& \ \text{Lexicon}$$

Languages are generative systems — that is, a finite store of base elements can be combined to create an often infinite number of higher-level representations. All of the higher-level representations that can be generated using the base elements are known as a language's "lexicon". In formal languages, the generation of a lexicon is constrained by production rules, while in natural languages these rules are much less controlling, if they exist at all.

Programming languages can specify complex behavior. Formal languages, though, have clearly defined syntax rules. Computer programming languages — an important class of formal languages — have a very rigid operating syntax. Programs will only understand commands if they are syntactically correct. Fig. 6.48 shows the "language" of a particular computer program; if the language were not written correctly, the program would not function. Variables such as "x" form the lexicon. This is a trivial example of a program meaningful programs model the world. The basic elements of a programming language are assignment, loops, conditionals. Parsing to determine syntax errors. In a formal language the meaning of an expression, its semantics, is its behavior. Algorithms (-A.5.0).

Procedural languages. Functional languaes. lambda calculus.

A formal language allows the creation of representations for complex processes. Formal languages can be measured by their "expressiveness," which is the range of meanings they can support. As a simple example, we might ask whether a programming language can support recursion — that is, a program module calls itself repeatedly. Just as there is a difference between the basic syntax of natural language and the elegant use of natural language, programs can also be designed elegantly (7.9.0).

```
int x=1;
main(){
    while(x<=4){
        printf(" %d",x);
        x++;
    }
}
```

Figure 6.48: A programming language, such as C, is a formal language. Here is fragment of a very simple C language program which prints the numbers 1 2 3 4 and then ends.

Minimizing errors in synchronization.

Abstraction of processes[7].

Programming languages for a specific task. A programming language should make it easy to express what has to be done in that activity. This is not necessarily a general programming language. Of course, actually programming involves having expectations about the task and the limitations of the computer hardware on which the program runs.

Beyond Discrete Models for Languages

HMMs.

6.5.3. Agent Communication

Formal models for language beyond parsing. This is a formal approach for managing communication. It does not include the emotional and personal interactions that people find so important in social interaction.

Autonomous agents (7.7.8). Alife (-A.10.4). In multi-agent systems (MAS), it should be useful for helping intelligent agents to coordinate (3.5.3). For instance, they need to share commitments and contracts but in a highly controlled framework.

Coordinating agents need to sharing knowledge. Infrastructure needs shared meanings, shared protocols, shared communication infrastructure. Indeed, agents can considered to be defined by their communication [**?**]).

Figure 6.49: Protocol.

Reasoning by Agents

Goal-based model of intention. Practical reasoning often in a business context. Intention as a type of plan. Bounded optimality. BDI [**?**]. BDI and goals versus situated action. Speech acts.

Activity Theory for Agents Activity - Motive
Action - Goal
Operation- Conditions

Exercises

Figure 6.50: Activity theory.

Short Definitions:

Anaphora
Care-giver language
Citation index
Conversation
Dialog
Discourse Model
Floor control
Frames (verb)
Generative model
Genre
Given-new
Grammar
Honorifics
Institutional dialog
Interlingua
Intertextuality
Lexicon
Markers (linguistic)
Mixed-initiative system
Morphology
Narrative
Neologism
Paraphrase
Parsing
Polysemy
Pragmatics
Regular expression
Transition network
Transformational grammar
Semantic field
State machine
Speech act
Turing test
Turn taking

Review Questions:

1. What is the relationship between syntax and grammars? (6.2.2)
2. Give an example of semantic cohesion (6.2.3)
3. Give examples of each type of speech act in Fig. 6.21. (6.3.1)
4. What's the difference between "narrative" and "exposition". (6.3.6)
5. Give an example of the use of each of the "conversational maxims" in Fig. 6.38. (6.4.1)
6. Give two fundamental approaches for representing sequences. (6.4.1, 6.5.1)
7. Evaluate the following regular expressions following Fig. **??** (6.5.1):
   a) Does aXb match a*b
   b) Does aaaab match a*b
   c) Does abccccc match a*b*c
8. Is the statement "PQTUVY" legal in a context-free grammar with the following rewrite rules? (6.1.0, 6.5.1)

LHS	RHS
S	AB, CDE
A	J,KL
B	MNO
C	PQ,RS
D	TUV, WX
E	Y, Z

9. Differentiate between formal and natural language grammars. Give examples. (6.2.2), 6.5.1

Short-Essays and Hand-Worked Problems:

1. Is "hot dog" one word or two? Justify your answer. (6.2.1)
2. What are "concepts"? How do they relate to words? (6.2.1)
3. Find a videotape of a conversation (e.g., from a movie) and specify in detail the interaction between the speakers in it. (6.3.1)
4. Use the relationships described in Fig. 2.50 to code a discussion. (6.3.5)

5. Components of narrative. (6.3.6)
6. Describe how grammars are related to XML. (2.3.3, 6.5.1)
7. Specify a simple language, develop a parser for it, generate statements in that language and develop a compiler to validate those statements. (6.5.1)
8. The evaluation of mathematical expressions follows an "order of precedence" which are a type of re-write rule. Make a parse tree for the expression: 1+(2*3). (6.5.1)

Going Beyond:

1. To what extent do languages affect perception of objects is described? (6.1.0)
2. How would you define language. By your definition, do animals "have language"? Do computers "have language"?(6.1.0)
3. Is the use and learning of natural language a human instinct? (6.1.0)
4. Write a part-of-speech tagger. Include a dictionary of terms. (6.2.2)
5. Is it possible to cleanly separate syntax from semantics? (6.2.2)
6. There is a connection between word definitions and the creation of data models. There has been a proposal for creating structured word definition. How feasible is that? (6.2.3).
7. How do we know the definition of a word is accurate? (6.2.3)
8. What are the syntax, semantics, and pragmatics of a book cataloging system? (2.5.1, 6.2.2, 6.2.3, 6.3.1)
9. Explain the difference between "semantic structure' and "rhetorical structure". (6.2.3, 6.3.5)
10. Describe a brief discussion between a patient and a doctor. Develop a system of speech acts for a medical interview. (6.3.1)
11. Quote two examples of the given-new principle in a newspaper. (6.3.2)
12. How is explanation different from description? (6.3.4)
13. How is "conversation" by email different from spoken conversation? (4.2.1, 6.4.0)
14. Compare the S.O.A.P. principles for collection management in a library with Grice's Maxims for conversation (6.4.1, 7.1.2)
15. Observe and describe the difference in language use of school children, teenagers, and adults. (6.4.4)
16. Describe the relationship between discrete grammars and HMMs. (6.2.2, 6.5.1, -A.5.5)

Teaching Notes

Objectives and Skills: This chapter provides a conceptual foundation for understanding different aspects of natural language.

Instructor Strategies: The presentation could focus on either formal languages or natural language, Within natural language teaching could focus on either the structure of function of language.

Related Books

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Chapter 7. Information Institutions and Infrastructures

Large institutions often have complex information needs. Moreover, some institutions are devoted to supporting social information needs. Increasingly, such large institutions are closely integrated with information systems. Information systems facilitate the management (e.g., selection, organization, access, and preservation) of collections of information. These institutions include libraries and archives which serve as information resources to the community, ensuring trustworthiness and accessibility. In addition, we consider system development procedures and metrics.

Architecture implies coordination of physical resources and services. We can characterize the types of services provided by information systems. A set of coordinated information services compose an information system. We have already examined databases (3.9.0) and here we consider other sets of information services such as libraries and archives. The details of how the services work together compose the system's architecture. Services are the building blocks that compose the information system. They support the basic functions that are required to run the system. The services themselves may be defined by user needs (desired functionality, for example) or by the system needs (operating programs), and may range from content management to end-user services.

7.1. Information Institutions

7.1.1. Types of Information Institutions

Here, we consider some categories of information institutions in detail: libraries, archives, museums, as well as the related scenario of information management in business and other dynamic organizational settings. They can be examined as sets of services and they can be implemented with service-oriented architectures. Organizational and institutional connections. Common functionality of information systems. Many of the traditional distinctions are becoming blurred. s Many digital collections are established with the policies common for traditional institutions. Different traditions based on the purpose of the institution. Many pieces have to work together. Content, tasks, people, tools. In the next three sections we consider libraries, enterprise architectures, and archives. They are so well established that they are associated with established models for knowledge institutions. But, they can also be broken down into sets of services. they are still socio-technical systems and, hence, they help to define an ecology of content, use practices, and technologies. Nature of institutions (5.8.1). Institutions need to follow procedures and policies. Institutions have a need for continuity and stability. Types of institutions: Memory, Educational, Cultural, Research, and Knowledge. Moreover, we routinely distinguish among sub-categories of each of these, though these distinctions can be fuzzy. In addition, there are many ad hoc institutions such as for the management of data sets.

Management of Information Institutions. Management (8.11.0). Library and archive management. Because of disruptive technologies, many information institutions are in flux. But there are also many new opportunities.

7.1.2. Information Services and Institutional Practice

Institutions generally implement specific formalized services. These are traditional sets of services, but increasingly other sets of services are being defined. Increasingly, there are media intensive applications such as films from Major League Baseball. Science data sets and data libraries (9.6.3). PIM (4.11.0). Digital Asset Management systems which are generally extensions of database management systems. Assets of an organization may be kept in a digital asset management system. Supporting branding. Media libraries. Personal information management (4.11.0). Information commons. Personal archives. Possibly developed with use cases (3.10.2). Project management (8.11.3) for the infrastructure. Services could be implemented on a SOA. Creativity and collaboration. Web publishing platforms. Moreover, institutions need to include evaluation of their services.

Selection	Deciding what content to include.
Organization	The content should be described clearly. and structured to make materials easy to find.
Access	It should be available for users and facilitate collaboration.
Persistence	It should be available into the future.

7.1.3. The Nature of Collections

Collections allow rapid access to sets of related materials. For instance, they allow botanical research to identify new species of plants by comparing specimens to examples of other species. Coverage of a given topic.

Figure 7.1: Curiosity box. (check permissions)

Many motives for collecting. Difficulty of defining digital collections. Personal collections (4.11.1). Developing a collection for education and for reference. Formal collections require thought and effort and large collections need to be supported by an institutional framework.

Libraries are traditionally based around collections of published materials but with the advent of the web the boundaries of collections are much more porous. Collections are still important, they are less distinct when a lot of material can be presented remotely and at relatively low cost. One possibility is to redefine the concept of collection to consider it broadly as the information context rather than as a specific set of information resources [?]. Still, there are notable exceptions such as collections which are distinctive or exhaustive. Collecting for evidence of transactions.

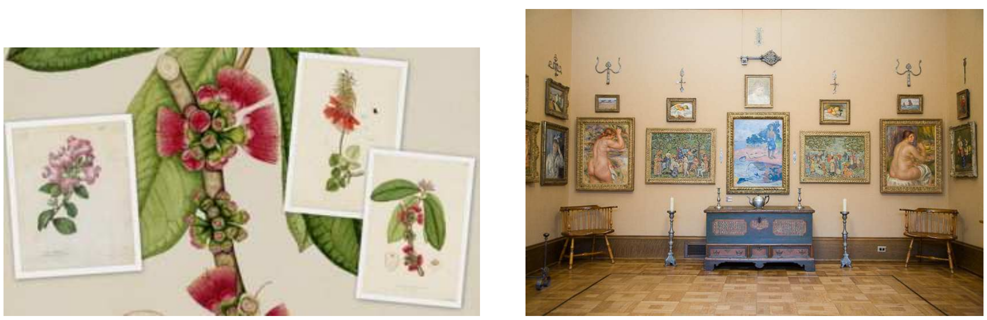


Figure 7.2: Collections are created for many purposes. Left: A herbarium data sheet from a botanical reference collection. Right: The Barnes Collection is a famous art collection in Philadelphia. Its presentation is based on the unique theories of Mr. Barnes for combining color and shape. (check permissions)

7.2. Libraries and Library Services

7.2.1. Libraries

Formally, a library is an institution that manages one or more collections of information resources.

Many types of libraries (**??**). Special collections.

There are several ways to view libraries: a community resource, a set of services, and as a collection of collections. Clearly, libraries are rich and complex knowledge institution (8.13.2), Traditionally, libraries have provided access to formally published materials. This can be an educational mission. Technology is greatly changing the distribution of books.

The very nature of collections is changing [?] since it is now possible to obtain digital copies of books. eCopies. Relationship of libraries and publishers. Libraries and publishers traditionally have had a symbiotic relationship.

One view is if libraries are community information centers and that the role of librarians is to facilitate management and sharing of information about a community. Librarians as experts in supporting the knowledge creation process. Libraries relationship to publishers (8.13.4).

Figure 7.3: Types of libraries: A) Public library, B) Hathi Trust, C) Rare books. D) Story hour. (check permissions)

Some other common types of libraries include law libraries, business libraries, map libraries, and music libraries. These are often known as special libraries. Academic libraries serve universities.

Libraries collect and manage content, Primarily, libraries manage collections of information resources. This is accomplished by a set of services. We will examine library services in more detail later in the context of digital repositories. The table gives a simple set services for content management. Physical libraries are changing; increasingly, physical space is used for research interaction and also for reflection. Libraries can be seen as places which provide reliable information for a group of constitutions regardless of how that information is organized. Access genres (3.2.2) and catalogs (2.4.3). Libraries as places where people facilitate specific type of interaction with information. Academic libraries in universities (8.13.2) and (9.1.1).

Beyond collection development by libraries have an active role in providing services which support the curriculum and educate the public. Libraries for scholarship (9.0.0) and learning.

Integrated library system (ILS). Platform.

Library Business Models

Several business models for libraries. Public libraries. Cost-center or profit center. Subscription library especially for eBooks. Digital lending rights. Interdependence of libraries and publishers. Value of library services and budgeting[57],[59]. Information economics (8.13.3). Increasingly, collections are being maintained by publishers. Though, in some cases, universities are trying to maintain a collection of their own intellectual products.

Library Customer Service and Service Populations

Libraries and customer service. It should also be built and maintained for a specific service population, whether that be young adult readers (as in a middle-school library), senior citizens (as in a retirement community library), or a cross-section of the population as in a general community library.

Information needs and approaches for youth. Youth services.

Libraries are developed for many purposes and there are many models, digital libraries being just one. Libraries may be grouped into categories such as community libraries, research libraries, special libraries, and university libraries. These categories are based on a library's user groups, on the type of collection it houses or on the specific types of services it provides.

The main function of libraries is to serve patron information needs. Thus, we should measure the library's effectiveness at doing that [44]. But, we also know libraries as cultural organizations (5.9.3). and, indeed, many physical libraries also serve as community education centers [65]. Most traditional libraries facilitate collaboration. Focusing on collecting information versus what's popular.

7.2.2. Library Services and Collection Management

We considered reference service earlier (3.3.0)and here we consider collection services. Libraries are sometimes described as a collection of collections. One of the changes for digital libraries is that the nature of collections is becoming less distinct as digital copies of texts are available. We have already discussed bibliographic metadata (2.4.0).

Workflows for collection managment.

For many tasks it is difficult to tell what type of information will be needed. Therefore, library collections emphasize a wide range of perspectives on a topic. Information resources and scholarship are continually evolving. The collection needs to evolve as new content becomes available and the needs of users change (Fig. 7.4). They facilitate information and data sharing by providing one or more collections (7.1.3) of information resources and associated services. Collection management can include establishing collection policies which define what types of materials should be acquired for the collection and what materials should be removed. The basic collection management services can be summarized with the acronym S.O.A.P. which stands for Selection, Organization, Access, Persistence. Focusing on the services which form he basis of a library can be helpful when developing services for a digital repository (7.8.1).

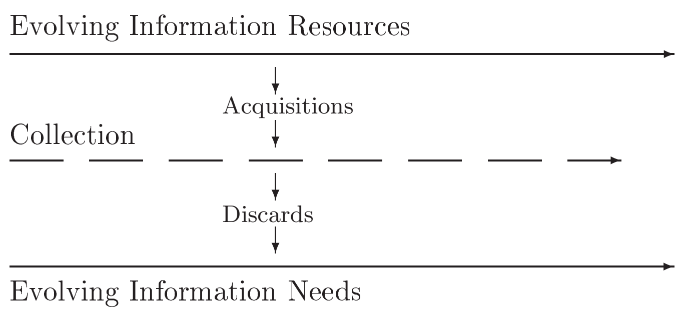


Figure 7.4: A collection is a set of selected information resources. Both the of information resources which the collection represents and the information needs of users evolve through time (left-to-right); thus, the collection also has to evolve through time. The collection policies define what types of materials should be acquired for the collection and what materials should be discarded. (redraw)

A library collection could provide a broad perspective on a given topic. Building a good collection [43] may include a variety of perspectives on a given issue. Special collections, which are used is special libraries (7.2.1)need to design their policies to match the requirements of the institution is which they are based.

Collection development. Determining what's missing in a collection and attempt to complete it. Collection development focuses on building and enhancing a collection. A collection development policy can be created by analyzing the stakeholders and the needs of likely users. Log files can be useful in filling gaps in a digital collection by showing what a person is looking for. Basically, this can be thought of as another way to predict what is likely to be helpful to users of the library. For digital collections this means determining the supplement to the information environment available to patrons.

Libraries must select what information to store in their collections. Many books, journals, reports, and other publications are produced each year, and librarians must determine which acquisitions will best serve the information needs of the library's users. An adequate collection provides the possible coverage across a given topic, gives people the broadest possible perspective on information. The library's collection level and commitment goal are part of its stated policy. A "research level" goal of the collection is described in Fig. 7.5. This means that the collection is intended to have resources available for serious research. Other policies might highlight other collection goals, such as increasing circulation statistics, securing privacy, limiting information access by children (8.1.0), or promoting "community standards". Although a given collection may change slowly, all collections become stale. Periodically, it is desirable to eliminate, or "cull," items that are no longer useful. Here again, a collection policy might state the basis for this culling such as that the materials are outdated or that they simply are being used. This is a re-appraisal or re-selection.

> The Berkeley Digital Library SunSITE collects... at the research level in the areas of digital library development and information technology. In other subject areas, the resources and projects we select are reviewed by the appropriate selector for that discipline and gauged against our existing collecting levels for print publications in that area.

Figure 7.5: A brief collection policy.[5]. (check permission)

We can ask how well an actual collection matches to ideal standards for a collection. Measuring the quality of a collection. Such as whether it covers the topics specified in the collection policy. Scope of the collections[89]. We have discussed repository metadata (7.8.4). Increasingly, we think of objects as multiple levels. An entire collection can have metadata; this would include the collection name and its scope. Indeed, the metadata should reflect the collection policy. Conspectus.

Digital libraries can be service-oriented architectures with repositories. Virtual repositories. Library workflow. Complex digital object (7.8.4). Hathi Trust (10.1.6). Providing services such as a pipeline model for decomposing a complex problem into manageable pieces (3.7.1).

7.3. Organizational Information Systems and Knowledge Management

Organizations have several types of information needs. Earlier, we considered organizational structures. Here, we consider the use of information.

7.3.1. Knowledge Management and Organizational Information Systems

How to fit information systems to match the complexity of organizations. We have, for instance, considered DSS (3.4.2). Special libraries. EDMS.

Knowledge managing knowledge assets and databases. Knowledge management for models of formal inferences via the Semantic Web. Knowledge management and internal corporate communication [**?**]. Knowledge management in medical settings (9.9.3). This involves systems, users, and content. Avoids redundancy in an organization.

Unlike libraries enterprise content is an ongoing part of business activities. Mining organizational data. Active information which is more directly task oriented. Management information systems (7.3.2). Records management. Business classification systems.

Describing how documents in a work process are related to each other. Documents show work processes. Modeling Roles and Activities. Indexing and retrieval of these documents.

Creating knowledge. Sharing knowledge across silos. Organizing knowledge. Disseminating knowledge. Tacit and explicit knowledge.

The context of archival resources help us interpret them. There are many difficulties such as where in the organization the knowledge is found. Unlike libraries which collect available resources, information in an organization needs to be more systematically assembled and managed. These active information repositories can be a dynamic record of a community's activities and thoughts. They may also have special services such as information brokering and organizational memories. The effective use of information and knowledge can help an organization increase its efficiency and accomplish its goals.

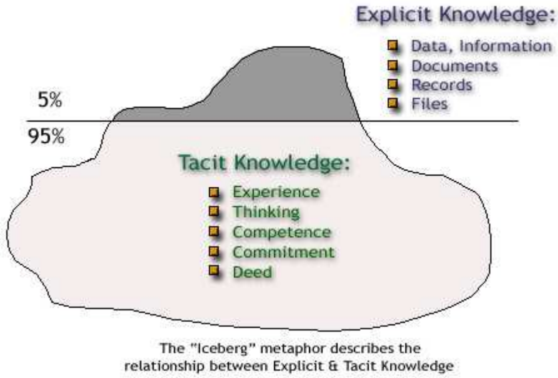


Figure 7.6: Tacit knowledge. (new figure showing person) (redraw).

Knowledge in organizations is kept in many forms not just to documents. Information processes can improve the efficiency of business and organizations (8.8.1)[92] but also introduces difficulties.

Organizational Knowledge Management

Like individuals, organizations need information to make decisions. We considered organizations themselves earlier (5.7.0); here we focus on information within organizations. Knowledge management tries to make sure the right information is available when making a decision. There are many types of information in organizations. Knowledge management focuses on effectively collecting and organizing the information that is used in organizations. Information in an organization can be very fluid, and organizations use different types of information systems than those utilized by libraries. Thus, knowledge management often includes capturing and distilling organizational knowledge. An organization may not maintain clearly defined collections as do libraries, but simply sets of documents that are frequently updated. Useful in the design of information systems (7.9.1). Collaboration. Teams.

7.3.2. Organizational Information Needs and Use

We have described organizations earlier (5.7.0); here we explore them in more detail. Internal and external information needs. Organizations possess large stores of both formal and informal information. However, this knowledge must be codified for capture in a knowledge management system. Typically, this capturing process must occur both at the front and back end of an organization's system. New knowledge must be incorporated into the overall system at the same time that old information is reformatted for consistency. There are many areas of application for information in an organization and, indeed, there may have to be several different information systems.

Efforts to make sense of what is really happening in an organization's environment [86]. Like more general sensemaking (3.1.1).

Managers have particular needs for information and information management. Indeed, Management information systems (MIS) are designed to provide managers information environments. Decision support systems (3.4.2). Enterprise Resource Planning system and a lot of data available. These generally keep active business document and records which are then transferred to records management systems (7.4.1) as those documents and records become less actively used for the purpose for which they were created.

Organizations often have individual or departmental information systems based on specified roles. But, the larger question is whether or not the roles or departments themselves are designed to handle the flow of information as it actually happens, and not as it is supposed to happen. It is an enormous challenge to design, or redesign, an organization to handle the flow of information effectively for routine activities (8.11.2).

Task specification in an organization may be described as workflow (5.7.2). The structure of a group and its tools has an effect on the way that information is used and transmitted. Roles such as “manager” are assigned certain tasks within the hierarchy of an organization and they are often given procedures for completing those tasks. These structures and procedures either facilitate or inhibit information flow. Genres of organizational communication. Regularity of organizational processes. Organizational grammars. Organizational communication genres.

In many organizations, there are groups whose main purpose is managing information relevant to the organization. The Chief Information Officer (CIO) is typically responsible for this at the organizational level, and will manage several other departmental information officers.

An individual functions in an organization and has his/her own perspective on it. Individuals may mental models of how thing work in the organization. These may include not only formal specification but also of the human interactions. People try to determine what is really going on in the organization. Related to structuration. Ultimately, the information system needs to meet the organization’s information needs.

7.3.3. Supporting Organizational Culture, Planning, and Change

Organizations need management. While it may seem obvious that information processing plays an important part in the success of any organization, effective information management is necessary. Moreover, there are often communication channels that supplement these the formal channels. Formal and informal models of information flow in organizations. Organizations often do not follow their own formal policies.

The organizational culture and the manner in which information is handled are often counterproductive to efficient information systems. Also, because organizations necessarily have a mix of goals, information often gets distorted when being transferred from one location within an organization to another[13].

Figure 7.7: Many organization do not survive change. Here are some logos of organizations which no longer exist.

There are many types of organizations and many strategies for meeting organizational goals. Organizations have a distinctive style, ranging from regimented, button-down conservative organizations to the more open dot-com era organizations of the past twenty years. One of the most indicative elements of organizational culture is often how information is shared among different levels and departments.

This sharing can be the result of many factors. The expectations of the upper-level managers and officials regarding an organization’s culture, financial goals, productivity, and public image is one means by which organizational culture is created. Another is the type of people who populate an organization, which is the result of the industry in which the organization is located, its geographical location, and the hiring practices (7.3.6). Problem of resistance to information sharing.

Organizational culture has many ramifications. It can both cause and reduce inter-organizational power struggles, it can stimulate and stifle the sharing of ideas, and it often determines what people actually know about the organization of which they are a part. The extent to which the management shows a willingness to hear contrary opinions. The willingness to learn from bad news allows the organization to respond to that bad news[3]. Information systems need to be compatible with the organizational culture. Open discussion forums may be appropriate for entrepreneurial and research organizations while more secure communications are appropriate for financial organizations. Change is inevitable and it has been particularly common in this era of disruptive technologies.

Strategic planning seeks to utilize all of the internal strategic knowledge within a company to come up with a plan for company competitive advantage. An organization may explore how to collect information. A SWOT (Strength, Weakness, Opportunity, Threat) analysis maps possible activities on the four dimensions of a graph. Like affinity diagrams, SWOT diagrams can be a GDSS tool (3.4.3). The horizontal axis runs from weaknesses to strengths, and the vertical axis runs from threats to opportunities (Fig. 7.8).

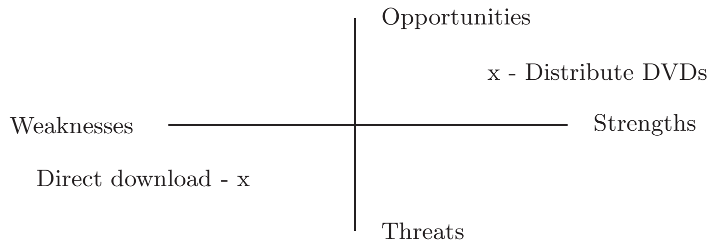


Figure 7.8: Example of a SWOT analysis for the video-store example.

7.3.4. Tacit Organizational Knowledge, Organizational Memories, and Lessons Learned

Tacit Organizational Knowledge

Tacit knowledge is difficult to capture. It includes know-how and the knowledge employees have about "the way things actually work". It is the context-laden, implicit knowledge that people have about their work and its procedures, which people follow often without being able to articulate their reasoning for it. If the tacit information possessed within organizations could be captured systematically, it could be put to many practical uses, such as training new employees, as well as simply being a vast source of useful information. Capturing this information creates an "organizational memory," which could be invaluable if the staff changes, for example. Tacit knowledge can sometimes be captured with improved procedures. Knowledge creation from tacit knowledge[68].

In other cases, it is inherently ill-defined. Artifacts such as jotted notes and emails can be physical examples of this tacit knowledge, however they are generally not satisfactory for creating organizational memories because they lack sufficient context [25]. A variety of techniques have been proposed for capturing tacit knowledge organization members and other "experts"; the techniques are generally known as "elicitation" or "extraction". Another strategy explores informal workplace interaction. Dialog and task description (6.4.0). Formalize tacit knowledge. For instance, an internal Wiki allows sharing and discussion of ideas.

Bureaucratic Organizations versus Learning Organizations

Organizations must find a balance between being rigidity and flexibility. Some organizations tend to become bureaucracies — they adopt routinized practices[84]. Having a strict routine can be very efficient when the environment is highly predictable. However, it is very difficult for such organizations to adapt to new conditions. Disruptive changes [42]. When the environment in which an organization operates changes, and all environments eventually do change, the organization needs to adapt. Knowledge capture and reflection: after-action review, mentoring, communities of practice.

Structured organizations often develop an orthodoxy which makes them slow to change. Making traditional organizations more adaptive. Encouraging organizational innovation. Learning in organizations has been characterized as involving a double loop (Fig. 7.9), that is there can be adaptation within a given structure or the structure itself can change. Some organizations are so flexible that they can make these loop changes seamlessly, but those organizations also often have high overhead.

Records and data warehouse (7.4.4). Sales. CRM (8.12.5).

Focusing on quality rather than immediate costs may result in a long-term reduction of costs. Mature businesses may focus on Six Sigma[21] efficiency and TQM[47]. Quality improvement can drive customer

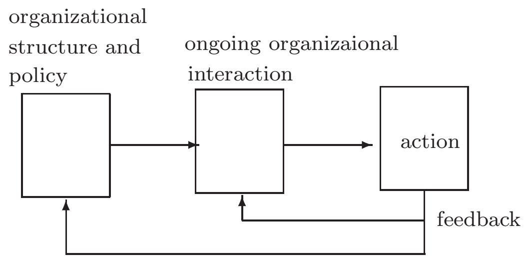


Figure 7.9: In most cases, an organization adapts to its environment but sometimes the organization itself needs to be changed. This is an example of double-loop learning[28].

focus and process improvement.

Organizational Memories and Lessons Learned

A learning organization collect information about itself which can be used in reflection [76]. There is often resistance to knowledge sharing in an organization. Adaptive organizations have a feedback mechanism in which the experiences and knowledge of organization members is displayed throughout the organization as a whole. These are learning organizations[28], which work by changing the representation and processing of information from an individual perspective to a community perspective. A learning organization typically learns to process information more efficiently.

Mechanisms for learning facilitating learning by organizations. Representations of organizational knowledge. Attempts to create learning organizations have sometimes focused on lessons-learned, which are attempts to summarize what was learned by different projects. It is necessary to describe these lessons by metadata, however, and there is a problem of context in the search field. What exactly were the "lessons-learned," for a given project, and how are they best described. Furthermore, because tacit knowledge of the lessons-learned variety is typically internalized by individuals, it is a social artifact and may reflect the social perspectives and demands of the individual who observed or created them and do not apply easily to other individuals. Lessons learned can be considered a type of failure analysis. Probably the most effective way to capture these lessons is in policies of organizational procedures. Science (9.2.0). Math (9.7.0).

7.3.5. Information about the World Outside the Organization: Environmental Scanning, Business Intelligence, and Competitive Intelligence (CI)

Organizations are affected by the environment beyond their boundaries. Therefore, it is essential to understand the environmental trends that may affect an organization or an industry. This knowledge can to determine business model and strategy. Environmental trends do not simply mean the natural environment — an organization's environment consists of all the variables that affect its existence in the world, including regulatory and political considerations, market forces, technological innovations, worker relations, competitors, and innumerable other factors. Developing a sound strategy necessarily involves taking stock of these trends as well as the position that competitors are taking in response to them. The more complete a picture an organization has of its environment, particularly the place its competitors occupy in that environment, the less uncertainty it will face and the better strategies it can devise. One method of reducing uncertainty is to increase environmental scanning. This might include observing how other businesses are dealing with the uncertain environment. Normally an environmental scan would use public resources but these analysis techniques such as data mining can also be applied. Asking the right question is a challenge. Intelligence analysis. (sec:intelligenceanalysis). Potentially, this can be captured and stored in model such as those employed by DSSs and MIS environments.

Business intelligence report identifying trend in computing and evaluating their potential for disruption.

An important aspect of any business is a thorough understanding of competitors' strategies and capabilities; this is known as "competitive intelligence" (CI). Two companies in the same field may have

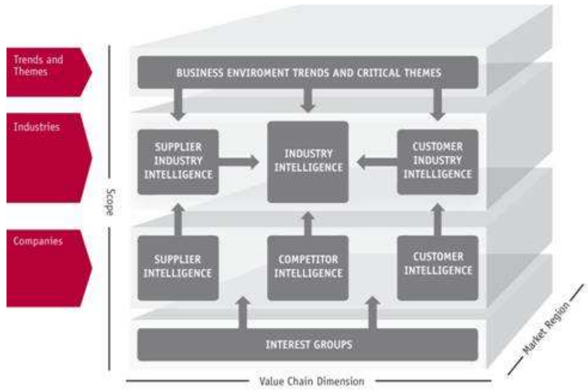


Figure 7.10: Competitive intelligence. (check permissions) (redraw)

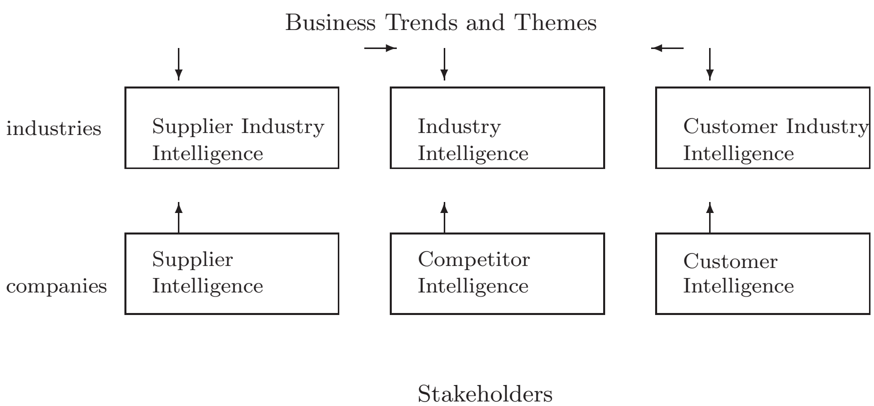


Figure 7.11: Competitive intelligence requires intelligence at several levels including broad trends, developments within industries, and specific companies. (check permission)

very different strategies and different business information needs. Collecting information on each other may show that one has a better strategy, which could force the other to mimic it or be outperformed. Understanding the context in which organizations operate is essential to understanding gathered information. Information is valuable only if it is known how to use it. Competitive intelligence ranges in scope from researching a competitor's publicly available company profile to developing a computer model of the competitor using insider tips. More than simply seeking any information about a competitor, CI seeks to answer the question "what types of information would be most useful," and attempts to acquire it. understanding the competitive advantage can help formulate a business strategy.

Forming a mental model of the competition. An analysis of competitors could include the way they are reacting to the environment. A further level analysis would examine the competitors' competitive strategy. That could employ game theory (3.4.1). Developing models, such as financial models (8.11.4) of how competitors are responding to competitive threats.

Ethical principles should always be applied in information collection. There are permitted resources as well as illegal ones. CI is not business espionage — it is simply a means of collecting, analyzing, and using publicly available information to form organizational strategy. Others do not always play by the rules, and information security is needed to prevent business espionage (7.10.3).

Due diligence about a company. Voluntarily released information for instance before entering into a contract. Checking personal information but also confidential.

7.3.6. Organizational Information Management Systems

An Organization's Strategic Knowledge

The most important information in organizations can be called "strategic knowledge". What does the organization know and what does it need to know in order to facilitate decision making. Having a top-to-bottom understanding of a company, with solid information, can help in reaching effective decisions. What is an organization all about? Understanding an organization's niche is central to sound decision making. Does it make sense for an organization to both make medical instruments and run a fast food restaurants? An organization's core competencies (8.11.2) are its foundation.

Information management can provide a competitive advantage for an organization. Information about a company could be contained in formal documents, but could also be the situated knowledge of several key employees. Dispersing that knowledge throughout the company creates the conditions for informed strategic planning. It is important to identify the bottlenecks that prevent the flow of information need to identified and removed.

Business processes (8.11.2).

Strategic management seeks to combine and organize all of the necessary requirements for maneuvering a company to a better fiscal position. This involves much in the way of decision making, which in turn, requires excellent information. Specific systems for processing information in an organization can be instituted to facilitate strategic management processes, such as decision support systems (3.4.2). These seek to utilize all of the internal strategic knowledge that is available within a company and make it centrally available for use. Indeed, this can lead to an electronic records effort.

Enterprise Architectures

Describe enterprise-wide data and information management. This might be implemented with a service-oriented-architecture as a service-oriented enterprise (SOE). Business reference models. Common information model. Office information systems. Roles for managing access and permissions. Emphasis on business processes but remember the perspective of practical action (3.5.1). Paper is still common in offices and photocopying is often critical to information management in offices.

Organizational Information Structure: Silos and Stovepipes Organizations need to balance the control of information with the advantages of the free exchange of information. Sharing Information Resources within a Knowledge Community. Many organizations keep information for different departments or divisions in separate locations. These different locations can easily become over compartmentalized and turn into "silos" or "stovepipes" Sometimes there are good reasons for carefully managing data, such as security and organizational culture. On the other hand, excessive protection can lead to poor communication and lack of information where it is needed. However, there has to be a balance between the need for security and knowledge. Data management issues (9.6.3). Organizations may stake out turf by trying to control how language is used. Beyond boundary spanning.

> It is well established that United States' intelligence gathering capabilities are severely hampered by the lack of information sharing between agencies and further weakened by the absence of an adequate system to analyze the intelligence they collect.

Figure 7.12: Testimony about the problem of "silos" in the US government at the time of the 9/11 attacks[30].

While one of the primary functions for organizations is the effective coordination of information, aspects of organization that sometimes lead to the distortion of information. There are many impediments to information flow within an organization. There are institutional procedures that promote information security that prevent communication between various departments; there are individuals who hoard information out of contempt for others, or because they do not understand either the need or the technology of the information system. Sometimes individuals or departments have conflicting goals and seek their own achievement at the expense of another individual or department, or fear the reverse. Indeed, organizational players can take advantage of these tendencies[92].

Document Management Systems

Document management systems are information systems that are designed to be closely related to the tasks of knowledge workers. These area also closely linked to Electronic Records Systems. Electronic document and records management systems (EDRMS). Combined with records management (7.4.1). Document management focuses on providing knowledge workers access to a variety of materials that are related to current work. Document management systems are like digital repositories, though they are often more interactive than ordinary repositories. They may include versioning capabilities, allowing documents to be time and date stamped to determine whether they are the final iteration of the ideas they represent. Document management to support the entire document lifecycle (1.4.1). For instance, after the active use of a document is completed, it may be "locked down" in the repository so it can be viewed but not revised or deleted. Office information systems. Tools and environments for sharing information resources. Chat services within an organization. Records (7.4.1).

Roles. Permissions. Workflows.

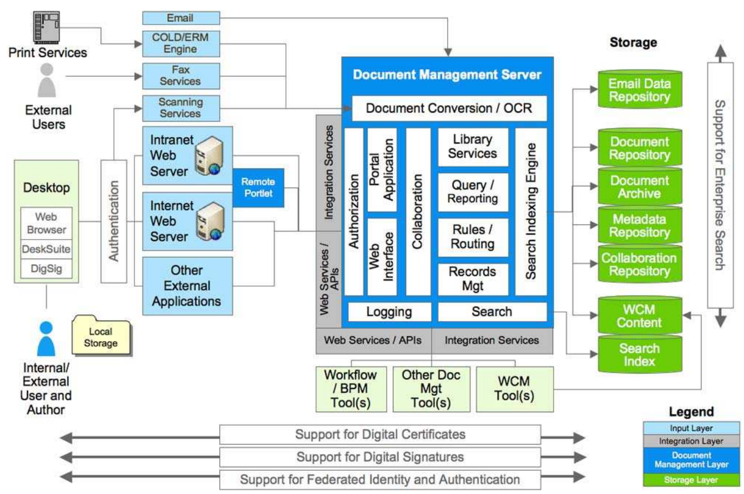


Figure 7.13: Organizational document management system. (check permission)

Enterprise Content Management

Keeping the information systems consistent in a very large, distributed, or dynamic organization can be difficult. Enterprise content management systems are total systems designed to manage all the information associated with any given enterprise. They control and track the information flow in organizations and make knowledge available where it is needed.

In addition to organizing and storing the information contained in an organization, enterprise content management systems are also designed to control the flow of information and put in the hands of those who need it. Taxonomies for organizing enterprise information. This many be use because almost every business has a different set of attributes.

topics

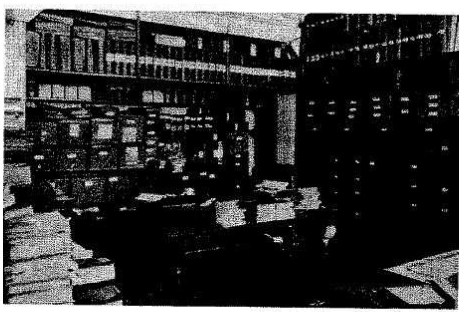
Figure 7.14: Organizational thesaurus.

Accurate descriptions of the resources make the content model useful. Capturing, coordinating, and updating organizational ontologies. Finding organizational information with enterprise search (10.11.1). Many indexing systems have been developed for business and legal applications. Semantic Web and ontologies for organizing information. Document management systems. Specifying an organization's information architecture. Enterprise classification, metadata, and taxonomies. From content management to eCommerce. Also need to manage access permissions. Thesauri are common for describing enterprise content. (2.2.2). Models based on organizational contexts. Enterprise applications. Composable applications.

In many cases, enterprise information may not be well enough defined that it can be easily managed (7.3.4). The management of information should aim to make information available when and here it is needed in an organization. That is, the information value chain [9], which we introduced back in the first chapter, needs to be managed. By streamlining organizational processes and facilitating communication, knowledge management systems can also produce better decisions, and thereby reduce risk. Risk is inherent in business, and acts as a constant. Institutions are often risk averse. Knowledge management systems that allow the sharing of information across a wide spectrum of organizational operating arenas produce an information environment in which better decisions can be made. By knowing the downstream consequences of actions, risk can be managed.

In some cases, especially for some businesses, information resources have value. Publishing and management of information as an asset (8.13.1). Information is an asset of an organization. Because information has value, it is worthwhile spending capital on it. Enterprise level risk analysis and assessment.

Procedures for information security in organizations. Part of organizational roles and norms. DSS (3.4.2). Intranets (Fig. 7.15).



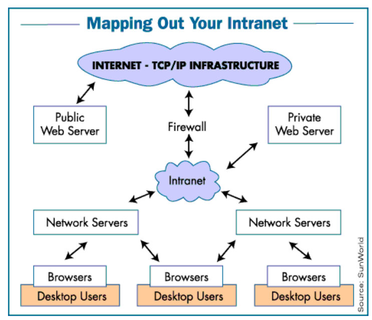


Figure 7.15: Internal information about an organization (right). These days, the information would be kept on the organization's intranet (right). (check permission) (redraw)

Policies are needed for managing corporate information such as employee email.

Impact of Information Systems in Organizations

In every model, however, information, about the company in question and its competitors, plays a central role. The idea that knowledge management systems offer a competitive advantage over other companies is itself not without debate, however. It has been argued that while a lack of any sort of information technology system is a disadvantage to a given company, knowledge management systems do not offer a specific advantage in today's world because the technology for them is almost ubiquitous among all companies[39]. Business process re-engineering (8.11.2)when business conditions change.

Information map. Knowing where to find information in an organization. Overview of an entire organization's information products.

Changing organizational culture is not an easy task. Often, the procedures and outlooks of an organization are firmly entrenched in the mindset of all members. However, because organizational culture is at least partially a result of business practices and operations, often the first step toward cultural changes is to change the way an organization is run. This is sometimes described as un-freeze, move, and re-freeze an organization's practices. Learning organizations (7.3.4). Metrics for knowledge management.

Cost-benefit analysis (7.10.3). Impact of computerization on organizations[75].

Organizational transitions. Mergers, acquisitions, change of management. Difficulty of changing organizational culture.

7.4. Records and Records Management

A record describes a transaction. There may be records for government, businesses, and even individuals. Because it describes a transaction, a record can be very useful as evidence. Thus, it is important to ask how should we manage the record so that it remains as persuasive evidence.

In some areas, records overlap significantly with archives which are considered below (7.5.1). In addition, Records also overlap with the management of data sets (9.6.0). Good records management is an essential aspect of accountability and transparency.

While there is a lot of variability in the way the terms are used, we may say that records management is concerned with the information while an archive is concerned with keeping the physical or perhaps digital manifestation of the transaction. In addition, business records management is closely related to knowledge management (2.2.2). Knowledge management often focuses on supporting the information needs of an organization while records management emphasizes the storage and re-use of records. Obviously, these are often highly interrelated.

There are generally many legal requirements for formal records. For instance, they should managed in a way that they can provide legal evidence (8.5.4). Reliable records in laboratory notebooks are needed for patent claims (9.6.3). Guaranteeing authenticity. Fixity is the requirement that a document retrieved from an information system is identical to the original. Properties of record-keeping systems. Information security (7.10.3). Distinguish between keeping the document and keeping the record. Data governance.

7.4.1. Types of Records

Records are evidence of events or transactions by organizations and governments. The functional goal is accountability. Typically, they describe administrative activities. In a business, records can include invoices, shipping tickets, payroll accounts, and database transactions. Many formal records management systems focus on business records and often don't consider other types of records.

Records found in other areas such as medicine and government often have specific policies and systems. In medicine, patient records are essential for effective treatment (9.9.3). Documents such as marriage licenses, birth certificates, immigration records, property deeds, and government records such as budgets and laws, as well as transactions such as real-estate sales, need to be open for public inspection. Family records. Records of natural phenomena such as weather. Scientific data sets can also be considered a type of record. The concept of cultural records is closely related to the topics addressed in archives.

Records may be seen permeate modern society. This are somewhat closer to archival records. Web archives as electronic records. Such records may include: QUOTE emails, faxes, spreadsheets, databases, maps and plans, samples and objects, information in business systems, letters, text messages, minutes, policy and briefing papers, photographs, research data, social media sites.
locate emails, documents or information when needed, reuse valuable work that you or someone has done in the past, determine the most recent version of a document, produce evidence as to why a particular decision was made, protect yourself, your clients, citizens and the Government, support cultural, social and historical values, helping future generations understand history, society, culture and people. ENDQUOTE

Genealogy. Family.

Special requirements for some types of records.

Authenticity, reliability, integrity, usability.

Figure 7.16: Birth certificate. (check permission)

7.4.2. Records as Evidence of Transactions Relevant to Organizational Current Needs

Presumably, records will provide accurate information. Indeed even more strongly, records many need to provide legal evidence. There are often definite legal requirements to keep records. Records and lifecycle management. Fixed form, stable content, stable media, archival bond. Social function of records to provide continuity across time. Evidence versus legal evidence (8.5.4).

The management of these records is essential for the effective functioning of society. Archived records of property deeds are essential to property rights (8.7.1). Government accountability is greatly facilitated by public access to government records. Government open data. As discussed with regard to knowledge management, the ability of individuals to view the records and rationales for government actions is an important element of creating an informed citizenry. Archives are also important as evidence and for legal records. Indeed, the roles of Archives and Electronic Records management are closely related. Archives tend to emphasize the memory function of the collection but that is not a boundary. Furthermore, Archives tend to maintain documents which electronic records systems keep database like records. Records are a foundation for bureaucracy-oriented organizations and institutions.

Formal records are saved intentionally and they should be distinguished from other types of organized information. Records in organizations may be required to demonstrate compliance with regulations such as accounting records and standards and they often have a legal mandate.

To be useful they must have certain properties. Digital provenance. Accurate records are integral to any organization, large or small. A record is authentic to the extent that it accurately reflects the past.

7.4.3. Records Management

Records systems are more than databases management systems, because they include organizational policies. The policies and technique needed to ensure the integrity of records – that is, in their role for providing evidence. Security concerns. Ensure that the features of records shown in Fig. 7.17 are implemented. Not only are records need to be managed but non-records – those information resources which are not to be saved also need to be properly managed. This highlights the problems of using simple backup tapes as storage – they keep a lot of material beyond the intended records. A records management protocol has to manage: Legal holds in records require that they cannot be deleted because of a court injunction. Records generally intentionally destroyed when the legal requirement expires. Data preservation issues.

We need to have confidence that the records have not been altered or corrupted. Indeed, the legal admissibility of electronic records as evidence in a court depends on such confidence. Reliability can be enhanced with transparent and routine processes for record development and handling. best practice guidelines could formalize the procedure. Records could always be: created (a set of procedures for what constitutes a recordable action/event), created at the same point in the process, stored in the same place, maintained in the same way, and accessed by the same people for specific purposes. The need for trust in the records is similar to archives which we consider in Section 7.5.1. Procedures include regular audits (7.10.2), record security (7.10.3) and preservation policies. More broadly, the organization also needs a supporting culture for information management [**?**], an information culture.

Records are essential for complex social and organizational structure. Records management policies for businesses should follow the business processes and business rules (8.11.1). They must also follow legal requirements. A proposed set of functionalities, which indeed, could be implemented as services, are shown in Fig. 7.17. The attributes of effective records include attributes of the organization, of the system, and of the content. Ultimately, this can become a type of metadata. Functional requirements (7.9.1). Functional descriptions may minimize the need for subjective archival descriptions. Scenarios as an alternative to functional requirements.

Conscientious Organization
  Compliant (1)
Accountable Recordkeeping System
  Responsible: Assigned (2), Documented (3)
  Implemented (4)
  Consistent (5)
Functional Records
  Comprehensive (6)
  Identifiable (7)
   Complete: Accurate (8), Understandable (9), Meaningful (10)
  Authorized (11)
   Preserved, Inviolate (12), Coherent (13), Auditable (14)
  Removable (15)
  Exportable (16)
   Accessible: Available (17), Renderable (18), Evidential (19), Redactable (20)

Figure 7.17: Functional requirements for authenticity. Records should link back to the business processes which generated them. Attributes of an effective business records management program[32].

Records are live documents which are part of the company's activities.

Automatic capture of metadata upon creation. In practice these policies are summarized by ARMA GARP. Record keeping and economic development. Records serve a social function. Court records. Metadata for permission to access.

Edit and audit rules. Records audit and procedural audit. Transactional database. Record-keeping metadata.

Electronic mail which is required for ongoing legal, fiscal, audit, administrative or operational purposes must be converted to the most suitable storage medium for retention (e.g., bond paper, microform or electronic format). These materials must be classified and scheduled according to ARCS or ORCS (Operational Records Classification System). They are not classified as transitory records.

Figure 7.18: British Columbia government retention policy on treating email as electronic records[4].

It is, at times, necessary to make certain documents and records, particularly those involving government agencies, sensitive or top-secret. However, decisions such as those made by government agencies may later be disputed, and records of how those decisions were reached must be kept as part of the public record and made available publicly when the necessity of their secrecy has passed. The "Freedom of Information Act," or FOIA in the U.S. allows individuals to make specific requests for information from any U.S. federal agency, and these agencies must honor the requests as long as they do not violate particular amendments of the law. However, there are generally some limits of Freedom of Information Act releases such as national security.

Freedom of information and privacy protection (FIPP). Records and classification of content. There are several special applications of archives. Medical records. HIPAA for managing the privacy of medical records (9.9.3).

XBRL - extensible business reporting language[23]. This can provide consistency and greater transparency across companies.

7.4.4. Data Warehousing

Databases have been used in active business information system to long-term storage. The actual collection of records would probably be done with a database. Although many organizations do not employ full records management procedures, their databases are, nonetheless, a valuable asset of that organization. Indeed, complex organizations may employ many different databases. For long-term reference, these data need to be linked together and stored into "data warehouses", although, increasingly, businesses run integrated content management systems where they apply several of the techniques we have discussed such as organizational workflow (8.11.3). Enterprise Resource Planning system and a lot of data available. Big data (9.6.0).

Preservation of data becomes entangled with broader questions about the business rules reflected in those data and the metadata associated with the data. In short, the data needs to be treated as business records. Need by an organization for business records for auditing. The issue becomes collecting the right data across the enterprise. This often means reconciling the attribute definitions of the data, as the data models that contribute are not always consistent.

Data mining may be applied to a data warehouse. Increasingly, there are unified company-wide systems. However, one strategy involves organizing data in a cube — a so called "data cube" (e.g.,[88]) as a "star diagram" (Fig. 7.19). The Dimensional Data Model is less efficient than the Relational Data Model since it does not normalization of attributes but it allows greater portability. This is useful for obtaining a broad view of the interaction of components of the business (8.12.0). and the large amounts of data can be mined for potentially interesting patterns (9.6.5). Conceptual models for capturing organizational structure[79]. Data warehouses often use data mining. Increasingly, external information sources need to be incorporated into the data warehouse.

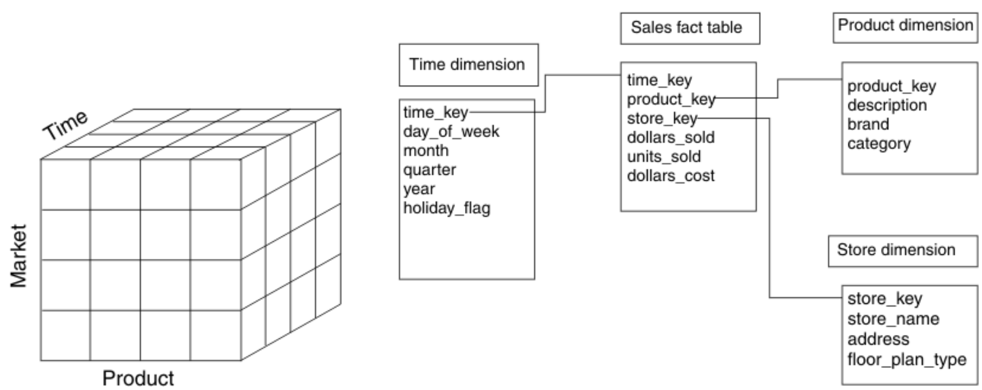


Figure 7.19: To consolidate and save the complexity of an organization's data files, an data cube (left) may be developed. This may implement dimensional data model (right), which is a simplified version of the relational model. (check permission) (redraw)

7.5. Archives

7.5.1. What is an Archive

People like to save things including information resources. Sometimes they save them as memories and sometime they save them as evidence. In some cases, the information resources may be saved systematically and specific procedures developed for them. Indeed, in some cases, that preservation may involve and entire institution.

While libraries typically hold published resources, archives hold documentary heritage. Cultural memory. Typically, this includes unpublished materials such as working notes, letters, and manuscripts. Compared to Records Management Systems, Archives hold information resources (even if they are digital) records systems focus on the information itself rather than the resource. Ultimately, we will need to go back to the fundamental concept of what makes a document (2.3.1) to understand the issues of how they should be saved. Indeed, the fact that archived documents are often carefully examined out of the original context of their creation means raises many deep questions about the nature of documents.

Archives covers a range of topics, from collecting and managing business records to preserving historical materials to preserving ancillary materials such as fan blogs.

There is a close relationship between Archives and Records. Indeed, some argue that they are identical. Although it is subtle and sometime contentious issue, we will associate the simple recording of transactions with electronic records and complex objects (whether physical or digital) with archives.

Whereas records often meet specific legal requirements, archives tend to emphasize cultural and societal materials. It may also include less that official organizational records such as email. Digital records do more than simply change the form of paper records. The cost on managing information is much most than the basic storage cost. Memory practices in science (9.2.0). The designated community is the community for which the archive is being developed.

Figure 7.20: Types of archives: A) U.S. National Archives, B) NASA data library. C) Film archive.

Transfer to an independent organization. Archival barrier.

Authenticity and integrity.

Archives keep materials for which there is just one copy. Uniqueness. Often, these were created without focusing on whether they would be saved. Providing authenticity and reliability. There are several types of archives, cultural, organizational, government, business, and personal. Each of these has distinct challenges but they also have issues in common. There are several viewpoints about the way for archives to record social and organizational activities. Here, we consider three of them:
1) Collection of documents from an organization.
2) Capturing organizational practice.
3) Documentation based on a specific initiative or activity.
Evidence and memory. Archives can provide valuable documentary evidence for history (5.13.0). More than organizational archives. Cultural archives.

Ideally, archives would dovetail with knowledge management. Similarly, the goals of archives are similar to electronic records. Together, archives and records provide evidence to provide accountability and information. Archives are views as providing support for journalists and historians while records are more often associated with business compliance. Archives and the content lifecycle (1.4.1). Archives and workflow. Archival information model.

Difficulties in the literal meaning for preservation since the meaning will be different for different viewers. This does not keep the context of the original records (Fig. 7.21).

Archives, like libraries and other information systems, need information management policies. In some cases, the goal is legal evidence (like electronic records) and the value of cultural memory. Game preservation (11.7.3). Archives of scientific data (9.6.0), technical, social, and medical data (9.9.3),

In many cases, archival material is effectively a record but we may make a distinction between the

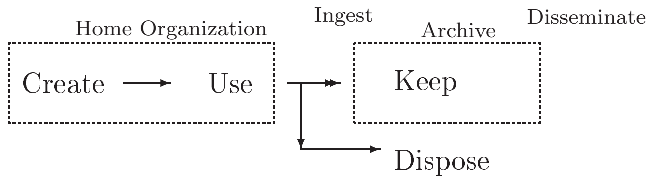


Figure 7.21: In the “Lifecycle model” of archives, material is transferred to an archive from its home organization. Among other issues, this creates a strong distinction between Electronic Records and Archives. A second model, the Continuum Model, emphasizes the continuity of records and the frameworks of record-keeping systems.

physical objects and the record it contains. Archives are repositories that store and protect the physical manifestations. Community memory can be a type of social capital.

Archives are often confused with libraries, but they serve a different function; archives emphasize preservation. While a library usually collects published works, most of the holdings in an archive are unpublished. Furthermore, the archive is typically focused on preservation while the library is focused on providing access to information. These materials are kept for historical analysis. However, maintaining archives for an entire government or organization is a difficult task. An archive should have standards for record selection, maintenance, preservation, and conservation. Preservation for long-term access.

Changing nature of organizations and continuum model (Fig. 7.21). Archives must be supported by an organizational commitment. Hand-off from the originating organization to the preserving organization.

Documenting versus traditional archives.

The United States National Archives in Washington, D.C. is the main repository for U.S. Federal Government records. The U.S. National Archives also houses important historical material, including the originals of the Declaration of Independence, the Constitution, and treaties such as the approval of the Louisiana Purchase. Treaties and agreements between the U.S. and other governments are also kept in the archives.

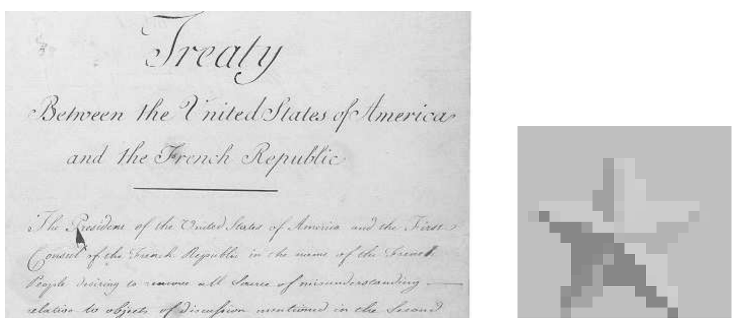


Figure 7.22: The original of the (left) Louisiana Purchase Treaty is kept in the U.S. National Archives. It helps to demonstrate that the Louisiana Territory belongs to the United States. Forgery (right) can be especially easy with digital documents.

Trust from several sources. From well managed repositories and from inspection.

Integrity and authenticity. Cannoicalization.

Documenting vs archival practice.

The Role of Archives

Film archives. Historical societies are also related to archives. Historically, one of the best ways to validate the authenticity of records was to verify the authenticity and age on the medium on which they are inscribed. Convergent documents provide evidence vs. Smoking gun. What to make on digital documents that have not be kept in a trusted environment.

Archives serve the need to keep information resources for the long-term. These are intended to be used as support for investigations by historians (5.13.0). This is traditionally focused on access. Archives are often associated with processing cultural and materials of historical significance while electronic records (7.4.1) are more often based on legal requirements.

Thus, the provide organizational or social memories." Institutional archives versus personal and informal archives. Many other types of preservation efforts: Meeting archive (5.6.4). Group and design archives. Design rationale (3.8.7). Data warehouses (7.4.4). The goals and ambitions of archival institutions are already changing. Popular memory archive. Archives versus memorials (4.6.2).

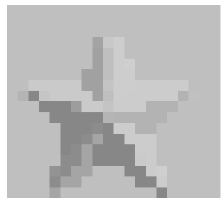


Figure 7.23: CEISMIC disaster archive.

7.5.2. Persistence, Preservation, and Conservation

Obviously, we want confidences that the material we save in an archive is not tampered with. An emphasis on persistence is the most distinctive aspect of archives. While we emphasize capturing practice, many archives emphasize capturing and management of documents. Some information resources may need to be kept for a very long time. Records and archives can give future historians the evidence on which to base their analyses. Because there is often social re-interpretation of history, documents can be valuable for "showing history as it really happened"[52] (5.13.0). Sustainability.

Government documents, such as treaties need to be protected (Fig7.22). Archives have more emphasis on persistence than libraries, and attempt to follow the S.O.A.P. doctrine: selection, organization, access, and persistence. While libraries periodically cull their collections of outdated and unused materials, the content of an archive is often kept on a specific schedule. Preservation plan.

These materials may need to be kept indefinitely because they are of historical interest, or because they have a very long life, such as treaties, contracts, or blueprints of buildings. There are certain terms associated with archiving that are important to understanding the field. Preservation only focuses on preserving the content of an information resource, and not the original resource medium. Preservation of the Declaration of Independence would be to copy the words. When a fire damages a valuable or famous painting, great effort is made to minimize the damage and restore it as nearly as possible to its original condition. In contrast to preservation, this process of protecting and restoring content in its original form is known as "conservation. Focusing on the carrier of the information or the content. In many cases, the medium and the content are not as inseparable as a painting on a canvas; in those cases we care more about the content than the medium. Keeping the original paper census records from 1920 (conservation) is not as important as keeping the data that was obtained in that census (preservation).

While procedures for archives are now well established for organizational records on paper, preservation of many other materials Preservation of multimedia or hypermedia content. Not only does each component need to be preserved, but the coordination among them also needs to be preserved. In the extreme, we may wonder how well would our culture be preserved if a new dark ages started in the next few years[11].

Just as human memory can be distorted by changes across time, cultural memories can also be distorted with time. Some of these issues can be reduced if we know that the material has not been directly corrupted and if some of the context (e.g., the workflow which generated the artifact) are maintained. Nonetheless, there remains a difficulty in interpreting archived materials.

Keeping track of the use (or re-use) of records and archival materials. Indeed, the reuse is often as informative and interesting as the original document.

Archives may also store documents from meetings, or scientific information such as astronomical and environmental datasets (9.6.3). These are typically collected via the agency for which the research was done. Personal papers (10.1.6) are also often archived, though on a scale of lesser magnitude. Archives need to provide at least limited access for use.

With archives, the emphasis is typically not on ease of access but on the integrity of the records. When records are stored, we need to know whether or not they have been tampered with. Trust in the authenticity of documents must be based on effective policies for the management of documents — without confidence that the archived materials are authentic, the entire reason for archiving them in the first place is lost. Increasingly, cultural records are stored in electronic form. Thus, the traditional methods of preserving them by saving papers and books will no longer work. Moreover, the Web is much more dynamic and contextual than printed archives. It may be necessary to save entire Web sites and not just Web pages, because a page should retain the context of its links. Culture (5.8.2). Lost books[58] and lost movies.

Policy-driven repositories. Capture early in the workflow process.

InterPARES rule.

Figure 7.24: Example of policies for developing a trusted repository.

7.5.3. Developing an Archive: Appraisal, Selection, Ingest, and Retention

Imagine that you have been asked to archive somebody's computer files. One of the greatest puzzles is what to save. Would you save everything, or just "important" documents? Only material that was selected to be saved is available later. How would you know what was important? Although it is tempting to try to save everything, it simply isn't possible. Is there a bias toward collecting only certain types of material – for instance, material representing only a given sector of society?

Ideally, archives select systematic and value-neutral selection of material. It is difficult to decide what cultural objects should be saved[81]. Often, those with power and money are preserved. Underserved communities are often not well represented in archives.

Appraisal determines the archival value of documents. Collecting the evidence in the context of the workflow. No interpretation of the documents.' Automated preservation assessment. Risk analysis. Earlier we considered the document lifecycle (1.4.1). Where in document lifecycle is the document brought into the archive? Continuum model[82] and duality of viewpoints about the archive. Documentation strategy. Documentation could also apply to scientific data sets. Attempting to determine the temporal dynamics of the value of data is difficult. Macro-appraisal emphasizes determining the context. This is often associated with finding organizational function of documents.

Protecting personal and private information.

Archives might be based in the organization where the documents originated. But it is often better to turn over control to an independent organization. Moreover, archiving is a specialized skill and organizations are not well suited to judge what should be archived due to changing policies and goals. Indeed, they may be tempted to selectively pick records which cast them in a favorable light and to destroy any unfavorable records. In other cases, the selection may be integrated into ongoing workflow. Functional appraisal.

Retention is built into organizational policies These policies may include what description of content to keep and for how long it wants to keep it. These are known as permanence ratings (7.5.4). Dynamic Web (10.10.1). In other cases, records need to be examined by an archivist as they are transferred into the archive. An archivist will choose documents for archiving based on a set of retention guidelines (Fig. 7.25).

> The Preservation Department should seek to raise awareness of the importance of library preservation, and of the need to identify priorities for preservation in [Glasgow University Library] GUL as a whole. This will involve discussions with departments and subject specialists within GUL, so that specific recommendations can be put forward regarding the selection of materials of significant bibliographical, historical or aesthetic value which should be preserved for the benefit of research and scholarship in the longer term. Consideration should be given to the rarity or uniqueness of the materials in our collections, their national or international significance, and to our own local needs and special interests, bearing in mind the possibility of placing such materials under restricted conditions of use, and of storing them in a specially controlled environment. Where appropriate, material will be selected for re-formatting as microfilm and/or digitally scanned files to limit unnecessary handling of originals and to facilitate access.

Figure 7.25: Preservation policy for the Glasgow University Library[51]. (check permission)

Broadening the base of archival practice through social media. Moreover, the availability and relative low cost for digital materials make preservation and linking across a wide variety of materials more feasible.

The development of retention policies. should help determine the materials to save, as it is difficult to know what might be important in the future. Indeed, because documents help to define history, the selection of which documents to save can, in a sense, affect history itself. There are different strategies for archiving. Some say that documents that are used regularly should be saved. Others argue that random sampling is the strategy, because it is difficult to predict what may be useful in the future. Once the material is selected, it must be "accessioned" or "ingested". This means that ownership of the material is typically transferred to the archival organization and it is incorporated into the archive. Workflow processes for ingest. Less process more product. Supporting access to materials. Risk analysis in copyright.

7.5.4. Description and Access for Archival Items

Earlier, we considered bibliographic metadata (2.4.0); here, we consider archival metadata. There are several particular challenges for archival metadata. It should be able to be understood by people from a different cultural background. In a different sense, the context of one item in a collection of items is essential. There is a particularly close connection archival description and electronic records (7.4.1). Traditionally, individual items are not described but sets of materials with similar provenance are described. The ordering often provides valuable context. Increasingly, we see multiple modes of description. Quality in the collection and management of data. Rights and responsibilities of data.

Organization related to the preservation model of the archive. Fonds, Series vs. Function.

Description to Support Users of Archives

What sort of description do historians need?

Provenance and Provenance Metadata

Provenance is the history of an object's ownership or, at least, control of it. Thus, provenance can help to guarantee its authenticity. Across a sets of records, provenance may be seen as a process for ensuring authenticity (7.5.2). One of the strongest ways to establish provenance is tracing a chain of custody. Provenance has applications in the history and origin of information resources: what was created, where, when, and for what purpose. This helps to ensure that information is not tampered with after it has been deposited.

Provenance tells us about the origin of information and it provides an indication that the information has not been changed. For instance, attribute of records is their organizational history. It is helpful to maintain an account of where and when each piece of information originates; this is known as its "provenance". Managing the provenance for information resources is analogous to tracking the provenance of physical objects (7.6.1). Provenance through chain of custody in trusted repositories. Tracking provenance helps to demonstrate the authenticity of the materials because the origin of information can be authenticated either by eyewitness testimony or by its logical consistency when compared to other information from that time and place. Digital provenance for conversions between formats. Provenance data models and transaction logs. Provenance metadata.

The full import of some material is not evident from the material itself. It is only when it is seen in its proper context that its meaning becomes clear. For some archives, it can be important to maintain the context of the source material. This can be troublesome; an archive usually holds only a fragmentary record of material that is old and was often not created to be widely distributed, and recreating its context might not be possible. Sets of documents may belong together because of the activities which generated them [77]. Difficulty of capturing tacit knowledge. Context tells us a great deal about information resources. Keeping a rich context.

Formal models for provenance.

Preservation Metadata

We have already noted that preservation is a integral part of the information lifecycle. And, of course, preservation is the most distinctive function of archives. As with other types of repositories, metadata are essential for supporting access to archival records (2.4.0). PREMIS vs Functional Requirements for Records. PREMIS is especially useful for digital objects. For instance, it describes Events with change the object such as transformations. Close to some standard which are familiar to the records management community. Technical environment metadata.

Metadata for dynamic documents (10.10.1). However, there are several distinctive aspects of archival material that needs to be considered. Preservation and context. Thus, "preservation metadata" might include a description of the reason the material was selected for preservation (e.g., [14]). Events associated with maintenance. Some archival content is intended to be kept forever. Other content has a finite lifetime, which may be indicated by "permanence ratings". These describe the permanence of the informational content itself, and not its desired archival duration [16] (Fig. 7.26).

Label	**Description/Example**
Permanent: Unchanging Content	The original copy of a treaty.
Permanent: Stable Content	An edition of a book.
Permanent: Dynamic Content	Today's newspaper.
Permanence Not Guaranteed	An ordinary Web page.

Figure 7.26: Permanence levels as descriptions for records[16].

Another problem is guaranteeing that a digital document is the original and has not been tampered with or altered. This can be done with hashing and checksums (-A.20.2). Another possible solution is to compare the file with other archived copies of the document to see if they match [72].

Formats and Representation Information

Representation Information Media formats versus file formats. How is a file format structured? Format repositories. Global format registry and validation. Format validation [54]. Some formats are so complex, it is difficult to understand them out of context. Preservation for especially complex design tools such as CAD systems here are particular challenges in the preservation of complex material such as architectural design, descriptions of cultural heritage sites, games, and new media art. Desiccated formats reduce the complexity of data set to just a few salient features. Self-describing content. Metadata can be wrapped with the object. Self-archiving content.

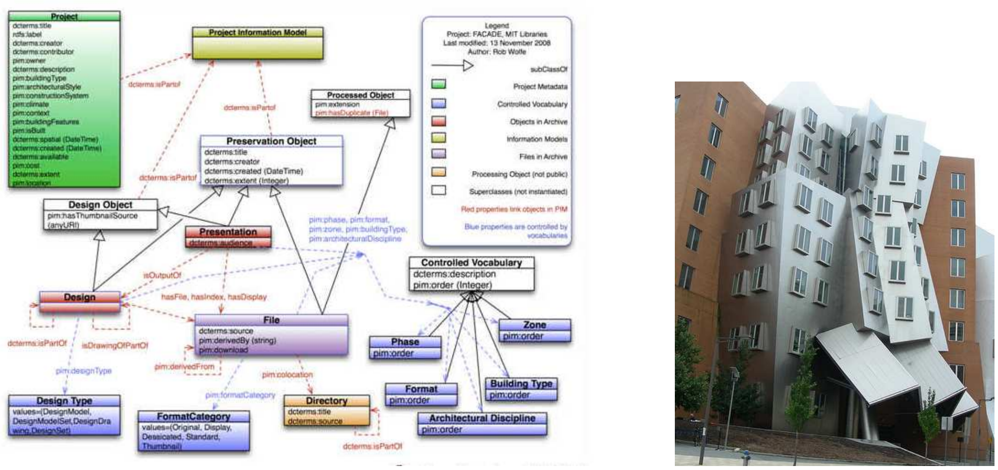


Figure 7.27: Describing the properties and relationships of a complex set of files related to a archivtecture. FACADE project ontology[64]. (check permission)

Archival Context

Describing objects in context is helpful because individual item will not tell the whole story. One organizing principle, the materials an attempt is often made to keep the context in which material was developed and used. This often mans keeping the materials in their original order; that is in the order in which they produced and used rather than the order in which they were stored or processed by the archive. The original order can be useful in providing the context in which they were crated.

Indeed, the entire collection of items may be considered as basic unit. This can be complex because because the actual collection may not be complete or it may be biased because it reflects selection decisions.

This is often different from the description of separate objects. That is, they are organized according to the way they were originally developed and used. Email messages might be kept in the order they were received, grouped by year, rather than by topic. For material stored in this way, one would access a record group, and then search through that group to find a specific record.

Figure 7.28: Archives typically try to capture the context of objects. Indeed, they consider several senses of context – how the object relates to other objects in the way it was used. (check permission)

Organization or Community Role Describing a complex combination of organizational functions. Archival series. Activity theory for archives.

Use after Ingest Interpretation of the artifact based on how the artifact in used and interpreted in that re-use. Continuum. Commons.

Finding Aids

Some archives collect assorted materials such as the files from a person's desk when they retire. In those cases, a "finding aid" could help a searcher to find out what sort of materials are included. The

Encoded Archival Description (EAD) is used to describe records in traditional archives. This finding aid is based on XML and it defines parts of an archived document. Increasingly, finding aids are being adapted to be sort of under interface to an archival collection.

Next generation finding aids and Web 2.0[91].

Overview of the Collection
Biographical History
Scope and Contents of the Collection
Arrangement of the Collection
Restrictions
Subject and Genre Headings
Related Material
Administrative Information
Inventory

Figure 7.29: Because most items in a traditional archival collection are not cataloged directly, sets of items are described in Finding Aids. Typical top-level sections of a finding aid. (check permission)

7.5.5. Preserving Complex Digital Materials

While conservation efforts generally focus on traditional materials (7.5.2), they are also necessary for digital media. Although the bits which comprise digital objects are ephemeral, they must be stored in some physical medium, which may be fragile. The iron oxide holding the bits may fall off a magnetic tape, making it unreadable. Archiving techniques must address the formats to be used, and devise methods for ensuring their future viability. Data curation (9.6.3).

Modern information systems have created new demands for archiving practices. There is an enormous volume of email, word processing files, and Web pages already extant, with more being produced every day. Should all of these documents be archived? Increasingly, there is a convergence between digital libraries and digital archives because digital copies are managed rather than physical copies.

Email preservation. Beyond preservation of traditional documents. However, preservation of letters and manuscripts has been a traditional role for some institutions.

Game preservation (11.7.3). Preservation of multimedia depends in part on the resolution of the original. New media preservation. Describing the experience. Fan blog. Because of the rapid increase in the availability of disk storage, the criteria for selecting material can be loosened. Indeed, it been proposed that we can save everything[61] though that is often broad and we want to save a lot but not literally everything. We cannot literally save everything but we can save a great deal more than we used to.

Born digital materials often have links to other resources and those links are fragile. Evolutionary systems — those whose contents are continuously changing such as databases — provide a particular challenge to a database may record many of the transactions of a business, but it is subject to frequent changes. Is it necessary to keep all transactions and versions of that database (9.6.3).

One factor to consider is whether it is necessary to simply display the archived materials (maintain what the documents say), or whether their behavioral capabilities also need to be maintained such as the buttons on Web pages. Because of word processors and Web publication, revisions are easy to make. This has resulted in a proliferation of versions.

Preservation of complex objects such as games (11.7.3). Preservation of new media. Data curation (9.6.3).

Figure 7.30: Frame from a reconstructed NASA video of the first step on the moon. The original was lost.

There are a great many attributes of digital objects which could be saved. Among these are attributes of the computing environment which generated and accessed the digital object. This might include the version of the operating system and file creations software. Current operating systems makes this difficult. Indeed, there are so many possible attributes to save that some selection policies are needed to prioritize them.

Perhaps surprisingly, digital media are not necessarily better for preservation than traditional media. Indeed, modern information systems are very complex, and materials created by them often depend on the system that created it.

The recreation of every digital object requires a program. The management of relative standard programs such as word processors is challenging but the management of ad hoc programs can be even more challenging.

As with traditional archives, there is a range of content types for digital materials with different expectations about how they should be handled. One policy is that there should be multiple copies of every digital object so that if one is lost, the others will survive. Replication of the entire information resource can also be useful in case the originals of the resources are corrupted or lost. If this is managed automatically, these are "self-healing archives". LOCKSS (-A.20.2).

Preservation of functionality.

Both formats and base technologies change and several strategies have been proposed for keeping media current: migration, emulation, encapsulation. Other strategies include desiccated formats and re-enactment. Migration from one compression format to another is transcoding (-A.2.1). There are limits to this approach, however. For one, the amount of data to be transferred would increase every time. For another, it is rare that we have "lossless" format conversion, which allows the original to be exactly copied. This would mean that some quality is lost every time a transfer is made. Backward compatibility of standards and programs.

Attacks on cultural materials. Suppression of certain viewpoints.

Another possibility is to keep at least one example of every old computer, its environment, and the programs that created the records running, but this does not seem practical. The underlying operating system and hardware would have to be emulated and the emulations would have to be cumulative such that newer emulations would run on previous emulations. In the end, it is not possible to keep all versions of all base technologies running. Evolution by virtual machines (7.7.6). Fig **??** rendering (7.5.5).

Probably, the most practical current strategy for complex digital preservation is encapsulation, for which metadata is essential. Encapsulation associates metadata with objects, and organizes the objects

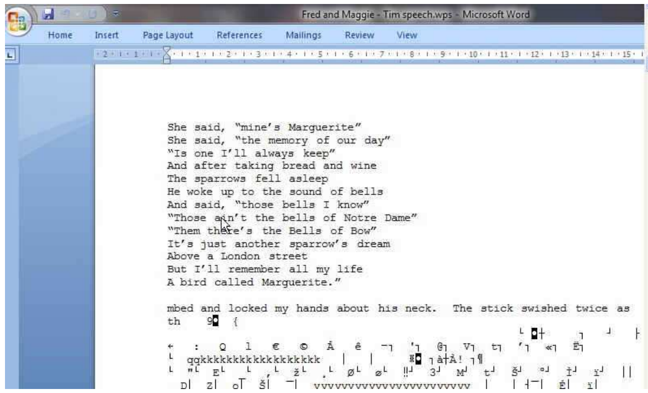


Figure 7.31: In many cases, an exact match for the software environment on which a program originally ran may not be available. In those cases, partial information may be retrieved. Here MS Word accurately recovered some information from a file but it also inserted some noise (from [?]). (check permission)

according to metadata similarities or logical connections. Encapsulation (7.5.5) is often applied when packaging digital objects for including in the file to facilitate later searching. Emulation appears increasingly to be possible. The application of emulation requires detailed knowledge of the software versions. Indeed, both migration and emulation have strengths and we may use both of the them.

Web Archives, Preserving the Cultural Record, and Mass Preservation

Many large digital collections are now being developed. Complete copy of the Web. Big-data (9.6.0). Mass digitization (10.1.6). Digital surrogates. How often should the web pages be sampled. Web curation tool for capturing and storing web content. Records need to be made for every page. WARC. Internet Archive and Wayback Machine. Managing copies of Web pages as legal evidence. Part of regulatory compliance for electronic records.

Figure 7.32: Democratic (left) and Republican (right) political party Web pages (cropped) from the 1996 presidential election. These are among the earliest sites preserved. This is an archive of political web pages[55]. Wayback museum.

Evidence and Forensics

Determining evidentiary value of an information resource. One set of issues for the evidence about physical media. Additional considerations for digital media. Several senses of forensics. In this case, we're considering whether a photograph has been tampered with Fig. 7.33. Trusted digital objects (7.5.6). Both legal implications and implications for scholarly accuracy. Determining legal evidence from examination of digital objects.

Figure 7.33: Digital Forensics: The ducks have been added to this photo. You can detect that by noting the shadows on the ducks but note that there's no shadow on the people. [?]. (check permission)

7.5.6. Archival Repositories

Trusted Archival Repositories and Trustworthy Digital Objects. Documents from archives come with a special expectation of authenticity. Trust from policies and procedures along with physical controls. The storage environment helps ensure trustworthy documents. For archives there is a special emphasis on ensuring the persistence and provenance of the stored materials. Thus, there is an emphasis on ensuring that repositories are trusted. This is similar to the issues of information security and information assurance and information system security (7.10.3). This can be accomplished with reliable storage media, stable organizational support, carefully considered formats.

Cloud repositories. Description of basic services. Open Archival Information Systems (OAIS) [40]. Reference model. Standard operating procedure. Policy-based service definitions, especially those that lead to a trusted repositories. Audits of the system (7.10.0). Certification of repositories as being trustworthy [53].

7.5.7. Archival Policies and Institutions

Information culture (5.9.5).

Access Policies for Archival Materials

Part of the the braoder question of policies (7.5.3). Ease of access has not been the primary objective for paper-oriented archives because of the difficulty involved in handling and indexing each page. Documents are often not indexed simply because of the sheer volume of material received; there are so many records that they cannot all be cataloged. Archives have not, typically, supported end-user access but that is rapidly changing with digital content. Because digital material is so easily copied it dramatically changed the possibility of access to archival materials. Access restrictions. Archival escrow.

Providing access can add a great deal to the cost of preservation. Dark archives emphasize storage of material but have a minimal concern with providing access [38]. This may be done to reduce costs or simply because of access restrictions.

Risk Assessment and Audit

Many data servers were lost in the 2011 Japanese earthquake. Potentially, many family records would have been lost but the records had be backed up at the national level.

Management of the preservation and migration of information resources. Project management taking care of these processes efficiently. Risk and threat analysis (7.10.3) for what could go wrong.

Preservation Planning Policies

Preservation planning is an integral part of a trusted repository. As with other information systems, there are many social dimensions to consider. Organizational aspects of information systems. Requirements for the archive. Risks for the integrity of the collection (7.10.3). Audits based on the OAIS model: Ingest, Storage, Dissemination. Organization structures for supporting the development and long-term support for preservation system. Cost-benefit analysis.

Sustainability of archives and organizational and institutional commitment.

Preservation of files versus preservation of data records such as in a data-warehouse (7.4.4).

7.6. Collections of Physical Objects

Physical objects such as artifacts and specimens can also be collected and those collections need collection management. Data schema (2.4.1) but also information about the relationship of the object to the institution. Metadata-like descriptions can be applied to physical objects. Emphasis on item-level description.

There are a great many types of physical objects and there are many dimensions on which they can be described. In other places we have discussed description of designs (3.8.4).

Here, we desribe the description of cultural objects. Primarily we consider museums which are cultural institutions but there are other descriptive approaches in fields such as archaeology.

7.6.1. Museums

Museums hold collections of physical objects. A particular sense of empathy from viewing objects. The primary role of museums is the presentation and interpretation of those physical objects for the public. While the main goal is education, preservation of rare or unique objects may also be important.

Types of museums shown in Fig. 7.34: Art, history, natural history, science museums. There are also many museums dedicated to unusual or distinctive materials. Research museums keep reference collections for use by researchers.

Figure 7.34: Types of museums: A) Art museum, B) History museum, C) Natural history museum, D) Science museum. (check permissions)

Interpretation and Recreating Experiences. Museums as keepers of cultural records serve a sort of storytelling function. Virtual and augmented reality reality for museums. Museums may try to provide an experience, related to the way artifact was originally used. Or, at least, they may try to create an understanding of the experience. What do the objects in a historical museum actually tell us?

Interactive, hands-on exhibits. Art museums may collection digital art works. Material culture.

Exhibits. Period room.

Museum Informatics

Museums are primarily based on the preservation of physical artifacts. They serve both research and education missions. However, this is tricky because memory can also be distorted. Indeed, science museums generally focus on demonstrations. Some of these descriptive systems are similar to those for data about entities in the world (9.6.0). Because there is an emphasis on public education in some museums, there may be an emphasis on interpretation of the collection. Reference collections. Science museums are equal parts educational institutions. There are controversies around the ownership of some cultural objects. Provenance of physical objects. Educational goals. However, they also attempt to make educational exhibits. Objects as evidence. Primacy of the physical object. This can be distinct from archives which preserve information resources. Thingness.

CIDOC-CRM for physical objects. Coordinating CIDOC with intellectual objects with Dublin Core and FRBR. This is also related to Schema.org (2.4.1).

Describing Cultural Objects

We also need to consider collections of physical objects. Some types of museums hold cultural objects. One difficulty is that physical objects are generally most meaningful in their original context [7]. Bibliographic description (2.4.0). Photos of physical objects as works. Compare physical objects to reproductions of those objects. Metadata extensions include Cataloging Cultural Objects (CCO) [7]. CIDOC-CRM and events.

Figure 7.35: Small statue of a Japanese god (add metadata, from the Spurlock Museum.)

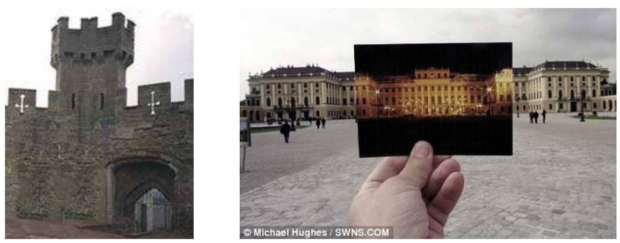


Figure 7.36: Describing parts of a building. (check permission)

7.6.2. Other Collections of Physical Objects

Objects in the field such as buildings. Some types of physical objects need to be indexed. Linking to explicit taxonomies and databases such as zoological and botanical records (9.8.1). These include zoos and botanical gardens. Data schema (2.4.1).

Interactive Museum Displays

Dioramas, exemplary specimen, comprehensive collection, interactive example.

Exploratorium.

7.7. Information System Architectures and Web Engineering

For the remainder of this chapter, we turn to considering technical issues which are associated with collections of information. Because information systems are complex, it is helpful to consider some principles. Through the evolution of information systems, there has been a decrease in hardware dependencies and increased alignment with services. Effectively using resources. Design (3.8.0). Reliability. Security. Scalability. Interoperability. Using resources effectively.

7.7.1. Networking and Distributed Systems

Networking (-A.16.0). OSI layers for managing complexity in a network (Fig. 7.37).

Network forensics.

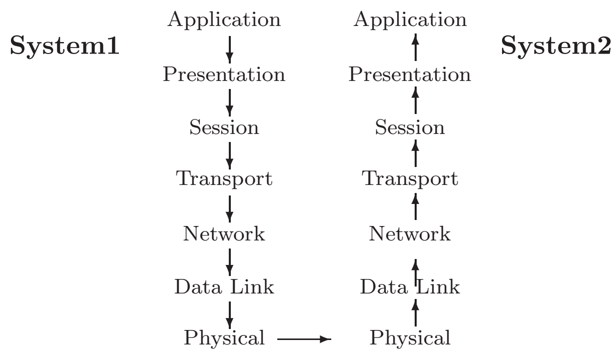


Figure 7.37: The combination of multiple network protocols makes for a very complex system. The OSI stack for networking manages this complexity with layering. In most cases, network protocols operate at only one of these layers.

Networking security (7.10.3). Playback attack. Some simple techniques are useful such as nonces and sequence numbers. Intrusion detection system.

Peer-to-Peer Systems

Peer-to-peer (P2P) systems are interacting sets of peer computers. Each of these are "peers" in that they are all equal within the network and there is no specialized servers or central coordination among the components. Thus, these are different from client-server architectures. Fig. 7.38 shows a peer-to-peer model in which each node has its own index and resources. Messages are passed from the originator to neighboring machines, with requests spreading outward from the center.

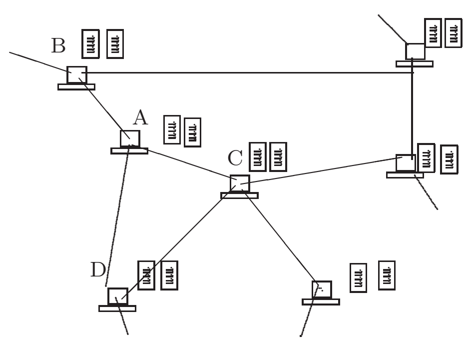


Figure 7.38: Peer-to-peer systems allow distributed searches without a centralized index. Rather, each peer has its own search index. A, B, C.

Searching in a P2P system spreads across the set of servers. With peer-to-peer systems, searches and document retrieval can be largely anonymous; the searcher can hide their identity. This anonymity is accomplished by stripping off identifying information as the requests pass each machine. Thus, peer-to-peer systems allow anonymous file sharing, but sometimes this may run afoul of intellectual property laws (8.2.2). Without a central index, the chance of finding a given item decreases as the number of items and nodes increases. In other versions of peer-to-peer systems, indexes can be progressively developed on each system. This is the basis of services such as Skype and Bit-torrent. Onion routing.

7.7.2. Global-Scale Information Service Platforms

Database foundations (-A.14.1). Networking (-A.15.0).

Grid and Cloud Computing

Support collaboration by distributed organizations. Overlay networks. Contracts for data management services. Service-level agreements. Many users are interested in protecting the value of the data

The Grid is designed to provide services on a very large scale. Later, we will also consider the "semantic grid" or data grid (9.6.0) but here we are focused on the network infrastructure. Grid coordinated database updates. To support the coordination of components there need to be standards such as consistent name spaces, metadata, and service descriptions. Cloud computing. Allows efficient use of computational resources. Security of cloud computing can be an issues because the data are not directly under the control of the owner. Federated searching has distinct types of searches in different clusters.

Europeana project has a federation of cultural objects. NIF has a federation of datasets.

Security issues for cloud computing.

An example of grid computing is the Search for Extra Terrestrial Intelligence (SETI; Fig. 7.39). SETI utilizes the spare computing power of thousands of ordinary home PCs to analyze radio signals coming toward earth from distant stars for any sign of extraterrestrial attempts at communication. This is a loosely connected type of Grid. Grid computing offers extraordinary computing power, but its development is still in its infancy. It will be necessary to develop user standards as well as security measures for grid computing. Other similar systems include. There are a lot of computationally intensive tasks which can be processed with this approach such as searching for the cure malaria.

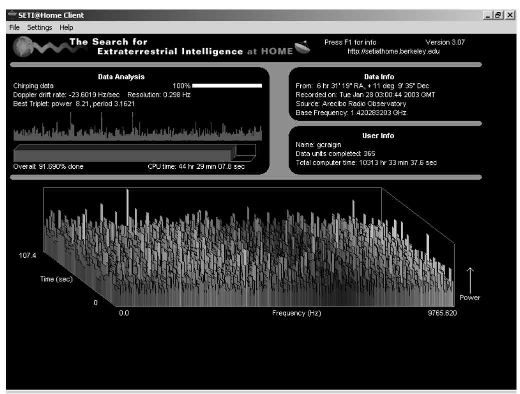


Figure 7.39: SETI@home distributed processing allows a networked computer to contribute un-used cycles to searching for extra-terrestrial intelligent life. This screen shows the results of an analysis of data from a radio telescope. However, no clear signs of extra-terrestrial life have yet been found! (check permission)

Tasks can be spread across computers on a Grid, workflow can be specified for completing tasks on the various computers. However, the management of data management on the multiple computers is particularly difficult because of synchronization.

Reliability of distributed network services. Stress test. Chaos Monkey.

File operations allowed. Public versus private clouds. Managing security for cloud computing.

7.7.3. Managing Networked Data

Different requirements for different services which provide the data.

Search engines have primarily push data. But there are back end challenges for web crawling. There are also challenges for indexing and real-time news feeds.

Data centers to support social media typically have a whole different set of challenges. Symmetry of friend relationships need to be updated. In addition, these have particular challenges for security.

Attributes of effective data specification (-A.14.1).

Cloud Computing

Virtual machines.

Data storage on the Grid is often provided by data centers (Fig. 7.40). Exactly what is being offered by the cloud. Service-level agreement. Quality of service (QoS) guarantees. Security issues and caution about placing sensitive records in the cloud. Difficulties of data centers for social network sites. Perhaps the greatest concern is whether the company or the country running the service is itself trustworthy.

Risk assessment for loss of a data center (7.5.7). Issues with legal access. For instance, what happens to data if the company which run the cloud goes bankrupt.

Figure 7.40: The Google data center in The Dalles, Oregon. Dams on the Columbia River (background) provide hydro power. (check permission)

Figure 7.41: This shipping container holds the entire Internet Archive. Potentially, portable data centers could be moved to places which had unexpected need for intensive data storage and processing. (check permission)

How much data storage is there? This is quite different from the question of how much information is stored but it is much easier to calculate.

Data Storage

Need increasing amounts for storage. Distributed file systems.

Challenges of cloud storage. While cloud storage is possible because communication costs are relatively small, they are not negligable. Is the data is replicated, then that replication must be synchronized.

Long term-costs of storage.

MapReduce. Google File System. Big Table[6]

7.7.4. Resiliance and Reliability of Information Infrastructure

As an engineering and policy question.

7.7.5. Information Infrastructure Governance

Information policies.

Coordinate with social policy. ICANN, IETF, Local laws versus cross-border law. Internet gambling.

7.7.6. From CPUs to Software

Virtual Machines

As an example of handling complex, we consider virtual machines (Fig. 7.42).

Figure 7.42: Virtual machines help to separate software from hardware dependencies. (hand drawing)

7.7.7. Software Architectures

Organizations do computing and we considered good organizational structure to make that efficient. As described above, developing modularity is helpful. What architecture do we need for general purpose computing. A simple functional breakdown of program components.

Networking allows independent computers to communicate. This can add complexity since data and computing resources may be in different locations. At the least, this can add time to computations because communication between computing resources will be slower than time for centralized computing resources. Distributed systems include redundant components (e.g., computers) which are located in different places. This can provide for a distributed system's reliability. Distributed systems are robust and not prone to failure because not only are the processing capabilities of the system dispersed. both of which prevent the entire system from collapsing even if one (or several) parts of it do — the remaining parts will compensate for the damaged ones. A large, well-known search engine company finds it cost effective to utilize thousands of low-cost PCs rather than a few large servers to run its system, even though individually the PCs have a high failure rate, because the engine is almost immune to system-wide crashes due to the built-in redundancy across the multiple processors.

There are advantages and disadvantages to centralized and distributed computer systems. As we have already noted, the primary advantages of a distributed system are its reliability, unlimited scalability and computing power, and relatively low cost. The use of distributed systems also makes sense when data repositories must remain separated. Tasks in a distributed system can sometimes pile up on one processor leaving the other processors lightly used. The processing can be spread across several machines or "load balance" so that no one processor is overly busy. There may be legal restrictions that require information to reside on different networks. The physical separation may also be inherent to the task, as with construction robots that work in different places.

7.7.8. Autonomous Agents

Autonomous agents are programs which interact with each other but do not have central control. They may have goals and an approach to meeting those goals as conditions change. Furthermore, they may interact with other agents. This is the logical extreme of distributed programs. If the framework is well constructed, such programs can adapt social and economic models similar to those which provide structure in human society. More agents and artificial life (-A.10.4).

Multi-agent systems. Multi-agent semantic web. Coordination (3.5.3). Because these agents are autonomous, coordination among them can be like coordination in economic systems (8.7.0). Useful in simulation (9.5.0). Learning SOAR (-A.7.3). Reactive agents[15]. Agents protocols (7.7.8). Alife (-A.10.4).

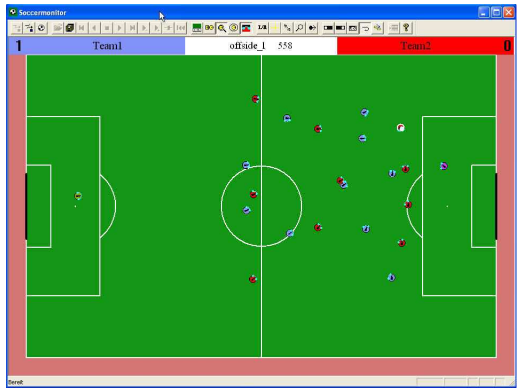


Figure 7.43: In RoboCup, teams of agents compete in a simulated soccer game.

7.8. Platforms for Services

We have already seen several examples of digital repositories. Web servers make documents available but they are not service oriented. A content-management system holds digital objects. The systems may also employ version control. A repository stores content, but what makes it unique is the services it provides. Incorporate annotations. Applications of repositories include digital asset management. Types or genres of information systems. Here, we focus on libraries, archives, and enterprise content management. Specification of services such as with UML (3.10.2).

Repository servers typically support collections. A collection of digital objects does not have to be on one server. It may be a virtual collection rather than a physical collection. As with all distributed systems, organization is particularly important (7.7.1). The Fedora digital library implements the following: Ingest, Dissemination, OAI provider, Search, Preservation monitoring,

7.8.1. Service Model and Service-Oriented Architectures (SOA)

We have emphasized services so it makes sense to develop computing platforms to support services. A first step is to be able to run processes on remote machines. the original Web was designed simply to deliver documents, but it can also provide a foundation for many other services. The key is to be able to run programs on remote systems that is to execute a "remote procedure call" (RPC) Specific service platforms include: Web Services Definition Language (WSDL) Service Discovery. UDDI.

7.8.2. Interlocking Services for Platforms

Search, ecommerce support, social networks. We have emphasized services. Repositories hold collections of information resources. Computing utility which saves local computing and storage resources. Micro-services. Service science. Ultimately, Internet features need to be based on the user needs and Usage patterns. In other words, the Internet itself is a socio-technical system. Composition of services. Social, mobile, cloud. This combination of services is termed a platform. Platforms include semantics such as from the media industry. Interlocking social interaction, content access and management, and ecommerce.

7.8.3. Distributed Repositories with Centralized Metadata

A good collection allows for many perspectives on a single topic Separate collections, one on Polish patriots and the other on piano players would both include material on Jan Paderewski. While a traditional library needs to manage its collection all in one place, a digital collection management node can provide services and manage a collection that is spread around the world. Fig. 7.44 shows connections to independent indexes and repositories from a meta-server. Relevant metadata from any digital document can be harvested from its source and built into a virtual collection. One example of collection indexing nodes is provided by the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH, Fig. 7.45). Access to selected documents can be controlled with link-resolution protocols.

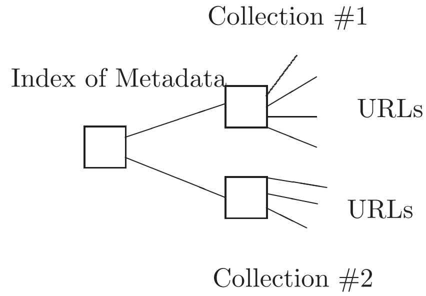


Figure 7.44: A virtual collection can be created by collecting and indexing metadata from remote repositories.

This leads some to an emphasis on information objects which are minimally structured. Or, at least, structure is not important. This view is quite different from the view of documents as works. As information objects, they can be shuffled, re-organized, and aggregated into new resources. This is view implemented by OAI-ORE (Object Reuse and Exchange) and in this approach, information resources are defined by resource maps. Learning objects and object reuse. Supporting other types of service such as discovery with distributed repositories.

```
<header>
  <identifier>oal::arXiv:9901001</identifier>
  <datestamp>1999-01-01</datestamp>
</header>
<metadata>
  <dc xmins“http://www.openarchives.org/OAI/dc.xs”>
    <title>Quantum slow motion</title>
    <creator>Hug, M.</creator>
    <creator>Milburn, G.J.</creator>
    <date>1999-01-01</date>
    <type>e-print</type>
    <identifier>“http://arXiv.org/abs/9901001”</identifier>
  </dc>
</metadata>
<about>
  <dc xmins“httpd://www.openarchives.org/OAI/dc.xsd”>
    <rights>Metadata may be used without restrictions</rights>
  </dc>
</about>
```

Figure 7.45: Example of Open Archive specification[60]. for a document in the “arXiv” repository (www.arXiv.org). (check permission)

Aggregation of Collections OAI.

URI.

Distributed Search Indexes

There are drawbacks to distributed collections. One of them is the difficulty of distributed searching. When the content of a collection is spread across many servers, a full-text search of the collection may be accomplished by contacting each of the servers (Fig. 7.46). Each remote server conducts the search and each has to respond. The problem with this arrangement is that the response time for the entire system is as slow as the response time of the slowest server. Indeed, if one of the remote servers is unavailable, the search may not be completed. Search engines (10.7.4).

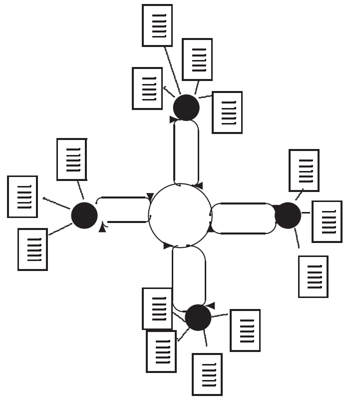


Figure 7.46: In distributed searching, the user contacts the central server and that request is in turn sent to remote servers (solid circles). Metadata for matching documents are then sent back to the central server. This approach can be slow to answer the query if any of the remote servers is slow to respond.

7.8.4. Metadata for Complex Information Resources

Earlier, we considered metadata frameworks (2.4.3). Metadata on the network.

Preservation of complex objects. Games (11.7.3). New media (7.5.5).

Metadata for Complex Digital Objects

Digital objects. Information Packages. Actual information resources are complex. They objects involve multiple metadata standards. For instance, a multimedia object. Packaging Services and Digital Objects in a Repository Micro-services. Use-cases. Information package includes the digital resource and associated metadata. Even more complex objects may include interactivity.

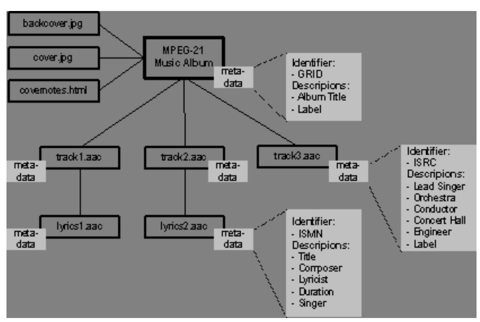


Figure 7.47: Describing a CD album with MPEG-21. MPEG-21 is a framework for metadata for each of the components. (check permission)

Front cover art

Back cover art

Figure 7.48: Describing a CD album with MPEG-21. MPEG-21 is a framework for metadata for each of the components. (check permission)

PREMIS is an XML standard is used with METS. METS from complex objects to composite packages.

Semantic annotation.

Content wrappers. Complete understanding of information resources requires many levels of description. A comprehensive encapsulation of content is a packaging standard. There are several of these such as XFDU, MPEG21. For instance, an album of music may be composed of several songs.

Here, we focus on the Multimedia Encoding and Transmission Standard (METS) (Fig. **??**) This is particularly important for archival description. METS example document. Resource maps. Struct-Maps are hierarchical. Limitations of hierarchies for document descriptions. (2.3.3). Beyond that, there are other standards such as MPEG-A.

This is particularly applicable to complex objects such as newspapers, movies.

From METS to genres.

MPEG-21 and MEPG-A. MAF and coordination of standards in application devices such as audio players.

Metadata Registries

They need to be indexed in order to be found. Information seeking may start with determining what strategy to employ. If a collection is adopted, the user must start with source selection. Collections in a networked environment. Repository severs and the services they provide are decentralized and it may be difficult to know what resources or services are available. There are several models of advertising services such as UDDI. is a generalized Web service registry. Moreover, because standard descriptions are so important for coordinating distributed services, it is helpful to have registries of metadata standards. Such as the Open Metadata Registry. Difficulty of interoperability. Cross-repository services. Storage resource broker. ISO 11179 is a standard which facilitates the reuse of metadata; it defines metadata on registries.

7.9. Software Engineering

Information systems can be complex and developing them a challenge requiring engineering. This process is itself highly information intensive. Software engineering attempts to develop quality software in an efficient manner.

Factors to consider are cost, complexity, disruption. These activities need to be coordinated with various stakeholders. a particularly complex set of design tradeoffs including content, people, and systems. There are both social and technical issues in the design and implementation of information systems. Bad design of information systems can be very costly (e.g., Fig. 7.50). Requirements specification and system design.

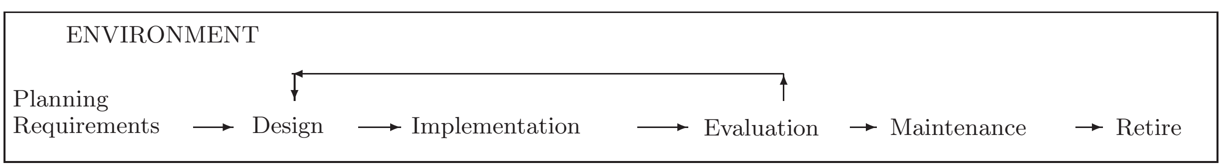


Figure 7.49: We briefly considered the system lifecycle earlier. We will go into much more depth and breadth. System design must consider the environment in which it occurs.

The software lifecycle depends on the system lifecycle – sometimes the software composes most of the system so they are close to identical. Once software is installed, it becomes enmeshed in an organization's other business processes (8.11.2); it is often extremely difficult to change. Thus, it is known as legacy software. Software as an information resource (8.13.8). Increasingly include off-the-shelf tools rather than custom-designed tools. Knowledge intensive firms. Intellectual capital: people, processes, relationships.

Challenge of legacy system upgrades.

> The FBI recognizes that its success will depend heavily on a greatly expanded role for IT. Given the complexity of its traditional and new activities, however, the FBI has found introduction of new IT technologies to be very challenging.
>
> Information technology's inherent capabilities must be fully exploited if the FBI is to use IT to help meet its operational needs. At this point, however, the FBI is not on a path to success in doing so.
>
> The most significant concern is that the FBI's technology efforts do not appear to be driven in a coherent manner by a strategic view of its mission and operational needs. The highest priority to address this problem is to formulate an enterprise architecture incorporating a detailed characterization of the Bureau's goals, tasks, and strategies. The FBI's efforts to do so, however, are late, limited, and far short of what is needed.

Figure 7.50: The FBI spent more than \$170M on software development that was not useful. Here is an excerpt from a report about the management of that project[45].

7.9.1. System Analysis and System Requirements

We have encountered many types of systems. Collecting data and analysis of those systems is valuable for helping to understand them.

This approach can be applied to understanding information systems embedded in an organization. Requirements form constraints which **must** be satisfied by an implementation. This is often the first step in the design of information systems. Many aspects of a system need to be specified.

Functional Requirements

We might require that a car have seat belts or we might simply require that provide a certain level of safety of passengers in a crash.

Most often, we focus on functionality - those which describe what the system needs to do to satisfy its goal – but there are also requirements that go beyond the immediate functionality. These are so-called "non-functional requirements" which include content, usability, costs, and environmental requirements.

> The Shuttle will transport cargo into near Earth orbit 100 to 217 nautical miles (115 to 250 statute miles) above the Earth. This cargo – or payload – is carried in a bay 15 feet in diameter and 60 ft long.
> Major system requirements are that the orbiter and the two solid rocket boosters be reusable.
>
> Other features of the Shuttle:
> The orbiter has to carry a flight crew of up to eight persons. A total of 10 persons could be carried under emergency conditions. The basic mission is 7 days in space.

Figure 7.51: Part of NASA's requirements for the Space Shuttle[20].

Critical systems engineering.

Developing Requirements

A system developer might say "if you can just tell me what you want, I'll build it for you". This seems simple enough; however, some projects such, say, the design of the space shuttle are so complex and expensive that it is not practical to proceed by trial-and-error. There many tasks for which the goals are less clear than they were for the Space Shuttle. The goals may be highly dependent on cost or other parameters. Nonetheless, it is helpful to systematically organize and clarify the details into specific requirements.

There are many approaches for developing requirements. One strategy is to interview a range of stakeholders. Requirements elicitation procedures can be used. Techniques for extracting tacit knowledge from analyses of knowledge management (7.3.1). Information systems themselves can be helpful for keeping track of requirements.

A second strategy is collaborative development. Requirements elicitation is ultimately a human process

[41]. Joint application development[90]. A JAD is similar to a GDSS (3.4.3) but devoted to design and development. JAD sessions are: Focused and conducted in a dedicated environment JAD participants typically include: Facilitator, End Users, Developers, Tie breaker, Observers, Has social dynamics. This approach emphasizes the social aspects and compromise.

Stages in the development of requirements. Early Requirements are often general. The need for a system upgrade is often determined by strategic planning. This planning process requires understanding the environment and the tasks completed in that environment. We will explore an approach which incorporates goals into modeling and specification of business processes (8.11.2).

Validating and Evolving Requirements. Are they what the user wants?

The application profile is the range of tasks to which a system might be applied.

Requirements Management System (RMS). ISO 9000.

Requirements creep.

Structuring Requirements

Requirements engineering and knowledge representation. If the requirements are specified with a formal language, logical inference can generate implications. The more subtle aspects of use case design such as coordinating the use case with organizational and user interface design constraints and in the internal system constraints. The difficulty of capturing tacit knowledge (7.3.4). There are many variations to user analysis. Activity diagrams can be applied for developing use cases (3.10.2). While UML shows the expected interaction, a great deal more detail is needed. Processing flows, System architecture, Detailed requirements, System Interfaces/Impacts, Global requirements, Testing. A requirements specification document itemizes the requirements. Systematic presentation of requirements for clarity and completeness

Use Cases

Cast the requirements into a formal specification. One of the main applications for formal models such as Unified Modeling Language (UML) (3.10.2) which we have discussed are for the formal specification of requirements. We should have a systematic exploration of what needs to be examined with use cases. What tasks the user needs to accomplish. These are task models dovetails with interface design where the task contributes to the organizational activity. Need more complexity for use cases. One of the most common problem with user acceptance is that important functionality needs have not been considered. A further problem is it's difficult to extrapolate to an entirely new point in a product space (e.g., iPhone). Beyond use cases to Scenarios ((sec:scenarios)).

Interaction with users is the most immediate aspect of an information system. For most information systems, the interaction is essential. Ultimately, the design of information systems is about linking processes to people. This is sometimes accompanied by type of UML diagram known as an interaction diagram (3.10.2).

Use Cases: Specifying User Needs and Activities. User needs analysis. Difficulty of predicting user needs for changing environments. Use case diagrams (3.10.2). User driven service specification. For highly structured information tasks it is possible to associate user roles with the types of tasks those users may be expected to do. As mentioned earlier (1.5.2), these types of information should be matched with access points in the data set (Fig. 7.52). Use cases don't necessarily describe the full environment.

Ideally such process-based design would also consider social interaction action issues (7.9.6). Elaborating use cases is a step toward system implementation (Fig. 7.53). Fully dressed use cases. Designing tools and task models.

7.9.2. Implementing the Requirements

Business process engineering (8.11.2).

Type of User	Tasks
Customers	Select video
	Place order
	Change address
Managers	Check inventory
	Accounting
System Developers and Administrators	Monitor system performance

Figure 7.52: Some types of users for a Web-based online video store.

Tasks	Activities
Select video	search, read description, listen to preview,
Place order	submit order, pay with credit card

Figure 7.53: A few use cases for the end-user tasks described above.

Formal specification of a activities.

Design.

Formative and Agile Development Strategies

For many projects, it is difficult to develop complete formal requirements before beginning development. Or, at least, the requirements cannot be clearly specified. Formal requirements are often overly constrained — projects change and requirements evolve across time. In these cases, requirements development begins to resemble design (3.8.0). This is formative design and development strategy (3.8.3). Modularize with many benchmarks as a development strategy. Software prototyping [35]. Formative design with lots of testing. The idea of agile development has become a catch-all for a number of inter-related issues with traditional requirements development. Evaluating prototypes. User needs in the context of task completion. Software testing (7.9.5) is an essential aspect of agile development. Testing procedures need to be well specified. A variety of techniques have been proposed. Rapid application development (RAD). Extreme programming. Story-based design and scenario-based design. Interaction design (4.8.1). Formative design. Beta release.

7.9.3. Software Development

Once the requirements have been determined, the system must be built. That may involve customizing software or even developing new software modules. The software is a design artifact which is both highly malleable and complex. Service architectures such as described in ((sec:architecture)). System design is interwoven with evaluation metrics which we sill discuss later in the section (7.10.2).

Refactoring and code management for reuse.

The issues range from specific tools to managing very complex systems. Managing complexity (3.8.3) in code. Software is highly structured and that structure can facilitate development such as editing. Many programmers work by implementing models for their programs and integrating them. These can be explored with techniques such as "pseudo-code" (Fig. 7.54) and UML.

```
while not at end of list
  compare adjacent elements
    if second is greater than first
      switch them
    get next two elements
    if elements were switched
      repeat for entire list
```

Figure 7.54: Pseudo-code provides a conceptual overview of the program modules. Here, a procedure for sorting a list of numbers is described.

Cognitive aspects of programming. Programming languages as building representations[24]. Modularity and increasing degrees of abstraction. Ways of specifying data structures such as trees which we have found useful. Software development (7.9.3). Differences among programming languages.

CASE Tools and Software Development Tools

Programming implements a design (7.9.3). Many tools have been developed to support programming. A syntax-directed structure editor employs these syntax of the programming language to support the guide the user. Similarly, debugging tools. Syntax debugging. Semantic debugging. Software development can be supported with integrated development environments (IDEs) (Fig. 7.55). Modern development environments include the ability to search the web. Computer-Aided Software Engineering (CASE) tools include UML (3.10.2). A complete UML specification is often close to being able to be compiled into an object-oriented program. In addition, the the raw specification, several other support tools are useful such as version management tools (-A.5.8).

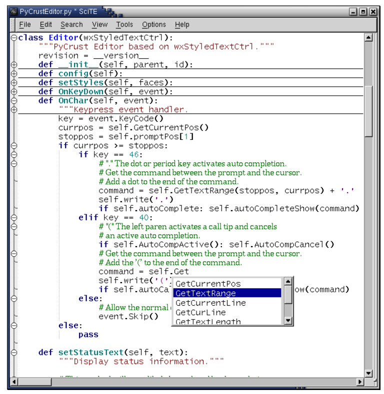


Figure 7.55: A screen from a software Integrated Development Environment (IDE)[8]. The same system could include compilers, version management, and even requirements. The editor for subroutines from a computer program "knows" the structure of the programming language. (check permission)

Software Libraries and Re-Use of Software Modules

Following the principle of object-oriented design, modules should maximize cohesion and minimize complexity (3.9.3, -A.3.4). Software itself can be treated as an information resource. Software can be collected into libraries in the hope that modules can be re-used. Information seeking for software re-use. Some software libraries, such as those which provide common mathematical functions, such as finding square roots, are routine. More specialized software could also be reused. One of the ideals of object-oriented design is the capability to share modules. Other collections are based around specific genres or media. Software and design libraries can facilitate reuse as part of the development process. Software collections must be carefully selected and organized; they should be easily accessible and persistent. Code metadata can describe the attributes of a program. Faceted classification systems (2.5.3) seem particularly effective.

Software, like other information resources, may be collected in libraries. Software management as information seeking. Software repositories[27]. Users are almost always interested in the functionality of the software more than the details of the code, so metadata and text descriptions are especially useful. Sourceforge — the collection of freeware source code — is a type of software library[22].

Software Development Organizations and Teams

Most software development is too much for one person to complete. Collaboration tools for supporting programming teams (5.6.2). Software development in an organizational context and is often a collaborative process. Because software development is an intellectual activity, it is difficult to understand the steps involved. Project management (8.11.3). These tools can also facilitate software project management. Coordinating large software projects. Even with detailed requirements, a great deal of development is needed.

Open source software (8.13.8) has a fundamentally different approach to software development[71]. Free-libre. The nature of the team may be affected by the development strategy and by business considerations. However, open source development is not effective for cutting-edge innovation [**?**].

Managing Software Development Teams Indeed, the development teams may be geographically distributed so this is an area in which collaborative support is helpful (5.6.7). Distributed management and consensus building. Software development communities. Management of software teams (e.g.,[36]). Implicit understanding of the task and the team members and project management. [74].

Adding people to a project team late in the software development cycle when that project is already late makes the project even later. This is has been demonstrated so many times that it is now known as Brooks' Law[37] after the software engineer who first proposed it.

The size of the development team needs to be coordinated with the software modules that are to be developed and there needs to be knowledge management for these teams. Information systems can improve communication and distribute necessary knowledge throughout the production process. Efficient processes coupled with improved communication allow organizations to confront unique situations.

A scrum is a type of programming team which employs overlapping phases of development[19]. A type of project management (8.11.3).

Coordination across software teams.

Tools for Supporting Software Teams Modularity is helpful for convenient development. Managing complexity of several interacting modules.

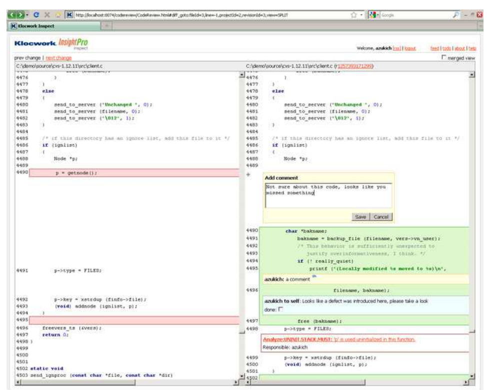


Figure 7.56: A collaborative code review interface allows comments from the review to be inserted and ultimately for approvals to be given. (check permission).

The process of systematically, recording bugs and attempts to fix them is known as bug tracking. Fig. 7.56 shows an example of collaborative development interface

7.9.4. Software Evaluation and Software Performance Standards

Difficulty of cost estimates for uncertain projects.

Software Quality Control

Attributes of quality software[34]. Consistency, impact. The principles we discussed earlier for quality control (1.4.3) can be applied to software quality. Design techniques and processes may improve quality. More formal methods and organizational processes. Software inspections. Code reviews. Quality and consistency of the design (e.g., ISO 9000). Total Quality Management (TQM) [47]. Process of improving quality. However, there are costs in over-emphasizing processes for quality. By allowing project managers to analyze the past production schedules of different products, prior methods can be used, discarded, or altered to meet the current demands. This allows to the organization to be adaptive, or to learn. Formal methods such as proofs of program correctness have been difficult to apply.

$Plan > Do(Implement) > Check > Act$

7.9.5. Software Testing and Software System Testing

Increasingly, we depend on software for critical functions but software sometimes fails (Fig. 7.57). Indeed, almost all complex software probably has bugs. When software is used in a critical system, failure can be dangerous. Controls may prevent such disasters when computers are involved in banking, airlines, and nuclear power plants. Software quality is essential for trustworthy systems. Confirmation testing.

> The failure of the Ariane 501 was caused by the complete loss of guidance and attitude information 37 seconds after start of the main engine ignition sequence (30 seconds after lift-off). This loss of information was due to specification and design errors in the software of the inertial reference system.

Figure 7.57: The Ariane 501 rocket was lost in 1996 because of a software failure[63].

Software needs to be tested throughout the software development process and as it is released for use, This testing can compare its performance to the requirements. Indeed, the testing performance can be part of the metrics (7.10.2) and it is integral to agile software development (7.9.2).

There are several testing strategies and methodologies: Testing can be intertwined with agile requirements development (7.9.2).

Development of performance standards for tests as the primary criteria for system features. This exactly specifies the criteria the system must meet. Test first[56]. The testing can be diagnostic – the test results can also be useful for suggesting bugs in the development processes.

Testing a program after changes have been made to it. Testing systems under load can often be helpful in revealing bugs. Testing can also look for unexpected conditions.

Normative software problem maintenance. Bug reports and bug logs. Open bug reports.

Many software systems are so large that they cannot be tested as a whole and must be tested as modules. Systems such as the telephone control switches may have more than one million lines of code. Can the system be tested as a whole, or is it adequate to test just the components. The testing of those components which have been changed is known as "regression testing"[17].

The use cases lead directly to testing. Joint Review and Testing by team (JRT).

Legal responsibility for software failures. Broader social context for software tools.

7.9.6. System Configuration, Documentation, and Roll-out

When an information system has been deployed its settings need to be configured. There are many setting in complex information systems. Keeping track of a settings is itself a task. Matching parameters of the environment in which it be used. Organizations and culture. Social media such as for support of trouble shooting.

Configuration Management

Tailoring setting of a complex system for a specific situation (Fig. 7.58). Configuration of setting on a personal computer. Software configuration. Configuration rules (-A.5.6) and constraints (3.7.2). Simple example. Dependency graph for showing constraints (8.11.2). Ultimately, we would like the configuration to match specification of the requirements and constraints of this particular application.

User Training and Documentation

We also need to make sure the users are on-board. Although we might like all interfaces to be intuitive, that is rarely the case. Users with different needs. Tradeoffs in training and documentation. Ideally, an information system would be intuitive, so the user can understand how to complete actions with a

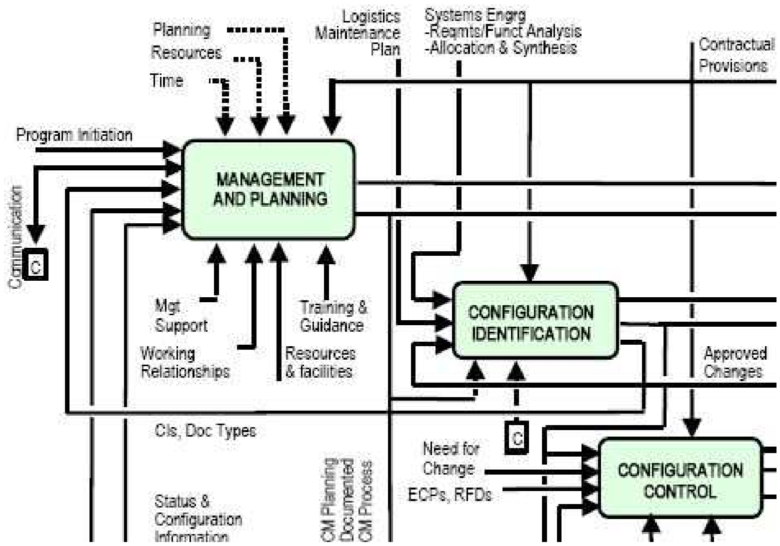


Figure 7.58: Complex information systems have many settings to adjust them to a given environment. The settings are often interdependent and changing one may also require changes to others. (redraw) (check permission)

minimum of confusion but this is rarely entirely feasible. Similarly, the system should require as little training as possible. When these ideals are not possible, supplemental training and documentation is required. Training and documentation can have a large impact on effective use and satisfaction.

Task-based documentation.

Training about information systems needs to be coordinated with other work processes. Effective training can be facilitated with knowledge of the task in which the user is engaged or on a user needs analysis. While the goal of user interface design is to make the interface as intuitive as possible, users still need training about most systems. This training can be based on generic educational principles such as developing conceptual models. In addition, people may learn about a system simply by watching and talking with other users.

Analogies for Explaining Interfaces

How the user may think about the interface?

Analogy can help to simplify complexity (6.2.3). Thus, a group of directories and files on a computer may be explained as being “similar to a filing cabinet”. Or, we might explain atoms by saying they are like little planetary systems. On the other hand, can a word processor be compared to a typewriter in the same way? While metaphor can be helpful, it must be applied carefully; thinking of a word processor as a typewriter will not give a user a complete idea of the word processor’s capabilities (6.3.4). The type of conceptual models given to students can impact on their ability to think abstractly.

Figure 7.59: Application documentation example.

In documentation, it is desirable to identify typical tasks the user is likely to complete. One strategy is known as “minimalist” instruction. This attempts to provide just the right amount of focused support [83]: (a) Choose an action-oriented approach, (b) anchor the tool in the task domain, (c) support error recognition and recovery, and (d) support reading to do, study, and locate.

The documentation of system features provides support to users. It is more effective when applied to actual work that a user is trying to complete — task-oriented documents perform this function. There is a question as to whether task instruction is preferable to documentation. Documentation and user needs/tasks. The need for documentation can vary depending on whether the system is being used for routine tasks or more unstructured tasks. Sometimes documentation is developed according to system functions rather than features. Increasingly, help for users is available from posting on blogs or on question-answering sites.

Interactive Help Systems and Interactive Performance Support

Queries to help systems. Imagine that you were writing a message with a word processor but forgot how to check the spelling. Ideally, an information system might track the actions of the user, and, with the task and system models, it may be able to figure out what the user is trying to do. So, when the user requests help from the computer, hat help is enhanced by the computer's understanding (even if it is quite limited) of the user's aims. The system typically knows the choices available to the user; it may have some history of what the user has been doing and knowledge of the range of tasks. Task models (7.9.3) can provide a framework for this kind of context-sensitive help. The method shares aspects of tutoring and training, such as assessing how to intervene with tutoring (5.11.3). This can be thought of as a plan recognition problem (3.7.2). The trick is to identify the "root cause" of the activity. Beyond providing explanations, the system might attempt to correct user errors.

Information Technology System Acceptance

There are many cases of failures to have information systems accepted. This is of information systems in businesses as well as libraries and hospitals. Ultimately, an information system has to be accepted by the users. Acceptance is often not trivial and has been explained as based on two factors: ease of use and usefulness[46]. Such perceptions are characterized as being based on attitudes and beliefs (4.5.0). Indeed, the likelihood of technology adoption can be indicated by statements of behavioral intention (4.5.2). Many attempts to integrate information system into an organizations have meet with failure — either the new technology does not reflect the organization's overall strategy, or it does not reflect the organization's established processes and the technology is not accepted (Fig. 7.60)[49]. The Technology Acceptance Model (TAM) proposes that acceptance of technology depends on two factors: Perceived ease of use and perceived usefulness. Self-efficacy and TAM. TAM and individual learning. Generational effects of TAM are related to the notion of "digital natives". TAM and group learning (culture). Factors contributing to Perceived usefulness include: norms, image, relevance, quality, and demonstrability. Ultimately, TAM is an application of the broader Theory of Reasoned Action (TRA (4.5.2).

Acceptance Factor	**Description**
Relative advantage	How much of an improvement is the new system over the previous one?
Compatibility	Does the new system support existing processes and structured?
Complexity	How difficult is it to understand the use of the system?
Trialability	Can it easily tested?
Observability	Is it transparent?

Figure 7.60: Factors in information system acceptance[49].

7.10. Organizational Information System Management

Once the information system has been introduced, it needs to keep it running well. Management of information systems, setting policies and making decisions about them. Changing environments often mean revisions to requirements. Managing the operation and effectively managing the entire software lifecycle (7.9.3). This is sometimes termed IT governance[10]. It is not unusual for maintenance costs of an information system to greatly exceed the development cost. Some of these issues also relate to management of content (1.5.2). IT groups are increasingly influential in organizations. Preservation planning as IT governance. Digital preservation and ITgovernance.

7.10.1. Organizational Frameworks for Information System Governance

There are many structures for organizations. We can break down a complex information system in components to deal with them effectively. One breakdown of information system components which can be used for management is shown in Fig. 7.61. This is a technologist's view of the organizational sub-system rather than a breakdown into subsystems based on business-function structure

Subsystem	Description of Subsystem	Example of Attributes
Input	Data Entry	Accurate input
Communication	Networking	Encryption
Processing	Operating systems	Accurate calculations
Storage	Database, File Management	Referential integrity
Output	Printing	Report printing capability
Boundary	Interface between system and outside world	Passwords

Figure 7.61: Subsystems of a typical information system (adapted from[85]).

Beyond the system view, there is a context in which it works. An information system should work seamlessly with organizational needs and goals. Information systems have many components and the following areas need to be managed[85]. There are many threats for the integrity of information systems and the information they contain. Human organization issues (Fig. 7.62). The implementation of those policies is essential. A policy must be enforced to be effective.

Organization	Examples
Top management	Staff, Leadership.
Systems development management	Planning, Design, Testing.
Programming management	Software quality and updates.
Data resource management	Content management.
Security management	Prevention and recovery from damage.
Operations management	Maintenance, workflow.

Figure 7.62: Organizational units involved in system management (adapted from[85]).

7.10.2. System Metrics, Audits, and Evaluation

There any many types of information systems and applications so evaluation of covers many perspectives. Many level of evaluation are needed. Because of the complexity of the information systems, there are many aspects which need to be evaluated. We have discussed evaluation in many places; here we summarize those issues. Quality. Prevention of defects, and correction.

An audit is a systematic evaluation of a system. Audit log for access and use. Identify subsystems which can be monitored: Understand the controls, Test the controls, Examine the results of the controls. Audits could inspect procedures and transactions. Information systems provide access control and better record-keeping about access. An audit trail provides a trace who has accessed which records.

System Metrics

Evaluation from successful usage but this is fuzzy. So, we emphasize, metrics for providing a standard for what is happening. Do the metrics actually test what intending to test? Construct validity. Need for organizational infrastructure as in trusted repositories. Evaluation. Outcome-based metrics. Ultimately, metrics should be ground in measurement theory (7.10.2).

Complex systems are so difficult to manage that they almost inevitably have failures. We have considered techniques for managing complexity in distributed systems (7.7.1). Thus, handling such failures should be built into the system. Accidents are common even in carefully designed systems[70] They occur from multiple failures and cascading failures. Often this is as much an organizational failure as much as a system failure. The system should meet the requirements. Ideally, we should refer back to design goals and the requirements to system performance. Scope of a metric. Goal, Question, Measures (GQM)[31] (Fig. 7.63).

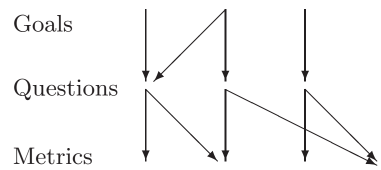


Figure 7.63: System design goals suggest questions and those questions suggest metrics.

System attributes: Number of users supported at one time. System metrics include availability (e.g., 24 X 7), the amount of down time, and security. Response time for user queries. Meeting a business model. Cost-effectiveness.

Organizational Environment and Content Metrics

Is the organization stable? Does it have reasonable policies? Disaster recovery plan.

The content metrics need to be matched to the tasks the users will complete. Many aspects of content management have already been discussed with respect to library services (7.2.2). We may evaluate the scope of the collection. The simplest approach is to count the number of items. How many records, what speed of access, preservation, quality of telephone reproduction? Database integrity. The "coverage" of my Agatha Christie collection can be measured by the proportion of how many of Christie's books I own out of all that she wrote. More generally, I am interested in the breadth and depth of coverage of a collection[89]. Coverage, quality, exhaustiveness. Implementing policies such as those for archives.

Attributes of quality: having few errors but also extensible to new contexts and new services.

Metadata quality.

Usability and Usage Metrics

Systems should allow users to be effective for accomplishing tasks. This means that they should not only be useful for the tasks for which they are designed, they should also be "easy" to use (Fig. 7.64). Checklist of features. Design and evaluation of interactive systems (4.8.0).

Aspect	**Description**
Learnability	Is it easier to learn how to use this information system than other systems?
Memorability	Once a person has learned to use an information system, can he or she remember how it works when they come back to it later?
Satisfaction	Does the information system change the user's job satisfaction?

Figure 7.64: Aspects of usability for an end-user (adapted from[67]).

ISO definition. Effectiveness, Efficiency, and Satisfaction

Many users show strong preferences for aspects of systems that do not seem to have any real impact on their effectiveness. Although there is no strong performance enhancement with color monitors rather than black-and-white, but today, almost all monitors are color. Information retrieval system and perceived effectiveness (3.3.3). In any event, user satisfaction is an important component of long-term system acceptance. Satisfaction may also increase motivation which is critical to use of educational systems. Attitudes, long-term usage.

Many approaches have been proposed for evaluating usability (Fig. 7.65) and there are tradeoffs about when these methods should be used. There is considerable debate about the value of interviews. In the "thinking-aloud" evaluation method, users talk about their experiences; while verbal protocols can be useful for determining a person's state, they may be biased (4.3.2). "Discount usability testing" can give quick feedback on design. As few as two or three trial users can provide sufficient feedback to detect major design problems[67].

Label	Description
Expert reviews	Analysis by experts of system components.
Heuristic evaluation	Apply rules of thumb.
Experiments	Systematic examination of variables. Typically, these are rigorous but may be difficult to generalize to complex situations
User surveys, interviews, and observation	Observation of the use of the system in a natural environment. These are less systematic than experiments but may reveal hidden clues.

Figure 7.65: There are several techniques for evaluating the effectiveness of user interaction with information systems.

Web usage metrics. Server logs (-A.14.2).

7.10.3. Information Security

An information system is not useful if we can't trust its contents. Corrupted information can have many implications. One example of lax security is shown in Fig. 7.66. This involves both content management (1.5.2) and systems. Basic procedures. Personnel files. Work product. Protecting an archival or master copy (7.5.1). These are system and policy issues. Security is a result of simple user choices and of group interaction. Trust (5.2.3). Trusted archival repositories (7.5.6).

Confidentiality and Encryption

There are many times when information needs to be kept confidential. Confidentiality of information, integrity without compromising usability. Encryption (-A.13.1). Both social and technical issues.

Data breaches. Some serious and some not.

Why Security Matters

Thus, security cuts across many levels from policy to implementation. Thus, security must address both social and technical dimensions. That is, the technology can protect the content in some points in its management but security at other points in fundamentally a human activity. We can apply the sub-division of the sub-systems described earlier (7.10.1). Scope of the system to include communication. Organizational policies which promote security. We have also seen these issues in the context of Trusted repositories (7.5.6). One type of attack in cyber-war (7.11.4) is to corrupt, or at least create distrust in the accuracy of information. Principles for developing secure systems. Advanced persistent threat (APT). Spear-phishing. Developing attacks through personal reconnaissance.

The tendency to protect all information but it makes more sense to prioritize information to be protected and the threats to it. Securely deleting data from digital media. There are real threats to information that is exposed out on the network. Authorization Managing policies: Metadata and descriptions for information security such as (2.4.0).

Forensics examines artifacts for evidence. Digital forensics plays a role in examining the authenticity of documents held by archives. It is also applied in criminal and security proceedings. For instance, a disk may be recovered as part of a police raid and its contents need to be examined for evidence relating to criminal activity.

Relevant data may include the context of other files on a disk. Digital forensics and its flip-side data cleaning need to consider that there may be several layers of pointers to data on a disk. Cleaning a disk needs to consider that simply destroying pointers to data is different from destroying the data records themselves.

Security within the firewalls.[87]

Although still in high school in 1968, Schneider started a company called Creative Systems Enterprises and began selling electronic telecommunications gadgets he invented. Each day as he passed the Pacific Telephone and Telegraph Company office, he scavenged the firm's dumpster for discarded equipment that could be used to build his gadgets. He also collected a wide variety of documents, ranging from invoices to training manuals. Within just a few years, he became an expert on telephone company technology and business, and reportedly knew more about Pacific Telephone's telephone equipment supply procedures than any of its employees.

In June, 1971, Schneider set into motion an elaborate plan to steal new telephone equipment from Pacific Telephone and resell it as refurbished equipment through Creative Systems. Eventually the scam would net him hundreds of thousands of dollars worth of Pacific Telephone equipment. Schneider accessed Pacific Telephone's computerized ordering system and by using a telephone card dialer succeeded in placing orders for equipment. To complete the scam, he needed to learn the telephone equipment budgets for individual telephone company's sites, equipment inventory levels and other key pieces of information. He gathered the required information by getting access codes to a commercial time-sharing service used by the telephone company for inventory control and parts distribution.

In January 1972, acting on information provided to them by one of Schneider's former employees, law enforcers raided Schneider's offices and a warehouse where they found equipment the district attorney said was worth $8,000. They also learned at that time that Schneider had stolen a total of $125,000 worth of equipment. Later, Schneider would admit that he had taken close to $900,000 worth of goods.

Figure 7.66: Effects of a security breach[18]. (check permission)

tavi	coo	elisabeth	mail	news	nobody	operator
calvin	elissa	pam	ftp	games	pcap	sshd
konchog	cobra	pass	adm	bin	rpc	smmsp
jflores	apache	lp	mysql	squid	mail	carloscota

Figure 7.67: Fragment of an actual security report for a Linux machine. Some hacker is probing the machine through the network trying to find valid user accounts. If one of these accounts were found to be active then the attacker would test a list of potential passwords against it.

Black hat, white hat.

Privacy depends on data security. Security breaches. Corruption of files versus obtaining copies of sensitive data. Loss of credit card information. Loss of health information.

Human versus Technical Solutions for Security

The major difficult for password security are the users rather than the encryption. Users often don't bother with firewalls or backups of their own files. Incentives for protecting one's own files with firewalls and backups. Organizational procedures

Vulnerabilities for Information Security

The cost of failure of an information system can be very large. When a society relies heavily on information systems, it might even be possible to disrupt that society by disrupting the information systems (7.11.4). Essential information can be corrupted; incorrect information can be deliberately planted.

Risks are a combination of technical and human aspects. Human aspects of information assurance. Some of the most serious threats to information systems come from insiders. These problems may range from simple insider abuse of resources to malicious attacks by disgruntled employees.

Attacks on different sub-systems described in Fig. 7.61. Attacks from outside the system. Connectivity to the broad public network has greatly increased the need for security. Some specific mechanisms for attacks include. Viruses (attached to other software) and worms (standalone). Trojan horse is hidden in something else. Entry into system via peripherals. Packet sniffing. Snooping on the network. Denial of service.

Attributes of security: confidentiality, authorization.

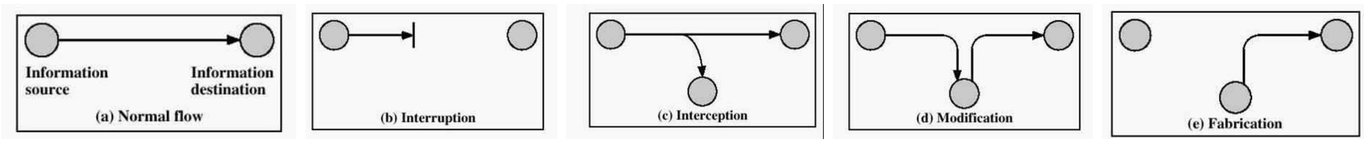


Figure 7.68: Types of attacks on network transmissions. (redraw) (check permission)

A large part of the security is the human procedures behind it. Security failures are often human rather than technical. Honeypots are sites set out by investigators to draw individual who may inclined to engage in unauthorized or illegal activities. This lure can also be useful for assessing the strengths and strategies of the attackers. It is difficult to control distributed networked services. Access to children. Policy and privacy issues. Do programs actually do what you expect them to? Operating system security.

Security Risk Analysis and Management

Given that there are risks, how do we access them for a given student? Absolute security for information is probably impossible; rather, it is more useful to analyze these problems with a cost-benefit analysis (7.10.3). When there is the possibility of a threat, the effort of risk-prevention activities need to be prioritized. More systematic vulnerability analysis. There are many possible failure points. Risk analysis and calculating the probabilities of threats. Particularly, for analysis of attacks. Analyzing and predicting risks. Scenario models. Difficulty of risk evaluation in the context of "group think" and conformity of opinions. Game theory (3.4.1) analysis

Security policies. Security policies and argumentation (6.3.5). Risk and argumentation.

Security audit as with other audits (7.10.2). Perception of risk[78]. Argumentation and risk assessment (6.3.5).

The human aspect of security risks can be modeled as adversarial situations and actions determined by game theory (7.11.0). Risk analysis may include likely strategies for attack. Once the risks have been determined, then protection strategies can be prioritized and developed. Includes cost matrix.

Security Risk Management Once the risks have been identified they need to be addressed. When the threat comes from a person or group we can consider what strategies they may adopt by applying game theory (3.4.1).

Security in financial transactions.

There are multiple levels at which security needs to be managed. Analysis, system and network, physical protection. Organizational processes. Security requires decisions. Best practices for IS management.

Developing systems that resist attacks. Encryption. Secure servers. Physical security for information is also important. Media should be protected from vibration and heat. Prevent users from accessing information.

Seemingly simple precautions are often effective. Passwords. Two-factor autentication. Multiple back-ups and out-of-state.

Prevention. Investigation procedures.

Cyber-army against the pro-democracy movements.

7.11. Highly Adversarial Situations

Information is often crucial in adversarial situations. Information security (7.10.3). Politics and economic self-interest are also adversarial but here we emphasize more extreme crime and war.

Offense and defense. Protection of evidence. Coordinated law-enforcement databases.

False information as a systematic attack. Attacking the information infrastructure.

Malware infections. Organize infected computers into botnets. This botnets can create coordinated attacks.

Phishing.

Espionage. Systematic attempts to uncover protected information. Commercial and governmental espionage. For instance, email among members of a corporate negotiating team may be attacked.

Increasingly, cybercrime and information warfare overlap.

Distinguishing police from military.

Defense: Assessing Terrorist Networks Information security (7.10.3). Social networks (5.1.0).

Collaborative emergency management.

Defense and prevention of attacks. Decision making for determining attacks.

Tracing the source of cyber-attacks.

Cyber-reconnaissance provides intelligence about individuals.

Systematic Disinformation

Disinformation (5.3.3). Attacks on history ((sec:attackhistory)).

Soft Power

Peoples and cultures often influence each other indirectly. When the influence of one culture on another becomes pervasive, it becomes a type of power[69]

Public opinion on the home front, in the opponent, and in third parties. This is an extreme form of attitude change. Persuasion (4.5.2). Culture (5.8.2). Battle for hearts and minds.

"Winning hearts and minds". Brainwashing.

7.11.1. Signals Intelligence and Intelligence Analysis

Could be competitive intelligence (7.3.5) but the consequences here can be greater. Collecting information by surveillance of different media. [**?**]. This is related to competitive intelligence (7.3.5).

Much of this is data mining.

Decoding messages. Traffic analysis.

Extracting a hidden story line (VAST).

Satellite images and image processing (9.10.2).

Critical analysis must consider the substantial chance of deception.

Many applications of sensors (-A.19.0). Dragon fly sensors (Fig. 7.69). This also raises privacy issues (8.3.1) and ethical issues.

Dangers of autonomy of lethal robots. This often minimize responsibility. Various battle robots.

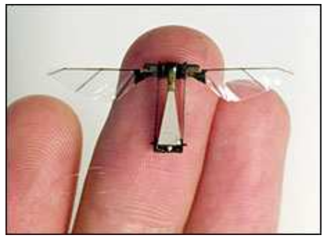


Figure 7.69: Artificial dragon-fly sensor. Eventually, this device might carry microphones and cameras[1]. (check permission)

Providing Decision support systems to support security analysis.

Complexity of intelligence information.

Figure 7.70: Complexity of intelligence information.

Cyber-exploitation. Collecting information through the network [**?**]

Loss of intellectual property through industrial espionage.

7.11.2. Information and Warfare

Information has always been essential for gaining an advantage in warfare. Indeed, there are several dimensions to information operations. Information systems can be fragile. Danger of formal reasoning systems when human activities and inference is involved. Art of War[2] (Fig. 7.71).

> Victorious warriors win first and then go to war, while defeated warriors go to war first and then seek to win.
> Pretend inferiority and encourage his arrogance.

Figure 7.71: Quotations from the *Art of War.*

Warfare often provides confused situations then information is essential. The fog of war.

Defense and counter measures.

Plan recognition of actors with hostile intent.

Tactical Intelligence

Spying.

Intelligence analysis. Collecting evidence.

Ghostnet.

In military combat, intelligence is used in both direct and indirect ways. "Intelligence" requires developing an understanding of what is actually happening. Directly, military intelligence is responsible for acquiring as much information as possible regarding opponent troop strength, locations, and strategies. This may make use of direct, visual information gathering, or it may utilize satellite imagery, prediction models, or intercepted enemy communications.

Timely information and analysis of that information is often not available in the "fog of war". Rapid decision making is critical. Reconnaissance. Information can assist the actions soldiers and their commanders take on and off the battlefield. Netcentric warfare is a catch-all term used to describe the new and advanced ways that the military is moving information amongst its parts. Military commanders may use decision evaluation software or even game theory to determine strategy and decisions using newly acquired intelligence. Logistical supply problems may be resolved using integrated supply chains. Personal battlefield computers are also being used as knowledge management systems designed to help soldiers make better battlefield decisions with all available information at hand.

Psychological Operations (PsyOps)

"Psy-ops," or "psychological operations" is a military strategy that attempts to discourage or disorient an opponent. This may include such far-flung tactics as dropping informational pamphlets from planes and playing loud, disheartening music.

Disrupting the social decision process. Information is also effectively being used in far more subtle ways during wartime. Hackers can attack the local cyber infrastructure, leading to enemy information isolation. Alternatively, disinformation warfare can be fed the same way. This is known as information warfare.

This is informational warfare on the cultural and sociological level. This tactic seeks to break down social boundaries between the two warring countries, though this is only perceived by one side, and make the cause of the war seem pointless, and the ideas and philosophies of the other side seem acceptable. In this regard, information and persuasiveness about social values is part of the point.

Intimidation, Terrorism, and Panic

Terrorist group organizations.

Complications of monitoring personal information.

Counter insurgency.

Categorization of content across media types. Sleep deprivation.

7.11.3. Netwar

Social networking facilitating coordination and infomation exchange by attackers.

7.11.4. Cyberwar: Attacks on Networked Information and the Information Infrastructure

Defense and offense. Strategic information warfare. Dominance of an opponent's information systems.

Cyber-security. Limitation of firewalls for defense. Problem of infection from consumer grade equipment. This can be a real problem but can also be exaggerated.

Defense by extensive encryption. Battlefield oriented cyber-war versus attack on military infrastructure. Disruption to command-and-control in the battlefield. Determining the source of attacks can be difficult. Swarm from multiple directions.

Attacking information infrastructure. This could mean scrambling data to make it unreliable or it could mean attacking the network itself such as knocking out the routers. Attack fundamental aspects of society: the financial system, the electric power grid, and traffic control in major cities.

Coordination of the elements in a non-hierarchical organizational structure. The principles of virtual organizations described earlier also apply to organized crime and terrorist groups[12]. Even the command-and-control structure of the traditional military is changing.

Insurgency versus revolution.

Terrorist and markets[33]

Many aspects of distributed information systems help terrorists. They may use web sites spread what is often incorrect information.

"Information war has no front line. Waging information war is relatively cheap. Boundaries are blurred in cyber-space. Opportunities abound to manipulate perception in cyberspace." [66]

Netwar is anti-hierarchical similar to the way that organizational hierarchies have been degraded (8.11.2)(Fig. 7.73). Pulsing attacks from the swarm.

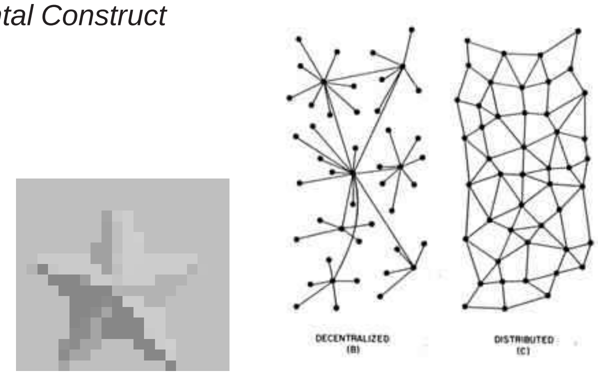


Figure 7.72: Centralized (left - to be drawn). Hierarchical organization versus situated context in a network. (redraw)(check permission)

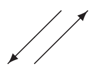


Figure 7.73: Centralized (left - to be drawn). Hierarchical organization versus situated context in a network.

Attacks by coordinated and often specifically teams of hackers can disrupt normal social interaction.

Botnets. Bot attacks.

Virus delivery by USB. Stuxnet worm attacking industrial control systems. Possibility of destruction in the physical world caused by illicit control of these systems.

Information security (7.10.3).

Cyber-war attacks the information infrastructure [29]. Disabling essential systems. More subtly, the attacks could make information less trustworthy.

Defense for cyber-attacks on individuals.

Stuxnet.

Many possible targets such as the electric power grid and the Internet itself. Defense against cyber-attacks. Security (7.10.3).

7.11.5. Adversarial Planning

Planning (3.7.2).

Game theory (3.4.1).

Exercises

Short Definitions:

API
Archive
Audit trail
Best practices (preservation)
Best practices (security)
Bureaucracy
Business rule
CASE tools
Chain of custody
Client-server system
Competitive intelligence
Conspectus
Dark archive
Data-flow diagram
Disaster recovery
Distributed searching
Emulation
Encapsulation
Federated system
Finding aid
Free and Open Source Software (FOSS)
Functionality
Habitable language
Heuristic evaluation
Honeypot
Information audit
Lessons learned
Load Balancing
Middleware
Micro-service
Migration
Peer-to-peer
Permanence rating
Persistence (documents)
Protocol
Provenance
Botnet
Cyber-crime
Data mining
PsyOps
Signals intelligence
Redaction
Regression testing
Repositories
Root cause
Stovepipes and silos
Strategic intelligence
Subject matter expert
Tactical intelligence
Tacit knowledge
Transaction (database)
Trusted repository
Walk-through
Web services

Review Questions:

1. How is a library similar to or different from an information system? (7.0.0)
2. What procedures does a library typically employ to demonstrate S.O.A.P.? (7.1.2)
3. In what way is a "digital library" similar to or different from a traditional library? Hint: Think S.O.A.P. ((sec:digitallibraries))
4. In what ways are records essential for modern society? (7.4.1)
5. What are the advantages and disadvantages of moving records from the organization that created them to a separate organization for managing records them. (7.4.1)
6. Explain what is needed for stored documents to be considered reliable evidence especially for them to be accepted as legal evidence. (7.4.2)
7. How are electronic records useful in business process management and re-engineering? (7.4.1, 8.11.2)
8. Distinguish between "libraries," "archives," and "enterprise management systems" ((sec:traditionallibraries), 7.4.4, 7.5.1)
9. How do libraries differ from archives? (7.2.1, 7.5.1)
10. Explain the difference between "preservation" and "conservation". (7.5.1)
11. Give examples of the strategies for handling complexity described in Fig. 3.46. (7.7.1)
12. Explain how peer-to-peer systems might create indexes. (7.7.1)
13. Describe the reasons distributed collections might be preferred to centralized collections. (7.8.0)
14. Why are repository servers better than Web servers for managing collections. (7.8.0)
15. Provide examples of three levels of training on an information system. (7.9.6)
16. What is an information system audit? How might an audit differ between a database and a digital repository. (7.10.2)
17. What are some criteria by which an information system might be evaluated? (7.10.2)
18. Distinguish between "risks" and "costs" (7.10.3)
19. What is intelligence analysis? (7.11.1)

Short-Essays and Hand-Worked Problems:

1. Is the Web a "collection?" Is it a "library?" Why or why not? (7.2.1)
2. Should community libraries be replaced by community technology centers? Explain. ((sec:traditionallibraries))
3. What are the similarities and differences in services provided by a video rental store and a public library? ((sec:traditionallibraries))
4. State a collection policy for a collection dealing with (7.2.2): a) animals of Australia, b) The Silk Road, c) information systems.
5. What is the business model for a public library? Who are the competitors for a public library. (7.2.2, 8.11.4)
6. Identify a situation in an organization with which you are familiar where information would be helpful. (7.3.1)
7. What are some metrics for effective knowledge management? (7.3.1)

8. Describe the electronic records needed to be kept by (a) a chemical company, (b) the marketing department of a manufacturing company? (7.3.1)
9. Pick an industry such as automobile manufacturing. Do an environmental scan. Pick a company and do a competitive intelligence (CI) analysis from the viewpoint of that company. (7.3.3)
10. Pick an industry such as automobile manufacturing. Describe the organizational culture of different companies. (7.3.3)
11. Tacit knowledge. (7.3.4).
12. What is the role of information in creating a "learning organization"? (7.3.4)
13. Describe a taxonomy that would be useful to describe lessons learned for a manufacturing company. (2.2.2, 7.3.4).
14. Suppose your company proposed to start a new product line. What information resources would you make available to the employees in the company. (7.3.5)
15. How should we value information? (7.3.5).
16. Find market share for three companies in the laptop business. (7.3.5).
17. Describe the business model adopted by each of the companies in the previous question. Describe the competitive landscape for them. (7.3.5).
18. If your company was planning to introduce a new product, what information would be most helpful to collect about a competing company? (7.3.5)
19. Identify information that is under-utilized in an organization. It is possible that XML could solidify existing organizational stovepipes. How might that be minimized? (2.3.3, 7.3.6)
20. What are some strategies for combining the organizational knowledge of when two business when they merge? (7.3.6)
21. Take an organization with which you are familiar. Identify the major information services and systems. Are they centralized? If not, what are the major barriers to that? ((sec:knowledgesources))
22. What are some of the reasons organizations develop stovepipes? (7.3.6).
23. When are silos appropriate for managing information in organizations? (7.3.6)
24. If you were an archivist and every 6 months you could select 1000 Web pages that would be saved forever, which ones would you select? (7.5.1)
25. To what extent does the integrity of a document depend on maintaining its original appearance? (2.3.1, 7.2.1, 7.5.1)
26. If you could archive 10 Web sites for posterity, which ones would you choose and why? (7.5.1)
27. Describe some steps that can be taken to improve the understanding of the context in which archival records are stored. (7.5.1)
28. Should a library ever remove any content? (7.5.1, 8.3.1)
29. If we could save all information, would we would we be able to find anything? (1.6.1, 7.5.3)
30. What policies would you suggest for keeping digital copies of (7.5.3):
    a) your personal photographs and movies,
    b) your local newspaper, and
    c) email messages among government officials?
31. In the course of your education, you will generate many documents such as notes, exams, bills, hopefully a diploma. Describe a retention schedule for these documents. (7.5.3)
32. What should you do if you want to archive a Web site? (7.5.3)
33. Suppose your job was to archive old newspapers but you had space to keep just three newspapers a month. What criteria would you use in deciding which ones to keep? (7.5.3)
34. Develop a policy for the preservation of a) university and b) corporate Web sites. (7.5.5)
35. Describe a complete museum exhibition you would like to develop. (7.6.1)
36. Explain some of the problems of encapsulation as a strategy for preservation. (7.5.5)
37. Describe several threats to the trustworthiness of digital repositories? Why might attackers want to delete or change records? (7.5.6) company that wanted to create a new position for knowledge management.
38. Your university student database probably runs on a single mainframe computer. Under what circumstances would it make sense to have the university database be a distributed system? (7.7.1)
39. What are some ways to defeat peer-to-peer systems? (7.7.1)
40. Peer-to-peer services. (7.7.1)
41. Imagine that you worked for a software design. Specify the design for a new information system that could be used by your university. (7.9.0)
42. What job description would you write for that position? (7.9.0)
43. Explain the limitations of the following requirements specifications a) A motor vehicle inspection system should handle 100 people per hour. b) The CPU should be at least 4 GHz.
44. Read about the Shuttle Challenger accident. Describe what went wrong. (7.9.1)
45. What requirements would you specify for an evoting system? (7.9.1, 8.4.3)

46. Develop task models for (7.9.3): a) Composing letters. b) Copy editing of a letter which has been marked up.
47. Identify a software library. Determine who are the target users. Evaluate whether their needs are being served. (7.9.3)
48. Describe what information an aircraft mechanic would have available when working on an airplane engine. How could interactive performance support help them? (3.2.1, 7.9.6)
49. Examine the documentation for an information system. Explain its approach. Describe its strengths and weaknesses. (7.9.6)
50. Collect and evaluate the training materials for an online information system. (7.9.6)
51. Pick a commercial ecommerce site. Describe how you would evaluate it. (7.10.2)
52. Suppose you had introduced a course-ware management system for the teachers in your local public school system. How would you evaluate its effectiveness? (7.10.2)
53. Design a plan that would protect a Web server from natural disasters and communication and power failures. Estimate the cost for your proposal. (7.10.2)
54. Evaluate the usability of a piece of software or an interactive Web site. Describe the intended users and tasks. (7.10.2)
55. What privacy controls should be in place for an information system audit? (7.10.2, 8.3.1)
56. What factors should be considered in determining whether a health information system is cost effective? (7.10.2, 9.9.0)
57. Explain security precautions for (a) a publisher's database, (b) a television production company's records, and (c) a Web-based catalog ecommerce records. (7.10.3)
58. Describe how you would conduct a "security audit" for an information system such as (a) a web-based auction site, (b) for a library. (7.10.3)
59. What audit procedures would be useful for bank transactions and accounts? (7.10.3)
60. If you were managing the data processing center of a bank credit card system, what precautions would you make sure that: the account balances had not been tampered with? (7.10.3)

Practicum:

1. Mini ethnography of system use.
2. Develop a preservation plan for a set of digital photographs.
3. Records management system.
4. Security audit
5. Organizational audits.

Going Beyond:

1. How should a public library determine its users' information needs? (3.2.1, 7.2.1)
2. Systematically observe patrons in a library of 30 minutes and describe what they are doing. (3.2.1, 7.2.1)
3. Find out what percentage of the people in your town have public library cards. (7.2.1)
4. Describe the workflow involved in cataloging a book for a library. ((sec:traditionallibraries))
5. Many libraries are not funded directly by public taxes. There are school libraries and corporate libraries. Explore the business model for one of these libraries. (7.2.1)
6. Describe what content you would select for (7.2.1):
   a) A library to serve just your family.
   b) Resources for a course on information science and systems.
7. To what extent is war a good metaphor for business? (1.2.1, 7.3.1)
8. When is a company liable for the actions of its employees in dealing with information? (7.3.1)
9. Suppose your job was to manage the information resources for a digital video distribution company. What approaches would you suggest for managing (a) external or (b) internal information? (7.3.1).
10. In Chapter 1, we emphasized the importance of representations for learning. What are some effective representation of information for organizational learning? (1.1.2, 7.3.4)
11. Is there a conflict between the notions of best practices and learning organizations? ((sec:tpractices), 7.3.4)
12. In what ways do metadata exchange standards facilitate the development of virtual organizations. (2.4.4, 5.7.3, 7.3.4)
13. How does information help an organization to learn? (7.3.4)
14. What issues should be considered in keeping strategic knowledge on a company's intranet? (7.3.6).
15. List the types of information stored in the finance department of a business. (7.4.1, 8.13.5)
16. The papers of important government figures such as Supreme Court justices are kept in the archives but sealed until five years after their death. Why are they kept sealed? Some people feel this is too long, other feel it is tool little. What are some reasons for each these positions? (7.5.1)
17. Develop a plan for the selection and preservation of a) public records and b) corporate records. (7.5.1)
18. Propose a preservation plan for a university professors papers which include so early word processing files. (7.5.1)

19. Who should be responsible for ensuring that digital materials are available far into the future? (7.5.3)
20. Should we preserve hate literature? (7.5.3)
21. In the U.S. government, the control of documents to be preserved is transferred from the originating organization to the U.S. National Archives and Records Administration. Why do you think this transfer is made? (7.5.5, 8.5.1)
22. How can peer-to-peer systems be used to create indexes on the content being held in the peer systems? (7.7.1)
23. How is Grid computing similar to or different from peer-to-peer computing? (7.7.1).
24. Imagine that you have been hired to lead a design team for an information system for a newly formed NASA project which is going to send astronauts to Pluto. Describe how you would approach this job. Describe some features the system you might build. (7.9.0)
25. Describe how the principles described earlier in this book could be applied to creating an effective JAD. (5.6.0, 7.9.1)
26. Can we develop requirements for a system which is intended to support novel tasks? (7.9.1)
27. Generate a requirements specification for an information system to be used by: (7.9.1)
    a) An organization tracking public health in a large city.
    b) An organization seeking to improve public school education.
28. In the development of services, what are the advantages and disadvantages of re-using existing software? (7.0.0, 7.9.3)
29. Create a task model for the steps involved in starting a car. (7.9.3)
30. Who should be responsible for software failures: a) the programmers, b) the employees, c) the firm which purchased the system, or d) the end-user? (7.9.5)
31. Diagram the states in an interactive performance support (i.e., sensitive to the context of user actions) system for a Web search application. (7.9.6)
32. Identify a group of computers which you believe has in security. Plan a security audit for them. (7.10.2)
33. What are the pros and cons of depending entirely on metrics? (7.10.2)
34. Develop a case study of a computer security incident. In your opinion, who is responsible for this incident? How could it be prevented from recurring in the future? (7.10.3)
35. Discuss the ethical issues in the use of honeypots for catching illegal information behaviors on the Web. (7.10.3)
36. Describe the security considerations in developing a certification authorization system for a Web site. (7.10.3, -A.13.4)
37. Netwar and cyber-war. (7.11.4)

Teaching Notes

Objectives and Skills: Design strategies. The students should be able to identify and discuss different types of distributed systems and services. Do a knowledge audit of an organization.

Instructor Strategies: This chapter could be divided and presented from two different perspectives: (a) systems and architectures. (b) services and the input of these services.

Related Books

- Allen, T.J., and Henn, G. *The Organizational Architecture of Innovation: Managing the Flow of Technology.* Elsevier, Amsterdam, 2007.
- Barabasi, A-L., *Linked: The New Science of Networks.*
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- DeSoto, H. *Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else.* Random House, New York, 2000.
- Evans, G.E. *Developing Library and Information Center Collections.* 4^{th} ed. Libraries Unlimited, Westport CT, 2000.
- Hoffer, J.A., George, J.F., and Valacich, J.S. *Modern Systems Analysis and Design.* 3^{rd} ed., Pearson Education, Upper Saddle River NJ, 2004
- Kahaner, L. *Competitive Intelligence.* Touchstone, Washington DC, 1996.
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- Lerer, F.A. *The Story of Libraries: From the Invention of Writing to the Computer Age.* Continuum Publishing, London, 1998.
- Newman, M.E.J. *Networks: An Introduction* Oxford University Press, Oxford UK.
- Sussman, G.J., and Abelson, H. *Programming Languages.* 2^{nd} ed. MIT Press, Cambridge MA. 1996.
- Weber, R.A. *Information Systems Control and Audit.* Prentice Hall, Upper Saddle River NJ, 1998.

Chapter 8.
Social Informatics and Economics

In this chapter we examine some of the ways that information is used and controlled in our society. Modern society balances many components such as political and economics and Information management is essential for the development of complex social, organizational, and economic systems. Interlocking systems of government, political systems, and economics. Public policy, governmental accountability, marketing, intellectual property, and modern warfare all are information intensive for better or worse. These are highly complex systems (Fig. 8.1). They seek equilibria in many subsections. Indeed with many dimensions of change, even those partial equilibria are changing. Part of the goal of creating social order is to try to create stability and predictability in some areas that allow other areas to flourish. We start with some policy issues which develop tradeoffs and balance.

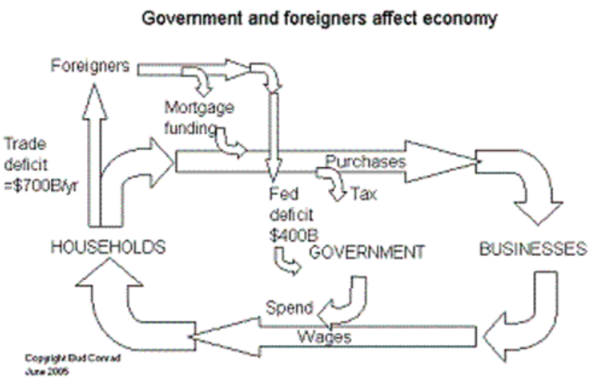


Figure 8.1: Society can be viewed as a complex adaptive system. Indeed, it is particularly complex because the laws and norms are fluid and individuals have many different (sometimes contradictory) agendas. (redraw)

8.1. Social Policy: Freedom and Control of Information

Freedom of expression is a cornerstone of democracy. Along with transparency in organizational and governmental processes, freedom of expression is one of the foundations of an Information Society. Freedom of information is essential for critical thinking. Social complexity[75].

The free exchange of ideas helps to resolve social issues. However, in some cases information can damage the very systems and institutions it has helped to create. This has led to a variety of traditions, laws, policies, and procedures for dealing with information. These seek to balance the sometimes competing forces of individual rights, the power of knowledge and information, and the good of society.

There can be legitimate reasons to limit the distribution of information — it may be personally confidential or it may be under copyright, for example. Some information is also potentially very harmful, such as instructions for making bombs or a hate group's literature, and there may be very legitimate reasons for preventing it from being freely exchanged.

8.1.1. Freedom of Speech and of the Press in the U.S.

Freedom of information allows all sides of issues to be discussed and analyzed. It is fundamental to democracy and a market-based economy. Among other advantages, the press provides a watchdog role on government and business activities. The First Amendment of the U.S. Bill of Rights guarantees the freedom of speech, of assembly, and of the press. While the First Amendment is broad, not all speech is protected. It only covers only government regulation of speech and not speech that is regulated by organizations with which a person is associated. Moreover, some types of speech such as libel, blackmail, fraud, and child pornography are considered so antisocial that they are not protected. Yelling "Fire!" in a crowded public place, such as a theater, when there was no fire would similarly not be protected by the First Amendment because it is fraudulent and because of the potential for injury among the panic-stricken theater goers. However, the definition of pornography is based simply on "community standards"; what constitutes pornography, what constitutes a community, and which community is setting the standards are all questions that need to be determined.

Objecting to what people do rather than to what they think.

Down-side of freedom of the press is patently false information.

Commercial speech which is speech employed in the conduct of business, can be regulated more than other types of expression. For instance, a business can't make fraudulent advertising claims. The U.S. courts upheld a ban on cigarette advertisements on television, but they would be unlikely to ban any sort of political speech (such as a campaign advertisement) in the same way. Moreover, there are some cases when speech is compelled such as requiring the ingredients to be listed on food products.

Freedom of speech protects a person from censorship by the government but it doesn't protect a person from retaliation by an employer.

Civic data. Data about local government and community.

In the U.S., information generated by the government is owned by the public. There are, of course, cases where it is necessary to keep information from being widely disseminated. Disseminating individual census records would violate individual privacy. Some military secrets may need to be protected as a matter of national security. As a means of allowing the public access to governmental records, the Freedom of Information Act (FOIA) was created in 1966. This law allows the public to petition the government for access to governmental records. However, the law does allow for exceptions to the release of information for reasons such as individual privacy and national security. Freedom of information for releasing records in governments around the world[5].

Claims for access are reviewed by a government office and ultimately by an independent judge. When documents are released under FOIA, some sections may be hidden as redactions (8.2.4). Records and archived material (7.4.1, 7.5.1) may contain sensitive information. When a record or document must be made public, such as in response to a Freedom of Information Act (FOIA) request (8.1.1), parts of it may still have to be held back, or "redacted". This is generally related to the legal requirements of the records system. For some other types of material there are too many copies of any published material so it is impossible to retract it. Classified material. Open government data. Limitations of FOIA - slow response. Identity of author of a message and responsibility for its content.

Unrestricted freedom of expression. Slander. Defamation. Libel. These must be adjudicated. Shield laws for the protection of journalist's sources.

Examples.

8.1.2. Freedom of Speech and of the Press outside the U.S.

In Britain the libel laws are much stricter than the U.S.

Hate speech.

8.1.3. Censorship

Censorship is intentionally blocking access to information resources by information consumers. That is, it distorts one part of the information creation and dissemination stream.

Several types of censorship can be identified: Political, moral, and security. Political censorship is particularly harmful to an informed public in a democracy.

One example of censorship which is accepted is giving parents control over what information resources are available to their children.

There are a variety of approaches to implementing censorship sBook burning. Banned books (Fig. 8.2). As is the case with a lot of computer-based language processing, much of the nuance is difficult to automate consistently Thus, some automated filters remove references to a breast of chicken or breast cancer.

When censorship is implemented as a social policy, its purposes and limits should be clearly delineated. Need for freedom of information may be be balanced with community control of appropriate content.

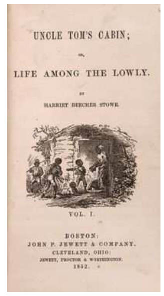


Figure 8.2: Some banned books: *Uncle Tom's Cabin* (left) and *The Adventures of Huckleberry Finn* (right).

Potentially, content filtering can be censorship.

Information monitoring. Technology can both circumvent and facilitate censorship. Great Firewall.

Fig. 8.3. In other cases, only certain types of material are selected for collection. State secrets doctrine. Versus FOIA (8.1.1).

Figure 8.3: Nazi book burning.

8.2. Social Policy: Intellectual Property

8.2.1. The Logic of Intellectual Property

We are accustomed to the idea of ownership of physical objects such as clothes, cars, and houses, but less so to the idea of ownership of intellectual property. Knowledge and ideas can be of great value to society and to their creator. The output of creative intellectual activity may yield a type of property. The idea of ownership of ideas is found in the discussion of plagiarism (5.12.3)but it is also the basis of a legal construct. As a legal construct, intellectual property differs from real property ((sec:realproperty)). There are five major types of legally protected intellectual property: copyrights, patents, trademarks, and design patents. Trade secrets, such as formulas for soft drinks, are also intellectual property, but they are not protected by contracts with employees.

Not all creative activity is protected. In the fashion industry, it has proven difficult to protect creations. In some other cases, intellectual property is enforced primarily by social norms. For instance, top comedians apply social pressure that discourages stealing each others' jokes. Intellectual property,

Figure 8.4: Mozart had no intellectual property protection and died a pauper despite producing great music.

unlike other types of property, can be quickly and duplicated and someone's hard work and creativity can be usurped by another. Laws for protecting intellectual property attempt to balance the rights of the creator with the needs of society and the practicality of enforcing the rules. Ideally, copyright facilitates a healthy publishing industry that is independent of government control.

Intellectual property laws are not always clear, and the emergence of new forms of technology constantly pushes for new legislation. We now see additional complications of music copyrights (8.13.3). [55].

Intellectual property right for digital materials and methods is fuzzy.

> The Congress shall have Power ... To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries

Figure 8.5: Article 1.8.8 of the U.S. Constitution on the need to protect intellectual property.

8.2.2. Intellectual Property Law in the U.S.

Copyright

Copyright and patents are specifically authorized by the U.S. Constitution and are administered by the Library of Congress (Fig. 8.5). As stated in the U.S. Constitution, the main justification for protecting intellectual property in the U.S. is that it serves as an incentive to others to create new works. There are major challenges to copyright from digital works.

> Congress shall make no law respecting an establishment of religion, or prohibiting the free exercise thereof; or abridging the freedom of speech, or of the press; or the right of the people peaceably to assemble, and to petition the government for a redress of grievances.

Figure 8.6: The First Amendment of the U.S. Bill of Rights which guarantees the free exchange of information in many public settings.

Copyright Law In the United States, the United States Code (USC 17) [20] defines copyright law. A copyright can be granted to "an original expression fixed in a tangible medium". A "tangible medium" may include text, music, film, painting, and even sculpture. Copyright law in the U.S. is slightly different from that in other parts of the world, and even within the U.S., some of the details have changed frequently, often owing to other innovations and technological advancements. In essence, however, copyright law extends legal protections to a creator's ability to obtain benefits from their work (usually monetary) and their ability to control how their work is used. Opt-in versus opt-out.

What Can be Copyrighted Copyright not only protects specific wordings and other types of materials such as books or music, but also creations such as type fonts and sculptures. There are limits, however; copyright protects the expression of an idea and not the idea behind it. A newspaper journalist does not have an exclusive right to use the facts behind a news story; rather, the copyright would simply protect the way that journalist describe the events. Similarly, in the 1992 court decision about whether the "look-and-feel" of the Macintosh desktop interface could be copyrighted, the judge determined that only the specific design used for the desktop could be copyrighted and not the idea of the desktop.

A complex multimedia production may have separate copyrights on different components of the production; there may be music rights and narrative rights, for instance. The selection and order of works in an anthology can be copyrighted, even if each work is copyrighted separately, as there is intellectual effort in the selection process. "Works for hire" (i.e., those you are paid to complete), however, are owned by the person who hired you unless otherwise stated. In addition, works for the U.S. federal government are owned by the public.

Re-mix. (Fig 8.7).

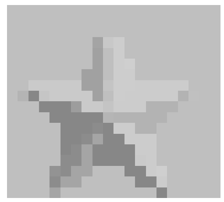


Figure 8.7: Mashups as fair use? Girl Talk.

Rights Granted by Copyright Copyright protects original expressions by granting the five rights listed in Fig. 8.8. The basic right is that of the creator to control the making of copies of the work. There are rights related to this first one that may not involve the actual making of physical copies, such as in the case of theater. Here, these rights are known as "performance rights". Further, performances themselves can be copyrighted separately from the copyright on the work performed. Thus, a specific singing of a song or reading of a poem can be copyrighted and it will be a separate copyright from the copyright on the poem or song itself. This is sometimes described with the claim that copyright can apply to both matter (the work) and energy (a performance). Works are sometimes adapted or expanded into more complex works; those derivative works can be copyrighted as well, but the copyright also depends on permission to copy the original source.

Right to copy
Right to distribute copies
Right to make derivative works
Right to perform
Right to display

Figure 8.8: The five rights granted by the current U.S. copyright law.

Under current law, the creator of an original work automatically holds the copyright on it from the time it is made public, and extend for the author's lifetime plus 70 years thereafter In previous versions of the law, the creator had to register and deposit a copy of the work at the Copyright Office, which is part of the Library of Congress. Once copyright is established, it can be transmitted to others by a contract or license. Normally this agreement gives the publisher the right to market, distribute, and sell copies of a work and gives the creator a royalty in return.

Copyright infringement is the illegal use of copyrighted material. Copyright infringement for commercial gain is called "piracy". Generally, before an infringement is determined, the owner of the copyright must send a "cease-and-desist" letter to the person who is using the work. If the person does not stop using the copyrighted material, they may get sued. Indeed, in the current version of the law, any content can be captured and posted under the "safe harbor" unless the owner opts out.

Exceptions to Copyright In the U.S., several exceptions to copyright are recognized (Fig. 8.9). One of the most widely discussed exceptions is "fair use," which allows limited use of a copyrighted work for certain purposes. However, the limits of fair use are difficult to define — Fig. 8.10 lists the factors considered. Fair use allows a reviewer to quote material in book review; in general, the use of quotations from a copyrighted work for the purpose of explicating criticism or comment is allowed. Photocopying a work for personal use is acceptable, and a limited number of copies may also be justified for educational purposes. Fair use has also been interpreted to allow parodies of works. Parody uses a work to make a comic point (Fig. 8.11). It is obvious that without the fair use exceptions for parody and criticism, no copyright holder would allow the use of their work for those purposes. Digital rights and fair use.

Exception	**Description**
Fair Use	A limited amount of public use of copyrighted works is allowed as "fair use".
First Sale	A copyright holder can collect royalties only the first time a work is sold. If a used book is sold by a used book store, the copyright does not apply.
Library Exception	A library may make copies of works that are out of print for the purpose of inter-library loan.

Figure 8.9: Major exceptions allowed by U.S. copyright law.

Factor	**Example**
Purpose	Is it for personal use or for sale? Is it for education? Is it a parody?
Amount	Is it just a brief quotation or a full chapter?
Nature of work	Is it primarily factual (e.g., biography or history)?
Effect on value	Are the most unique parts selected?

Figure 8.10: Factors typically considered in determining fair use of copyrighted material.

Material that was never copyrighted or for which the copyright has expired is said to belong to the "public domain". Such material may be freely used by anyone; no permission is required and no fee is charged. Many materials prepared for the U.S. federal government are automatically public domain because they are created with public funds, but works for state and local governments often are not. There may be ambiguities about the facts and even about interpretations about fair use. Risk analysis.

?Twas the night before implementation and all through the house,
  not a program was working, not even a browse.
The programmers hung by their tubes in despair,
  with hopes that a miracle soon would be there.
The users were nestled all snug in their beds,
  while visions of inquiries danced in their heads.
When out in the machine room there arose such a clatter,
  I sprang from my desk to see what was the matter.
And what to my wondering eyes should appear,
  but a super programmer (with a six-pack of beer).
His resume glowed with experience so rare,
  he turned out great code with a bit-pusher's flair.
More rapid than eagles, his programs they came,
  and he cursed and muttered and called them by name.
On Update! On Add! On Inquiry! On Delete!
  On Batch Jobs! On Closings! On Functions Complete!

His eyes were glassed over, fingers nimble and lean,
  from weekends and nights in front of a screen.
A wink of his eye and a twitch of his head,
  soon gave me to know I had nothing to dread.
He spoke not a word, but went straight to his work,
  turning specs into code; then turned with a jerk.
And laying his finger upon the "ENTER" key,
  the system came up and worked perfectly.
The updates updated; the deletes, they deleted,
  the inquiries inquired, the closings completed.
He tested each whistle, and tested each bell,
  with nary a bomb, and all had gone well.
The system was finished, the tests were concluded,
  the users' last changes were even included.
And the user exclaimed with snarl and a taunt,
  "It's just what I asked for, but not what I want!"
Anonymous

Figure 8.11: A parody of "The Night Before Christmas". Parodies, especially, those with political intent are generally, protected from copyright restrictions relative to their source.

Digital Works and Copyright Reform Digital systems have greatly changed the nature of the copyright. Because copying digital objects is easier than copying traditional documents, modern technologies challenge many of the traditional assumptions on which copyright is based. Ultimately, there must be a balance between the creator's need for protection and the client's need for reasonable use, but it is unclear exactly where that balance point will be found. Should the rules that allow libraries to distribute books for short periods of time apply to digital libraries that are available via the Internet? Similarly, the "first sale" principle allows the owner to sell a used book, but can you sell a used digital file?

Technical protection measures. Most importantly, with digital systems it is easier to make copies that it was with traditional media. The Digital Millennium Copyright Act (DMCA), the most recent update of U.S. copyright, has many controversial sections. It does not permit attempts to decrypt content and does not allow the publication of certain encryption and de-encryption algorithms. This makes the mere distribution of software that enables copyright infringement an illegal act. Anti-circumvention.

Duration of copyright.

There are many challenges in copyright law. Works for which the copyright holder cannot be located are known as orphan works. But, because the copyright holder cannot be located those works can never be republished. Fig. 8.12 shows some variations of copyright licenses that have been proposed by the Creative Commons project[57] seeks to grant flexible copyright licenses that both protect the rights of the creator as well as promote open-source use.

Right	**Description**
Attribution	Whenever the work is used, always give the creator's name
Non-commercial	This work can be copied but is not allowed to be sold.
No derivative works	This work cannot be incorporated into other works.
Share alike	This work can be distributed by others under a license identical to the original license.

Figure 8.12: A copyright holder may care about retaining some rights but not others. Some of the rights formalized by the Creative Commons[57].

```
<cc:License rdf:about="http://creativecommons.org/licenses/example2">
  <cc:permits rdf:resource="http://web.resource.org/cc/Reproduction" />
  <cc:permits rdf:resource="http://web.resource.org/cc/Distributio" />
  <cc:requires rdf:resource="http://web.resource.org/cc/Copyleft" />
</cc:License>
```

Figure 8.13: A fragment of the RDF code for a Creative Commons Attribution license[56]. (check permission)

Trademarks

Trademarks uniquely identify a product or service. Trademarks prevent confusion with other similar products or services they are therefore, are essential to establishing a brand name. For the customer, the trademark provides evidence of a level of quality. Indeed, trademarks and the products they represent are often so tightly bound that it is difficult to think of one without the other. Phrases or graphics are the most common forms of trademarks, but it is also possible to trademark a musical jingle or even an animated character. A trademark must be distinctive and its unauthorized use must be controlled by the owner. In addition, trademarks are usually registered, which simply solidifies their ownership force both within and outside the product's common market. One recent trademark controversy concerned whether or not the statement "You've got mail" could be trademarked by AOL. However, the line was judged not to qualify as a trademark because it is a common phrase in everyday use.

Trade Secrets

Trade secrets, such as the formula for Coca-Cola, are also intellectual property. They are not protected by federal laws but they may be protected in two other ways. First, individual state law often protects such information. Second, companies interested in protecting their trade secrets generally include a "non-disclosure requirement" in employee contracts. Any violation of that clause can be prosecuted and damages can be sought. There are exceptions to non-disclosure agreements in cases where an employee believes that their company is concealing information that may be damaging to the public health or interests. Such people can often apply for federal whistle-blower status, in which case they become exempt from prosecution under their original employee contract. Branding (5.2.2). Industrial espionage (7.11.0).

Patents

Patents provide protection from the use of specific processes. Thus, they generally promote technological development while copyright often promotes artistic development. In return for the public disclosure of technical information about a device or process in the patent application, inventors are given a period of proprietary use for their creation. Fig. 8.14 illustrates the content of a patent. Under current U.S. law, patent coverage lasts for twenty years from the date of issue. Patents of a process may be granted for a "non-obvious extension" of a technology. Patent searches. Originally, an invention or process had to be "reduced to practice," meaning it had to be a completely novel process. Historically, patents have been applied to protecting machines which complete processes. In many cases this leads to patent protection for the products of such processes such as complex pharmaceutical drug. However, that principle is difficult to apply to software and processes have been accepted in the U.S.; these are called "method patents".

A successful patent can be very valuable; and some businesses are based primarily on intellectual property (8.13.3). In general, patents have proven to be a driver for a knowledge economy (8.13.2). In some ways, the intellectual property system has evolved in a way that actually inhibits innovation which was one of the main justifications for the legal framework in the first place. Patent trolls.

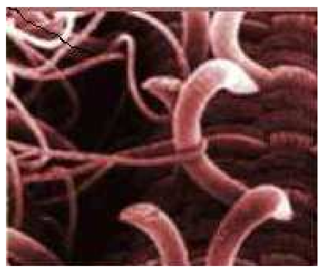


Figure 8.14: A close-up of Velcro which was awarded U.S. patent #2717437. (different picture)

Other U.S. Laws and Rights Relevant to Intellectual Property

Personality rights. In the U.S., some rights are typically granted by state rather than federal law. People have the right to control the right of personal information such as their name and photographs. However, most public figures, such as politicians, who exist in the public eye lose some expectation of being able to control their image or the use of their name in all but the most libelous of settings. On the other hand, in California — where Hollywood is located — restricts the use of images even after they died. Physical objects, even though they be "informational" in a sense, are considered ordinary property, and their owner can control their use. The Mona Lisa is owned by the Louvre Museum in Paris, and the museum is allowed to control copying its likeness (the Louvre does not allow photographs to be taken on its premises). Increasingly, intellectual property is coming to be regarded more like an ordinary property and is governed by contracts rather than by intellectual property laws. Patent searches in order to confirm that an idea is novel.

8.2.3. Non-U.S. Intellectual Property Laws

Intellectual property (IP) laws are usually associated with mature economies. Europe has IP laws which are similar to the US although they tend to include more compulsory licensing. Less common is a notion of fair use. In some countries, especially in Europe, intellectual property rights for creative works allow additional "moral rights" which go beyond the economic rights. These give the creator rights such at the right of attribution and permanent rights to control some aspects of the use of the work. For instance, a sculptor would be able to veto certain locations for the display of his/her work [11], or prevent it from being shown in certain contexts. Moral rights makes that case that intellectual property is an extension of the personality of its creator, and that as such, their right to their work supersedes that of copyright law. Some elements of moral rights are included in the Berne Convention treaty, but only in the context that each signatory country is required to enact in their domestic laws the extent and specifics of an author's moral right to their own work. This leads each country to have specific rules regarding the moral rights of intellectual property. Joint ownership of IP. Tribal IP laws. Piracy.

8.2.4. Rights Management

Rights are an integral aspect of information resources. There are frameworks for describing and applying rights. Contract-like documents, such as "terms and conditions of use," are often attached to information resources as a disclaimer. These explain the proper and allowable uses of the product. Any contract, however, is only as good as the ability to enforce it. Mechanisms for ensuring that the stipulations of a user agreement are upheld are integral to managing the economics of information goods (8.13.3). Passive versus active DRM. Copyright crawler. Rights metadata and contracts. Rights management organizations: BRR, ASCAP, BMI.

Digits Rights Management Technologies

Many options are possible. In the case of music, you might buy the rights to play a given song 100 times, or alternatively you could buy the rights to play it for one year. Solutions such as this, however, have not proven to be effective. As a general solution, a formalism can help specify rights; indeed, there could be rights expression languages. Repositories (7.8.0).

Digital rights management systems have been designed and proposed to more effectively accomplish this task. These systems encode or encrypt particular functional allowances into the file that is to be managed. These affordances prevent the user's equipment (hardware and software) from executing certain tasks, such as copying or distributing the controlled file. The particular affordances that are encoded are intended to be selected by the copyright owner and any other involved parties (such as the creator's employer).

Rights Definition Language (RDL). DRM metadata needs to be associated with implementation details. It may be possible to create a system in which one copy is loaned from one machine to another. The file would simply be deactivated from the first machine and placed on the second machine, and when the loan is completed, the file would be deleted from the second machine and reactivated on the first.

Usage rights can also specify what parts of the content can be used and under what circumstances. Fig. 8.15 shows some categories defined by a DRM language and Fig. **??** gives an example of the DRM language. These technical languages allow the user to define the components to be managed and then to set terms and conditions for their use.

Rights	**Example**
Transfer of rights from one user to another	Product movement from one repository to another
Rights to reproduction	Print and display of content
Rights to derived products	Using the product for creation of new products
Rights to file management	Creation and restoration of reserved copies
Rights to system configuration	Software installation in repository

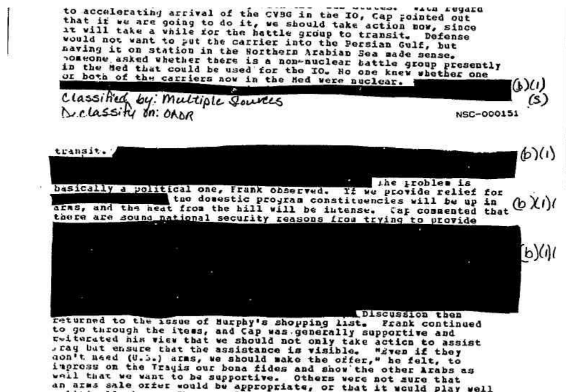
Figure 8.15: Categories of digital rights as defined by XrML[73].

Not all creators are protective of their creations as others are. While copyright gives an author several distinct rights, the author may not care to claim all of them. A contract can define "acceptable use" policies. These policies detail for what, and to what extent, a copyrighted material may be used. A copyright holder might sell part of a document for a single use or for a specified time period.

Other Terms and Conditions for Use

Contractual requirements rather than societal policy. The owner of the rights to a work sets the terms and conditions for others' use of that work. These stipulations may be based on copyright licenses (8.2.2) or other property rights, or they may be based on organizational policies concerning security and privacy. Acceptable use policies are one example. These are the conditions under which a user can legitimately use another person's intellectual creation. They may include such things as privacy of archives or personal papers, source citation, and the use of watermarks. Digital objects and rights metadata (8.2.4). Right clearance center.

Redactions block the presentation of certain material for privacy or security reasons in a document. Redactions have been applied to paper documents with magic marker (Fig. 8.16), but they can also be controlled electronically with XML-based tags. This could be a part of a repository management system.



... with regard to accelerating arrival of the CVBG in the IO, Cap pointed out that if we are going to do it, we should take action now, since it will take a while for the battle group to transit. Defense would not want to put the carrier into the Persian Gulf, but having it on station in the Northern Arabian Sea made sense. Someone asked whether there is a non-nuclear battle group presently in the Med that could be used for the IO. No one knew whether one or both of the carriers now in the Med were nuclear. [redacted] (b)(1) (S)

Classified by: Multiple Sources
Declassify on: OADR

NSC-000151

transit. [redacted] (b)(1) The problem is basically a political one, Frank observed. If we provide relief for [redacted] the domestic program constituencies will be up in arms, and the heat from the hill will be intense. Cap commented that there are sound national security reasons for trying to provide [redacted] (b)(1) Discussion then returned to the issue of Murphy's shopping list. Frank continued to go through the items, and Cap was generally supportive and reiterated his view that we should not only take action to assist Iraq but ensure that the assistance is visible. "Even if they don't need (U.S.) arms, we should make the offer," he felt, to impress on the Iraqis our bona fides and show the other Arabs as well that we want to be supportive. Others were not sure that an arms sale offer would be appropriate, or that it would play well

Figure 8.16: A paper document with redactions[17]. For electronic documents, redactions would be processed with XML and a Digital Rights Management system. (check permission)

8.2.5. Technologies for Rights Management

Secure Containers

Digital rights management systems require an environment in which the content is able to be controlled. Many DRMs require that a trusted system be implemented by requiring the use of specialized, common software and hardware. This would allow these trusted systems to restrict the use of a protected file only to systems where its proper and authorized use can be enforced, in effect creating a lock and key scenario in which a copyrighted file is transferred to a user in an encrypted (locked) state that requires a key to decrypt, and which simultaneously prevents unauthorized uses of the file.

Copy Identification: Digital Watermarks and Fingerprints

Digital watermarks and fingerprints encode a digital object in a way that identifies its source (Fig. 8.17). This can be helpful for copyright protection. "Watermarks" are indicators on a display that are apparent to an observer. The term watermark comes from the process of stamping paper with a unique symbol that is often used to certify its authenticity.

Figure 8.17: Picture with a digital watermark (from Mira.com, check permission). Note the "C" with a circle around it which appears to be stamped on the image indicating copy protection.

"Fingerprints" are hidden in digital representations. There are many ways to hide identifying information in an image. Codes may be hidden in the brightness or color signals. Fingerprints can be created by spreading code throughout an image. In a typeset document image, the spaces between letters and lines may be used[35] (Fig. 8.18). Fingerprints can even be hidden in wire-frame models used for computer-generated graphics (Fig. 8.19). Both watermarking and fingerprints can often be defeated by converting material across formats. For instance, the postscript file in Fig. 8.18 might be OCR'd and then reconstructed. Multimedia fingerprints.

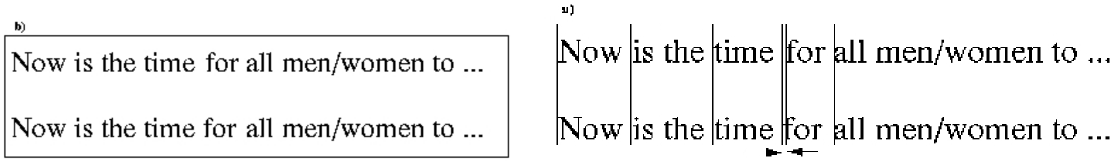


Figure 8.18: Using the spacing between letters to create a digital fingerprint. The word "for" has been intentionally shifted a small distance from its default position to mark this document[35]. (check permission)

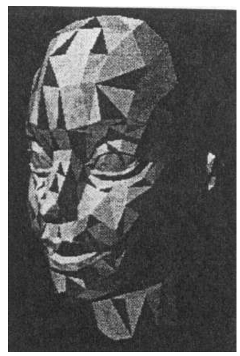


Figure 8.19: Watermarks can be hidden in shapes of polygons in a wire mesh for a 3-D synthetic object[21]. (check permission)

Duplicate and Plagiarism Detection

It is easy to make copies of digital resources. In some cases, this is highly desirable, but the copies may also be unauthorized and it would be helpful to be able to automatically detect them. Detection of copies can go beyond exact word matching but also semantic similarity. This can be an indication of plagiarism (5.12.3). This could be useful for detection of copyright violations, for detection of plagiarism, or for reducing duplicates in search-engine returns[39]. Near duplicates and imperfect matches are more difficult to determine. One strategy is to look for matches to distinctive fragments or authorship characteristics. Some strategies for approximate match are related to text retrieval. Multimedia duplicates. Fades into similarity matching by search engines (10.7.0).

8.3. Social Policy: Privacy, Anonymity, and Surveillance

8.3.1. Privacy

Modern technology and security concerns pose challenges to an individual's right to privacy. A certain degree of privacy is something that most of us expect in our day-to-day lives. This expectation extends to some of the information about us. We often want to control access to that information, and prevent other people, companies, or governments from viewing it. Indeed, while it is not explicitly stated, some parts of the U.S. Constitution are interpreted as implying a right to privacy. The 4^{th} Amendment of the U.S.Constitution protects against unreasonable search and seizure (Fig. 8.20). This amendment has been interpreted as granting a general protection of privacy.

But what exactly is privacy? People differ greatly in their conceptions of what constitutes privacy. Some people do not want even their address given out while others don't seem to care. Therefore, an invasion of privacy may best be defined as any "unwanted intrusion" [23] into a person's life. This definition is filled with difficulties, however, and in the end, what constitutes privacy (or a breach of it) may be determined piecemeal, as instances arise.

> The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.

Figure 8.20: There is no right of privacy specified explicitly by the U.S. Constitution. The Fourth Amendment of The Bill of Rights of the U.S. Constitution, which places limits on search and seizure, has been interpreted as implying a "right of privacy".

In some cases, privacy has more to do with an individual's ability to control social impressions rather with access to specific data. Privacy norms rather than privacy laws.

Information Privacy

Privacy about the information resources one accesses. Electronic media introduces many challenges to privacy. There is privacy from commercial interests.

However, there needs to be a balance between citizen's right to privacy, security, and the need for the free exchange of information. The government has the right to wiretap suspected criminals. This is a necessary and logical right, but it is regulated by requiring a court order to prevent abuse. Other such circumstances may include accessing private medical information in an emergency (9.9.3).

EU privacy rules.

Too much surveillance raises the possibility of totalitarianism. Big Brother.

Issue of privacy for information brokers who collect large amounts of personal data from web browsing and credit card transactions. Data brokers (9.6.0).

Privacy and willingness to disclose personal information. Privacy capitalism.

Location privacy.

Special protection for (a) personally identifiable information, (b) children and students, and (c) health information. On the other hand, there are times when in depth background checks are desirable.

Invasive technologies such as dragonflies (sec:infosecurity) and sensor networks. Balance with the need to beware of possible terrorist attacks. Privacy depends in part on information security (7.10.3).

It has been proposed that individuals could control their own personal information as a type of intellectual property. Types of harm due to violation of privacy. Costs of keeping privacy. Search warrants.

Many kinds of data. Modeling what a person will be doing. Location data. Behavioral extrapolation. Recommendation systems.

User expectations about privacy versus privacy itself. Privacy standards are changing. Perhaps because of the highly social nature of Internet interaction. Expectations about privacy differ greatly across cultures and even across individuals. In some social settings, there is little expectation of privacy. It is often said that in a small town, everybody knows everybody else's business. Different standards across cultures and generations.

Corporations sharing information about individuals.

A corollary of freedom of information is that a person's privacy is protected about what information a person accesses. In libraries, this is known as reading privacy. Records on the circulation at libraries and purchases at bookstores are, generally, protected. However, people are required to release a certain amount of information, for instance, when making applications to both the government and to companies. Privacy of reading habits. Library circulation records have traditionally been considered private. However, many social media applications record details of user behavior.

Data Mining and Personal Information

Massive amounts of information are collected about individuals. The data come from online behavior but also from activity in specific environments such as supermarkets or amusement parks (4.11.0).

Pattern-based surveillance.

Policies for Collection Availability of Personal Data

In contrast to physical privacy, informational privacy is harder to ensure. Information systems make the collection and distribution of information (particularly information stored in databases) faster and easier. Information technology facilitates the storage of and remote access to data. There can be many benefits of sharing data across databases. Data such as drivers' records, which used to be difficult to obtain, are often available online. Moreover, these data can easily be merged with other data, which can save time and money. Also, it allows security agencies to be more effective at monitoring suspicious people, including terrorists. This increase in monitoring ability creates challenges for privacy.

Personal information security. One of the dangers of the spread of personal information in information systems is "identity theft," which happens when one person poses as another person to spend their money or obtain lines of credit using their social security number. Fraud of this variety is rampant, and the costs to society are enormous. Privacy breach. Many records are corrupted. While privacy controls may not have changed, it will soon become necessary for them to be altered to reflect the new realities of the digital age. Fig. 8.21 lists several factors to be considered in data privacy. The principle of "individual participation" asserts that individuals should be able to view a profile of any personal information that is kept about that. The networking of information resources dramatically change the available of personal information. It is easy to find detailed information about an individual. Moreover, there can be a longevity of personal data that appear online. privacy and data aggregation. Credit score. Opt-in versus opt-out. Who controls dissemination of personal information. For instance, in the accuracy of personal information

Principle	**Description**
Collection Limitation	Data should be collected only by legal and fair means.
Data Quality	Data should be collected only for specific purposes
Purpose Specific	The purpose for which the data are collection should be clearly stated.
Use Limitation	Data should be used only for the purposes for which it was collected.
Security Safeguards	Once collected, personal data should be protected.
Openness	The existence and nature of a personal data set should be described openly.
Individual Participation	Individuals should be allowed to validate and challenge data that is held about them.
Accountability	Any organization controlling data should abide by these principles.

Figure 8.21: Data privacy rights for personal information in the OECD (adapted from[66]).

Privacy laws. Conflict of privacy laws across national boundaries.

An active digital footprint is personal information that individuals release, wittingly or unwittingly, about themselves. Part of the threat to privacy is that data about an individual from many sources can be coordinated. While any one piece of data may not be problematic, the combination of many pieces can be very revealing [?].

Loss of privacy through data aggregation (9.6.0). Having vast amounts of personal information readily available online seems qualitatively different from public records which had been kept in different records centers.

Social media sites and privacy. Balance of privacy and social media. Exchange of private information in social media can be an act of trust. Difficulty of forgetting. Right to oblivion in archival materials ((sec:oblivion)). Social forgetfulness can be a good thing[42].

Privacy and system security are closely interrelated. Cyber-crime may attempt to systematically attack personal records (5.3.4). Spyware is a term used to describe covert computer programs that install themselves on a user's computer without their explicit knowledge, and are designed to collect and report information about the user's computer habits. These programs can also gather personal information, ranging from names and addresses to credit card numbers.

Putting the User in Charge

Some internet initiatives are seeking to encourage companies to create fair and extensive privacy policies. Simply labeling a site with a clear, identifying mark indicating the site owner complies with privacy standards can help users identify trustworthy sites. "Seal programs," such as those from the Better Business Bureau (BBB), provide non-governmental certification of sites that follow approved privacy practices.

Data vault.

Economics of privacy.

Beyond Information Privacy

Multimedia and data processing technologies are presenting additional challenges to privacy. Face recognition and privacy (anonymity). Cellphone cameras and privacy.

Privacy and personal identification tags.

Drones.

There are even new types of threats to privacy. The results of DNA test may suggest that a person has a predisposition to certain diseases (9.8.1). That person may want to keep this information confidential. They may want to ensure their genetic privacy (8.3.1).

Management of private information by a separate organization.

8.3.2. Anonymity

In its strict sense anonymity is the total concealment of an identity, without the possibility of discovery. The more common form of anonymity, can be defined as practical obscurity, which can be thought of as being lost in the crowd. This holds true for much of our personal information as well. Effectively, anonymity is one way to achieve a level of privacy. Anonymity is a double-edged sword, however. Although it helps to maintain the privacy of individuals, it can also prevent the identification of people committing illegal acts. Generally, actors in society need to be responsible for their actions.

"Anonymity is dead." Generally, there is loss of anonymity.

In some cases, anonymity can lead to avoiding responsibility.

Balance between anonymity and free speech. Versus taking responsibility for ones claims. Pros and cons for anonymity of actions on the web. Anonymizer. Networking (-A.15.0). Onion routing (Fig. 8.22.) Online anonymity and tracking IP addresses. Cyber-hate. Personal VPN tunnel.

8.3.3. Surveillance

Surveillance is intentional observation. It can be done with cameras, by tapping telephones, or monitoring Internet traffic. Furthermore, it is enhanced with technologies such as face recognition. Surveillance, like anonymity, has both benefits and disadvantages. Focused surveillance can certainly be helpful — for example, patients in a hospital can benefit from being monitored (Fig. **??**) parents can watch a nanny minding their child, and surveillance in public places helps to both prevent and solve crimes. However, most people become uncomfortable when they know they are being watched. Indeed, surveillance undermines trust (5.2.3) and the internalizatiom of personal responsibility.

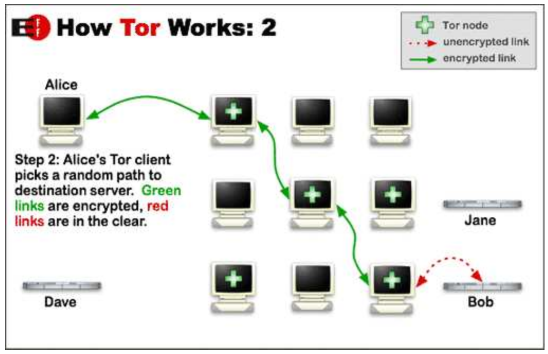


Figure 8.22: Onion routing[76]. (check permission) (redraw)

The widespread use of surveillance is sometimes compared to the pan-opticon model of a prison (Fig. 8.23). Algorithmic surveillance for instance with automated face recognition. Surveillance of Web activity through tracking cookies. The Constitutional limits of surveillance are unclear. Implications of long-term focused surveillance versus transient surveillance.

Increasingly, information systems are being used to monitor the activities of people on the internet. While this has benefits, such as apprehending criminals, many people are worried that the increased ability of information systems to monitor the actions of ordinary citizens and to gather together personal information about them constitutes an effective loss of anonymity. Parental surveillance of children.

Algorithmic surveillance. Pattern and fraud detection. Data mining for surveillance.

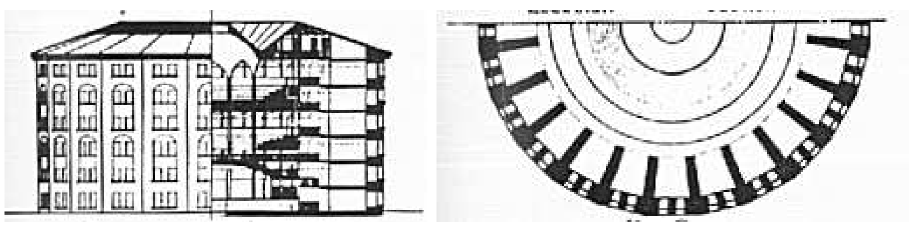


Figure 8.23: Bentham's 1791 drawing for a "pan-opticon"[34]. This is a prison with a circular design that would allow for optimal surveillance of prisoners with a minimal number of guards. Some people believe that information systems may lead to an invasion of personal privacy that will make society like a pan-opticon in which the activities of large numbers of people are monitored by a small number of observers. (check permission)

Some applications on the Web allow for identification and detailed tracking of individuals. IP addresses can be tracked and characteristic usage patterns can be monitored. Cookies carry identifying information about the users. Many companies use this information to develop marketing schemes that either directly target users via advertisements, or entire demographics via products and services. Massive amounts of click data and cookies. Data-driven marketing (8.12.5). Re-targeting. Predictions and profiles of individuals. Patterns of behavior. Descriptions of how to present ads. Taxonomies for ads. Auction of personal information.

Green Wall. Co-opting social media by the government.

There are many benefits to knowing where a person or object is located. It helps applications from cellphone call routing to supply chain management (8.12.1). Surveillance can help to protect society from terrorists. Monitoring patients in a hospital. Parents checking on children's activities online. However, detailed tracking of location for instance location-based services also threaten anonymity. Unique types of targeted advertising with location tracking. These issues are amplified by social location services Such as those which identify when you are in proximity to your friends. Video and surveillance (11.6.1). Location-based question answering. Problem of 3-D location. For instance, where a person is located in an office building. Anonymity can facilitate illegal and terrorist activities. Anonymity and personal histories. Right to oblivion (8.3.1).

Figure 8.24: Non-specific video surveillance.

Figure 8.25: Surveillance of hospital patients with sensors and monitors for their own safety. (check permission)

8.3.4. Personal Identification

To flip anonymity around, there are times when we need to positively identify a person. How does a person or society do that? What credentials uniquely identify an individual as the person they are claiming to be? For obvious reasons, it is necessary that this identification process be done with a high degree of accuracy and confidence.

Establishing identity with biometrics (8.3.4). Each of these has different identification effectiveness — hair color is not as an unique identifier than is a fingerprint, for example. Photo identification is a type of biometrics. A second type of identification consists of knowledge that only a single individual may possess. This form of ID is commonly used for automated verification processes, and includes PIN numbers and passwords. A third form of identification is items uniquely associated with an individual. In the United States, the most common form of this type of ID is a social security card/number. It is the mere possession of an item that confers identity. Social security cards and numbers are easily lost or stolen, and when used for verification purposes, need to be confirmed by another means. However, this is often not the case. Identity cards based on biometrics can be useful when there other forms of identification are not feasible. This is being done a large scale in India.

Face recognition can be applied in public spaces. Surveillance linked to face recognition (8.3.4). But, this has substantial implications for privacy. This can be both useful and intrusive even if the individual is not identified specifically.

An individual's privacy can be adversely affected by many identification processes. Because so many services require a person's social security number, for example, that identifier is easily obtained by others. Once it is obtained, it can then be used to access very sensitive information and authorize many different transactions. Beyond the technological details, there is an ongoing debate about the social implications of using biometric identity cards. The related concepts of authentication and authorization are discussed in terms of information security and assurance (7.10.3).

8.4. Government and Social Decisions

8.4.1. Government

Government is an institution for making and implementing social decisions. Government may be thought of as a social contract between citizens to implement policies which are in the common good.

It is a set of institutions that has been set up to provide a framework for social interaction. The government encompasses an enormous range of activities, and it is information intensive. Government provides a framework for dispute resolution. Government archives and records (7.4.1).

Open government and asking for suggestions from the public. Making government data sets available to the public. Government as a publisher of information. Maintaining the confidence of the public in the quality of government information. But it is rare that the details of are fully presented such as full disclosure of government contracts and grants.

There are many ideas about the role of government. This is the basis of political science. [30] There are different perspectives on the role of government. In one view, government as an umpire in a sports match. An alternative view government promoting fairness and justice. Beyond the theory of government, there are practicalities in everyday governance and crises such as natural disasters, economic dislocation, and foreign threats. Social contract. Government and governance.

We have already encountered organizational bureacracies (7.3.4). Government bureaucracy.

Government setting economic and industrial policy.

8.4.2. Government Information and Services

The government provides many different information services. From town councils through the federal government, citizens rely upon their government to provide services and information. Each one of these services, from driving licensing to economic statistics and monetary policy, involve the collection and management of vast amounts of information. The government's role in collecting and managing information. Open data for government (9.6.4). Public information. Government archives (7.5.1). The record-keeping tasks alone, such as birth, marriage, and death records, constitute an enormous amount of information that must be managed. Weather service. Improving the operations of government with eGovernment.

Disclosure and public information. Open government. Community information services. Civic data (8.1.1).

IT Governance. Government and information policy. Privacy. Risk Management. Compliance. Regulation.

Public Administration

There are a lot of databases in the public sector. Government data collection and storage. This includes datasets (9.6.0) such as census data, labor statistics, tax records, environmental data sets, and scientific data sets. These have many challenges ranging from political issues confounding their management to special problems of procurement of infrastructure because of budgeting for government information systems[53]. Transparency and FOIA. A totally transparent government would publish detailed budgets and contracts. Social information institutions that minimize corruption.

8.4.3. Social Decision Making

All the many aspects about how society works are social decisions. Social groups need procedures for reaching decisions. Sometimes these decisions are made by dictators, sometimes by representatives, and sometimes by democracy. Decisions made by small groups. Simulation could be used as a tool to support these decision aids much as it is used in DSS systems. However, simulations involving social policies are notoriously unreliable. Are organizations and governments rational? Public choice theory [40] asserts that governments and organizations often serve the personal goals of their leaders[26].

There are many strategies and procedures for decision making. Decision making in small groups (5.6.0). A social decision process must have at least implicit consent of the group for whom the decisions are being made. Often, there are too many voices to be heard in regard to issues that are too complex for simple discussion to be effective.

Information and Democracy

Democracy places the political, and hence, social, decisions in the hands of individual citizens. Democracy is most often associated with voting but it actually requires a balance of among many social factors such as freedom of expression (8.1.1) and stable social institutions. Because of this, each citizen needs to have rich information and the ability to analyze it. The possession of information is, of course, only part of the battle — citizens must also be educated to think critically about the information they have. Social media and coordinated social action. Personal democracy. One of the values of democracy is that it gets citizens to participate in the government.

Democracy also has many challenges. For instance, the votes of a simple majority and not protecting minority rights. A republic or representative democracy (in which the power of the citizenry is delegated to elected representatives), can be seen as a way to avoid the "rule of the mob"; the seasoned and informed temperaments of politicians can put the brakes on the wild swings of public zeal. Because citizens are not fully informed on many issues, and because some issues are extremely complicated (tax laws, trade negotiations and tariffs, etc.), direct citizen voting may not produce wise results in many instances. People can be swayed by short-term emotional reactions. This can be aggravated by the time-honored technique for introducing confusion among decision makers by providing misinformation. There can also be a "tyranny of the majority" in which the right of small, but none-the-less significant groups are entirely dominated by the majority.

Public discussions about complex issues often lose the subtleties. Some participants gloss the issues to score points. This requires knowledge and information, mainly about whether the views and opinions of the proposed representative are similar to those of the person voting for them. An uninformed, or misinformed, citizenry is, thus, less able to select representatives who reflect their intentions [60]. Pundits and prediction accuracy.

What do people accept as factual? How do they judge reliable sources.

News versus advocacy (8.13.7).

Social media and democracy movements.

Civil Debate in Adversarial Discourse To provide considered discussion of positions, discussions should be carefully considered. Such discussions are characterized by focus on the issue and collegial, non-threatening discussions.

Avoid direct personal attacks on opponents in a discussion, that is ad hominem comments and insults. These introduce emotional responses which may cloud the reactions of the participants and the audience.

Protest and dissent.

Public Discourse and Civic Media

Newspapers and other mass media can facilitate the free flow of ideas (8.13.7). Though, they may also do this while expressing strong political opinions. This is even more true of interactive media such as talk radio and blogs (10.11.2). Blogs and citizen journalism (8.13.7). Discourse (6.3.2). Effective democracy depends an educated, thoughtful, and informed citizenry. Deliberative democracy. Social decisions occur most effectively with transparency, and informed, open debate [7]. Political activism (5.1.4).

Ideally, political discourse would be respectful and restrained. This is often different from rowdy political conventions and gamesmanship of blogs. Freedom of expression and speech (8.1.0) are essential for an informed citizenry. Such a variety of channels of information encourages individuals to form their own opinions and make their own decisions. Freedom of information also helps expose political corruption and create a more solid government. For this reason, it is necessary in a democracy to have a large amount of government and institutional transparency. That is clarity of processed, public access to relevant information, and recording decisions.

Managing public opinion. Attitude change (4.5.2). Buzz analytics (10.11.2). By framing a public the debate the categories and issues are outlined. Biasing social discourse by creating a narrative and focusing on only one aspect. Indeed, there may be intentional obfuscation and sewing confusion.

Ideally, citizens would be critical thinkers and immune to attempts to bias their opinions. Collaborative analysis tools can help support deliberative democracy. Discussion of policy issues[49]. Argumentation systems (6.3.5). Social Decision Support Systems[77] (Fig. 8.26). Debate graphs. Blogging as social debate. Blogging as catharsis.

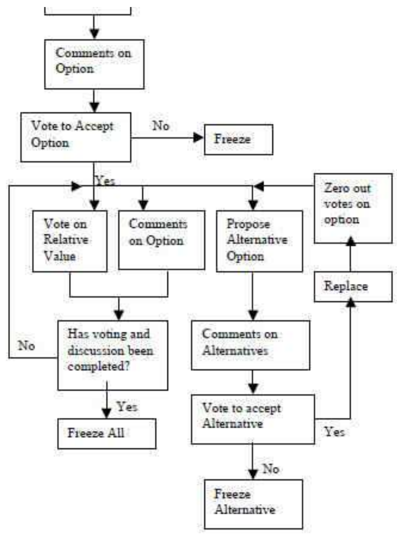


Figure 8.26: Social Decision Support System[77] can be systematic and similar to legislative deliberation. Potentially, these incorporate argumentation systems with decision support systems. (redraw) (check permission)

Confidential discussions in running government or any organization versus the need for transparency.

Claiming the legitimacy of scientific research for a political agenda.

Political Protests

Political protests.

Social media and political change. Political danger of synchronized groups.

Polling

Assessing public opinion for polling and surveys. Polling as a type of data analysis and analytics. Attitudes and opinions (4.5.2). Tracking public opinion with sentiment analysis (10.11.2). However, polls, can be greatly affected by the way questions are asked.

Big data analytics.

Public Opinion

Awareness and issues. Journalism (8.13.7)and blogs. Buzz analysis (10.11.2). Personal opinions (4.5.2). Seeking logical arguments with which you disagree And then developing a basis for the differences of opinion.

In a prediction market, people can buy options for predictions about future events. Prediction market (Fig. 8.28). but these can, sometimes be manipulated. Prediction market as a matter of public opinion.

There is a considerable incentive for politicias to manipulating public opinion and there are many ways in which this is done (5.3.3). Framing the debate. Creating an impression of crisis. Flooding media

Figure 8.27: Incorrect polling in the 1948 U.S. presidential election predicted that Dewey would beat Truman. This belief was so strong that one newspaper printed the incorrect result. (check permission)

Figure 8.28: In a prediction market people can buy options predicting future events.

channels (e.g., search engines) so that contrarian opinions can't get through. Demagoguery Distorting information. Spin. Providing alternative explanations. Focus on only one aspect of a complex syste

Making Social Decisions

Many social decisions are complex specialized. Representative government has the effect of slowing down the processes of government and legislation with debate and placing decision-making power in the hands of people with experience in the process. The use of a representative form of democracy is believed to be a buffer against the emotions of the people and the rule of the mob.

Distributed decision making. Transparency and how those decisions are made and in the responses to them. Of course, there are many forces opposed to transparency. Corruption and the distortion of public opinion. Transparency for institutional decisions consists of citizens being aware of the the processes by which decisions are made and also be having the deliberations about specific decisions be open. News provides information about government policies and events and it can be a watchdog examining the actions of government and public figures for hypocrisy, corruption, and wrongdoing. The Internet engages citizens in ways that traditional media cannot, by allowing them to actually participate in Web discussions on civic issues, for example. This grassroots power can lead to an emergent groundswell of public opinion through online communities (5.8.2) and popular websites. However, that same grassroots power can also be overrun. There can be a value in reputation of news organizations for a balanced presentation of the news though even that is increasingly rare.

Political campaigns. Part information, part persuasion.

Voting

Voting is a formal mechanism for reaching social decisions. The most obvious, and important, form of civic participation is voting. Direct democracy could maximize voter confidence in elections and issues, which as we have noted, often serves to increase citizen participation and interest in the political issues. We discuss more about voting in (-A.9.5); for instance, the problems of using a plurality rule when there are more than two candidates. Secret ballots help to minimize the possibility of retaliation for voters. Collecting electronic votes is related to electronic records management. Secret ballot related to privacy.

As noted above, information is vital to effective social decisions. An informed electorate.

Transparency in the election process.

Electronic voting systems have been proposed. These have many advantages but they may have many possible problems. The anonymity of voters must be maintained while also preventing voting fraud adding votes. Information systems, with their support for rapid communication could allow for a more direct democracy. which allows citizens to vote directly on issues. Security (7.10.3) and trustworthy results. Open source software for electronic voting machines can be reviewed to ensure that there is a very small possibility for fraud.

Multi-Party Democracy

Voters tend to align into political parties. Computation and argumentative nature of the proceedings.

In combination with freedom of speech, adversarial political opinions tend to illuminate aspects of social issues. Potentially, these can highlight issues.

Political parties usually provide a relatively stable coalition which form around clusters of significant issues.

Downside of multi-party democracy.

Political parties are often non-deliberative and often rely on brash advertising. Persuasive mechanisms of all sorts. Social media use for informing, persuading the voters.

This carries over into the mechanism of checks-and-balances in government. Effects of Internet fund raising in political campaigns. Micro-targeting of political messages like other targeted advertisements.

8.4.4. Polling, Campaign Marketing, and Voting Analytics

Big data for democracy.

Modeling the electorate.

Computational political science.

8.5. Policy, Law, and Regulation

We have seen the norms and rules are fundamental to social interaction. One of the main functions of government is to develop rules for society to function. Law is the result of implementation. Policies are statements of principle; laws are rules created to implement policies, and regulations execute the laws (Fig. 8.29). Law has is enforced with consequences. All of these pieces need to work together.

Policy analysis and development. Developing a model of how different components affect the topics to which the policy applies.

Level	**Example(s)**
Policy	Copyright should be established in order encourage people to be creative.
Law	Give an author copyright for a certain number of years.
Regulation	Details of forms which need to be completed. Develop appeal procedures.

Figure 8.29: Policy sets broad principles, law establishes rules, and regulations describe implementation procedures.

Network continuity.

Ethics and policy.

8.5.1. From Policy to Law

Policy

A policy is a statement of principle it emphasizes a desired condition. Policy is built on values and goals. We have also considered organizational policy (8.11.1). Some social policy is implements in laws. It outlines the strategy or tact that a government or organization is going to take about a particular matter. A good policy has several basic elements: it should be specific, it should be unambiguous, and it should be technology-neutral (because technology is normally an implementation detail). Also, policies should be well conceived; that is, they should have their intended impact [?], and not negative effects that careful analysis could have foreseen. Few polices are so carefully conceived and many idealistic policies are impractical to implement.

Think tanks. Epistemic communities. Multi-disciplinary perspectives which often deal with policy issues.

Legal Frameworks

In constitutional systems, such as the U.S., the constitution sets out the basic framework of society. Parliamentary system such as in the Commonwealth, do not have such a strict framework. A Constitution sets out the rules for the allocation of political power. It describes the structure of the government and provides checks and balances among the parts to keep any one power source from dominating the others. It is a sort of meta-law. Within that framework, laws and regulations are formal rules for creating a structure for creating a civil society. They are the tools by which policy is implemented. Parliamentary systems generally have a similar interpretation of constitutional conflicts. However, the Parliament is the final authority. Either way the meta-legal system must support the basic needs of a complex society. For instance, the rights of minorities should be protected.

A law, on the other hand, is a statement created and ratified by elected officials or legislators, and which outlines a code of conduct or a prohibited behavior. Laws should encourage a stable social consensus for how society could be run. It is possible to make a lot of rules to handle many different situations. Good laws should be easy to understand, easy to follow, and difficult to circumvent. Reasonable person test.

While laws are abstract and often imperfect there's a great social value in having people follow laws. People must be willing to follow laws and people who want to follow laws facilities a stable environment. Laws and norms provide a structure for society. Transparency of laws often comes from simplicity. Ideally, laws should be clear and effective. That is, they should be clear, easy to follow, not overly broad, and minimize side effects. There is a cost to laws and regulations. Formalization of norms (5.3.1).

Common Law and Case Law

In the U.S. and English systems, there is a distinction between case law, or common law, and civil law. Statues are the laws as passed by the legislature. Some other laws are so integral to the working of society that they are accepted as "common law". Common law is generally based on precedent which is the accumulation of effective action from court decisions. Laws do not exist in isolation. Rather, it's helpful to think about the entire legal framework. Consider the combination and interaction of many laws. Case law reasons from previous cases by analogy. Case law citations form a network which is similar to Networks of scholarly citations (??)(Fig. 8.31). Similarly, this would be true of interconnected patents.

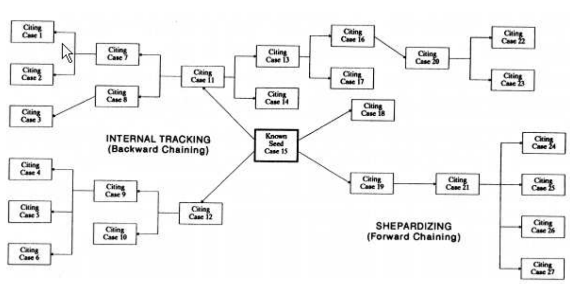


Figure 8.30: Case law precedents as a citation network (from [?]). Legal informatics. (redraw)

Statues leave out many details. These details are then often specified in regulations. Though sometimes the laws themselves also implements regulations. The details of the procedures for applying for copyright

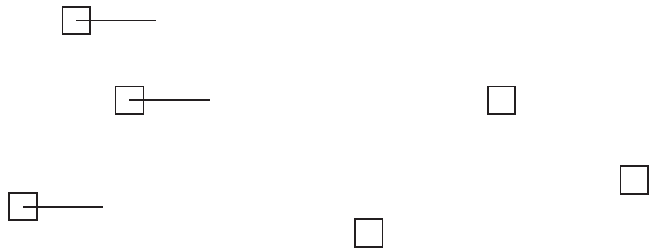


Figure 8.31: Case law precedents as a citation network (from [?]). (redraw)

in the U.S. are specified by regulations from the Copyright Office.

Food labeling. Banks have extensive regulations.

Some regulations promote transparency and disclosure of information are often desirable but even those need to be well crafted. On one hand, regulations can provide orderly management of activities, but they may also be overly restrictive. Regulations require compliance by the entity being regulated. Regulation as very precise rules but these sometimes have unanticipated consequences. Regulations do not carry the full weight of the law, and may be a clarification of the law, or guidelines for a law's application.

Build closed, controlled systems. However, people often go outside the law. Laws should discourage people from doing that.

8.5.2. Developing Effective Policy, Laws, and Regulations

There are a number of hazards for policies, laws, and regulations. Laws and regulations are often aimed at one problem but have unintended consequences affecting an entirely different area. Thus, a law should be based on an analysis of a wide variety of scenarios where it may have an impact. A law or regulation may be unenforceable simply because it is too broadly drawn. Or, it may be ambiguous and lead to misunderstanding. Jurisprudence is the theory of the law; there are two main threads natural and normative principles. We saw this distinction earlier with respect to copyright (8.2.2). Laws as behavioral requirements. Law as instructions.

Laws often reflect cultural and social norms but they may also be the result of political and economic pressures. Laws often, but don't always, reflect policy. Law should be internally consistent.

Laws must change as society changes; of course, this is the role of legislature. Electronic distribution allows more people to view government documents, and provide them with more information with which to make informed decisions. A record of the legislation before Congress, for example, would allow citizens to hold their representatives to account and petition them to reflect the will of their constituency [58] (Fig. 8.32). The legislative history is the record of the debates about the law in the legislature. That may be helpful to understand the intent of the legislature in creating the law. Hansard.

Figure 8.32: The Thomas system is a repository of legislation pending in the U.S. Congress.

Creating policy and laws requires reasoning about intended effects, enforceability, and likely judicial opinions. Information systems can provide greater transparency and public access to the records

(7.4.1) and the rationales that are being used in policy creation, and help to provide more detailed analysis. Version management tools (-A.5.8) applied to laws. However, the existing approach is not amenable to that.

Effective regulations, while aimed at eliminating some undesirable behavior, need to be able to be followed. That is, the regulations cannot be so restrictive as to inhibit growth and innovation within an industry. This is particularly apparent for information sciences. Regulation needs to preserve individual rights and privacy, but cannot throttle the development and marketing of new technology Policy, laws, and regulations need to be easy to understand and to be enforced. Too many laws or regulations may make people ignore them and may be difficult to enforce. Furthermore, almost from the time they are created, policies, laws, and regulations are likely to be co-opted, modified, and challenged.

8.5.3. Compliance and Enforcement of Laws and Regulations

Enforcing laws with penalties such as social sanctions such as fines and jail. Furthermore, the enforcement of laws and regulations is necessarily done by human beings, that is by the police and regulatory agencies. Thus, there are limitations to what we can expect from them. Expanded regulation can dampen industry, and wind up destroying the thing that the laws were created to protect.

Punishment and sanctions. The wording of a law is not important if it is not enforced. Compliance and enforcement are the main factors that contribute to a policy's efficacy, particularly for regulations aimed at information and information systems. The much-lauded benefit of modern information systems is that they open up the world to anyone with a computer. This, however, has the corollary effect of decentralizing and depersonalizing illegal activity, which makes enforcement of any legislation difficult. Developments in information technology will be needed to establish a balance between necessary control and desired freedom. A law or rule is only as good as its compliance — it does little good to create a policy with which people cannot comply, or which cannot be enforced. Moral agency.

8.5.4. Legal System and Informatics

Ecology of legal concepts. We would hope that the law is clear, and logical. Indeed, the law is a formal system, perhaps in some cases, it can be modeled with exact definitions. However, there is enough ambiguity that it is difficult to do that. Purely, legal constructs such as ownership. While this is an ideal, it can be difficult to model constructs such as the "reasonable person" test (i.e., what would a "reasonable person") do in a given situation. Ambiguity of laws (example). From legal informatics to law enforcement. Preservation of court records and trial transcripts.

Example

Figure 8.33: Ambiguity of law.

Trials and Hearings

Most trials are about establishing the facts of a case – what really happened; however, a few require interpretation of the law. Court hearings and other proceedings should maximize the chance the truth in a case will be found. This can accomplished, in part, by following standard procedures. That is by due process. The proceedings of a trial need to be orderly. This can be threatened by too much public speculation. In some cases, a judge may prevent public disclosure with gag orders. This includes a fair judge and suitable treatment of evidence. Independent judiciary.

Due process means that previously specified procedures are followed.

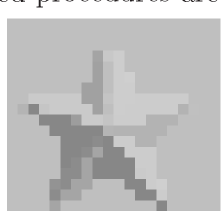


Figure 8.34: Trial.

Legal Evidence

We haveencountereed the notion of evidence several times. There are specific rules for what constitutes appropriate evidence in a trial. Physical evidence in hearings needs to follow a chain of custody so that it can be certified not to have been tampered with, much like the precautions we have discussed for electronic records. "Rules of evidence" Circumstantial evidence. Testimony. Hearsay evidence is not allowed. Criminal forensics. Records and evidence (7.4.2). Wiretaps.

A trial begins with discovery which is the sharing evidence between both parties. In very large cases, this may amount to several million documents and document management systems are required. Sometimes internal organizational information is well organized but in many other cases it poorly organized. ((sec:internalorginfo)). For electronic materials, this becomes electronic discovery or eDiscovery. This is a type of text data mining. This is a challenge because a great deal of content must be reconstructed. Digital forensics (7.5.5).

Legal Argumentation and Searching

Many aspects of legal proceedings which are information intensive. First, the law needs to specified. Second, in case law, the laws depends heavily on context. and related cases must be identified. Understand the implications of previous cases. Many laws are abstract. That is, the apply general principles rather than cover specific cases. However, they have to be applied to specific cases. Difficulty of searching legal digests. Often, it is not clear what the law requires. Furthermore, it is important for lawyers to identify as many of the relevant cases as possible. High-recall search. Fact similarity. Legal searching[29][37]. Adapting the legal system to managing large amounts of information. Legal argument can involve classification.

Define the law. Apply the law. Legal reasoning such as determining whether a given case is covered by a given statute. Laws are generally categorical, but many arguments are quantitative. This often leads to the slippery slope. Laws are highly structured. An argumentation system (Fig. 8.36) (6.3.5). can also be used for students to understand how legal arguments are constructed. Legal argumentation [65] (Fig. 8.35).

Whoever ...
2) intentionally accesses a computer without authorization or exceeds authorized access, and thereby obtains
A. information contained in a financial record of a financial institution,
or of a card issuer as defined in section 1602 (n) of title 15,
or contained in a file of a consumer reporting agency on a consumer,
as such terms are defined in the Fair Credit Reporting Act (15 U.S.C. 1681 et seq.);
B. information from any department or agency of the United States; or
C. information from any protected computer if the conduct involved an interstate or foreign communication;

Figure 8.35: Fragment of TITLE 18, PART I, CHAPTER 47, US Code. Fraud and related activity in connection with computers.

Styles of written argument versus oral argument. Dynamic argument (e.g., analogy) versus absolute standards.

Attorney-client privilege.

8.6. Goverment Structure and Services

Previous section described government as rules. This section described government as workflow and services.

8.6.1. Civic Data

Many data sets for civic functions. Collectively, these are termed civic data. Thses include polling and voting, economic data, land use, census data. Community infrastructure is a complex maze. Some of these are managed by the government while others such as utilities may be managed by utilities.

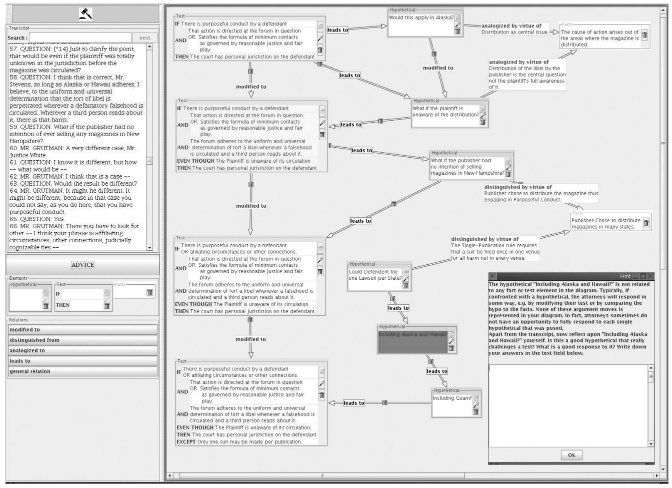


Figure 8.36: Argumentation graphing tool for students to analyze the discourse elements for Supreme Court arguments[28]. (check permission)

Just as interoperability of business records has proven important (7.4.4), interoperability of data sets is increasingly important.

Smart cities. Sensors (-A.19.0). Active environments (11.9.5).

8.6.2. Disaster Planning, Crisis Management, and Emergency Response

Information is particularly important in a crisis such as occurs after earthquakes, hurricanes, and terrorist attacks. Using information under pressure with high stakes.

Highly adversarial situations (7.11.0). Crisis management (8.6.4). The ability to quickly collect and analyze information can be particularly helpful for reacting in a crisis. Moreover, that information often needs to be rapidly disseminated to the public. Increasingly, that it one of the roles of social media.

8.6.3. Disaster Planning and Preparedness

Risk management. Vital records. Communication. Disaster planning.

8.6.4. Crisis Management and Emergency Response

Information systems that are integrated across agencies could allow for a coordinated response to an emergency that would far surpass in speed and efficiency the procedures that are currently in place. Emergency personnel could be dispatched to the most appropriate areas, available resources could be tabulated and dispersed, and evacuation plans could be coordinated between agencies much more fluidly using information systems. These types of disaster relief and crisis management information systems could provide clear information using simplified interfaces and syntax to emergency personnel to compensate for the distraction of the crisis itself as it reduces a responder's ability to retrieve information due to an increased cognitive load (4.3.3). Emergency preparedness and response. Adversarial situations (7.11.0). Difficulty of communication in a crisis can be difficult due to network congestion.

Evacuation. Hurricanes, floods, subways, stadia, and fires. What evacuation routes will people pick in a crisis. Figure 8.37. Application of social modeling (9.5.1)with agents simulations. Crowd dynamics (5.4.3).

Social media for individuals to communicate with each other and get local updates. Collaboration in crisis management. Collaboration in crisis situations such triage. Collaboration during emergencies on space station. Team schema.

Figure 8.37: Agent-based models for evacuation of Venice (from [?]).

Figure 8.38: Crisis management and emergency response; especially in real time. (check permission)

8.6.5. Citizen Information in a Crisis

Keeping Citizens Informed

Ad hoc communities of those affected.

Informing citizens what's going on.

Disaster health information. Dissemination of information from government and officials.

Citizen Information Behavior during a Crisis

Tweets during a crisis [?]. Re-tweets as information diffusion.

Crisis information needs.

"Situational Small-World" [?]. Traditional community boundaries shift. Ad hoc online communities spring up.

Person finder following earthquake.

Figure 8.39: Google people finder site following the 2011 Japanese earthquake and tsunami. (check permission)

8.7. Economics

We have look at social structure, now let us consider economic activity. Economics deals with the production, exchange, and allocation of resources among members of that society. The economy results from aggregate decisions made by millions of individuals. The production and exchange of goods is a fundamental human activity. The number of resources is limited.

Information is essential for economic activities because it helps people value what they are buying. Economics and minimizing uncertainty.

Ongoing interaction of politics with economics. Laws related to economics to structure the economy. At the societal level, we are developing a "knowledge economy". In such a framework, services apply knowledge to provide a benefit.

8.7.1. Economic Systems

There are many possible economic systems. Relative separation of political system and economic system. Most modern societies are based on some combination of economic constructs such as property, markets, and capital. Yet, modern society also interacts with other types of exchange between people and groups and those interactions need to be better understood.

Wealth. Cumulative wealth.

Economics is not gambling, but analysis of risks and opportunities which people find useful. An effective economy can improve living standards for its citizens. Ideally they should facilitate the efficient distribution of scarce resources. That is, in terms of game theory (3.4.1) it can produce win-win solutions. One of the goals of economic policies can be to find such win-win scenarios. For instance, incentives can be structured to get people to efficiently provide good and services which other people find useful.

Economic systems can be largely self-organizing but they are also complex systems and can easily be perturbed. Economic activity can be explained based on psychological principles. We have already discussed cognition and choice (4.3.4). decision making processes (3.4.1). While people will pick an alternative that provides the cost-benefit tradeoff. Ideally, transactions would be win-win interactions for both side and the cumulation of many such transactions would benefit all participants in a market.

8.7.2. Exchange Systems and Markets

Markets

The study of economics examines the effects of different ways of organizing economic activity. One of the key concepts is that of a market. People and companies often produce goods and services beyond what they need for their own use. They can then exchange those to other people for other necessary goods. A market brings buyers and sellers together to enable the exchange of goods and services. It should facilitate matching of supply and demand while using resources efficiently. By comparison, economics within a family. How companies fill market niches – industrial organization.

A market is efficient to the extent that it allows both the buyer and seller to optimize goals as much as possible. Market-based economies may be distinguished from "command economies," in which the allocation of goods and resources is at the direction of the government.

An efficient markets generally make goods available at lower costs. Markets provide ways to optimize the distribution of resources. They are based on people being able to project their resources (supply) and needs (demand). Thus, information is essential for efficient markets.

Procedures which maintain the integrity of the markets. Market makers. Orderly market. Regulations can facilitate an orderly market but some types of regulations can impede it. Competition (anti-trust laws)laws attempt to establish a fair market. For instance, they block collusion by participants in the market.

Industrial policy of governments.

Prices, Supply, and Demand

In economic theory, price is equilibrium point of supply and demand. Price is the metric around which the economic system organizes itself. On average, prices will tend to be determined by supply and demand. In the autumn when a big crop of apples is harvested. the price of apples normally drops. If small fluctuations in a good's price produce relatively large fluctuations in the demand for that good, the demand for that good is said to be "elastic"; if changes in price do not affect demand, a good is said to be inelastic. Similarly, the supply of a good can also be categorized as elastic or inelastic, depending on the market's ability to increase the supply of a good within a fixed period of time. Elastic supplies can be increased to meet increased demand (such as might be the case with auto assembly), while inelastic supplies cannot. Managing risk of price changes with futures contracts.

Fig. 8.40 shows supply and demand curves. As suggested by these curves, when the price is high, the supply will tend to increase over time. As the price drops, demand increases. The price should be the point at which the two curves cross. However, prices are actually determined by expectations of future supply and demand. Because the future is always difficult to predict, the prices may not match the actual supply and demand. That can lead to distortions and bubbles.

Because some goods are not consumed immediately after purchase, the price for them is set by the expectation of future value. If we expect that prices will be rising we might purchase early. If we expect that prices will be falling, we might delay a purchase. Either way, information and prediction models are helpful.

The law of supply and demand is not absolute, For instance, sellers may take advantage of unwary buyers. But in the long run, the prices will tend to match the supply. Information systems can set prices adaptively. Moreover, eCommerce sites may use user history to set prices for each individual. Furthermore, prices may be adjusted based on knowledge of characteristics of the individual buyer. Dynamic pricing.

Competition keeps prices down by allowing consumers to directly compare prices and products. This also forces supplies to be efficient and to develop new features. Transparent information about prices allows consumers to make better comparisons and price comparison web sites coupled with social media reviews highlight comparisons.

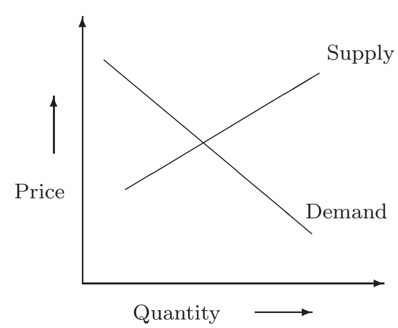


Figure 8.40: In an efficient market, the price will be the point where the supply matches the demand. (redraw)

Increasingly prices are personalized.

Economic Factors Beyond the Market

Goods may have benefits or costs beyond those directly reflected in the price. These often have implications for the broader society and are called externalities. Externalities are factors outside of the market which may affect it. One type of externality which is relevant to networking the number of people connected by that network. If there were just two telephones in the world, or two computers on a network, each of these machines would be virtually useless. The greater the number of participants in a network, the greater the value of that network (Fig. 8.43). This has come to be known as Metcalfe's

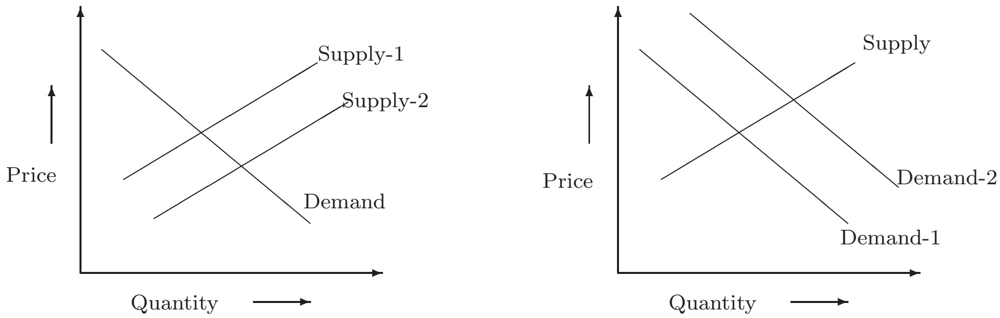


Figure 8.41: If there is a fundamental change in the supply (e.g., a new process is invented to make it easier to produce more of the product), the whole supply curve will shift (left). Similarly, a change in the demand, say as the result of marketing, will shift the price up (right). (smaller font)

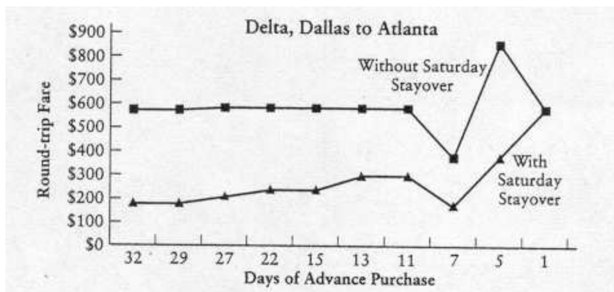


Figure 8.42: Pricing data for airline seats on a flight from Dallas to Atlanta from the 1990s[50]. More recent techniques are even more adaptive. (check permission)

Law. This is an example of a "network effect," or a network "positive externality,". This is a kind of positive feedback (-A.10.2) but external to the product itself but it leads users to focus increasingly on one brand (Fig. 8.44).

	1	2
1	X	
2		X

	1	2	3	4
1	X			
2		X		
3			X	
4				X

Figure 8.43: The number of two-way connections in a communications network is $(Nsqaured - N)/2$ of the number of participant (N). When there are two people in the network (left) then there on possible connection. When there are four people in the network (right) there are 6 possible connections.

Attributes of Goods and Services

Economic goods come in several varieties and these differences affect the way they can be used and, thus, their value. These attributes help to define how the supply is determined. The value of "perishable goods" decrease with the passage of time. Seats on an airplane cannot be sold once the airplane takes off (Fig. 8.42). Likewise, information goods such as news are perishable. There are two general categories of goods: public goods and private goods. Private goods have the following characteristics: "excludability," meaning that they can be denied to anyone not willing to pay for them; "rivalry," meaning that an individual's use reduces the overall supply; and "rejectability," meaning that an individual can reject the good, if they please. Public goods, on the other hand, are "non-excludable" and "non-rival," meaning that people cannot be prevented from using the goods despite not paying for

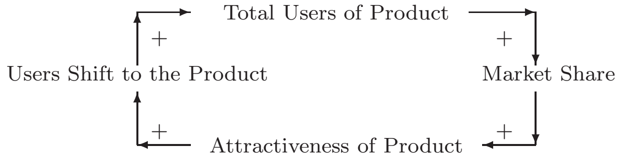


Figure 8.44: A simple causal loop diagram shows positive network effects such that the more people who use a service, the more valuable it becomes for all of them. Then even more people want to adopt that service. (redraw)

them, and that individual usage does not meaningfully reduce the overall supply of the good (Fig. 8.45). Information goods (8.13.3). Goods often incorporate a great deal of specialized knowledge.

	Excludable	**Non-excludable**
Rival	car, Walkman	unmanaged fishing rights
Non-Rival	movie in a movie theater, concert in a large hall	lighthouses, national defense, mosquito control

Figure 8.45: Rival and excludable goods: Two dimensions for characterizing how goods may be used[16].

Services produce value without producing physical goods. For instance, education is a service rather than a good.

Virtual Economies Virtual worlds (11.10.2). Digital assets. Fig. 8.46. Interaction of virtual world and the physical world. The value of virtual assets in the "real" economy. Virtual justice.

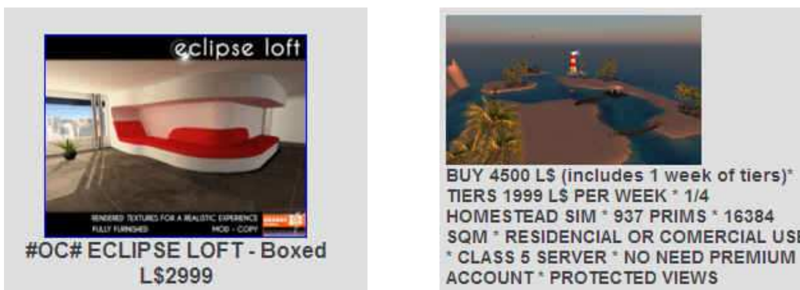


Figure 8.46: Virtual economies: Land sales from Second Life. (check permission)

Market Design and Computer-Mediated Exchanges

Markets are frameworks for the exchange of goods. They facilitate coordination but require infrastructure. They must provide a predictable structure — participants must fulfill their agreements. This can be designed this requires fostering trust.

An ideal market maximizes the transparency of trades and minimizes the "friction" (i.e., costs and inefficiencies) of transactions. [33]. A frictionless market would allow the prices more closely reflect the ideal illustrated in the Figure above. However, the notion of a truly frictionless market is an impossible idealization. Indeed, in practice, there may be major distortions. Potentially, electronic markets reduced transaction costs. Some sort of legal framework is needed. Some regulation seems to be needed but that needs to be balanced. Natural monopolies. Duoplogy. Market.

Auctions Auctions are one way to determine (how high bidder is willing to go). They are similar to but more more formal mechanism than haggling. Auctions can also have an emotional component. As shown in the table below, there are several types of auctions. The most commonly portrayed type of auction is a "cry-out" English auction. Offers are typically shouted out and accepted by a fast-speaking auctioneer, and the prices are raised until there is only one bidder remaining. This form of auctioning reveals information about bidders — what they look like, what was the highest amount they were willing to pay, or sometimes even whether they were bidding more out of a sense of competition with other bidders than out of a real desire for the auctioned item. In these circumstances, the winner of an auction sometimes has trouble knowing whether they bid too much; this is known as the "winner's curse". Some auctions do not reveal buyer information and the bidding is done silently.

Type	**Description or Example**
English - Cry Out	Buyers call out bids above previous bids. Examples are art auctions and cattle auctions.
Sealed bid	Bids are placed in envelopes. When the envelopes are opened, the highest bid wins.
Dutch	When multiple goods are available, bids specify both a price and quantity. Bids are filled in descending order until the supply is exhausted.
Reverse	Seller drops prices until a buyer agrees to it.
Double	Both sellers and buyers adjust prices (e.g., the stock market)

Reverse auctions and name-your-own-price. affective components of cry-out auctions.

Online auction sites introduce a number of challenges. They may include gamesmanship such as bad mouthing and ballot stuffing. These may reveal fraud. Automatic detection in fraud may be applied to auction sites (5.3.4). The pattern of purchases and endorsements may show unusual patterns.

Matching market. Internet archives.

Market signaling is a type of information transmission. One clever application of this was the introduction of a limited number of roses by the dating web site cupid.com. Each client is given a limited number of roses so sending a rose signals particular interest.

A free rider is somebody who gets advantage from a public good without having contributed to it.

Problems with Markets

While there is a social value in production and competition among businesses. There are, of course, problems of markets. The competition keeps prices low. However, uncontrolled competition sometimes leads to the end of competition and to corruption of the market. This can rapidly lead to social damage. Thus, the right incentives must be created to produce social benefits. This includes, managing the stability of the system. Transparency in business finances. Exceptions and not following transparent procedures, in other words corruption, hurts the overall economy. Avoiding insider trading.

Costs need to be aligned with the activities which generate them. Costs should be presented transparently to consumers in order for the consumer to know how what to prioritize.

Competition policy. Market manipulation. Perverse incentives. Corruption.

Markets may degenerate into collusion and private deals which can be minimized by efficient market regulation. Markets require a stable legal and social environment. Markets thrive from the free flow of information. Market efficiency is generally optimized by allowing direct comparison between a number of alternative goods; this is an efficient means of setting prices. A farmer with vegetables to sell will go to the local market and set price according to the quality of the produce, the season, the popularity of what is being sold, and competitor's prices for similar vegetables — this is, in effect, allowing the market (supply of vegetables, demand, production costs, and competition) to determine the price of goods. Sometimes, instead of allowing the market to determine the price of a good, vendors and buyers rely on bargain and negotiation. In many ways, haggling mimics market forces (competition, value, need), but invests them directly in the buyer and seller. Collusion. Markets.

Financial Markets

Capital and stocks. Electronic markets. Trading based on news analysis (8.13.7).

Agents, Brokers, and Intermediaries

Information systems facilitate the flow of information in markets and, thus, increase efficiency. Traditionally, many supply chains have "middlemen" who coordinate the exchange of goods and payment between the producer and the consumer. These include services such as travel agents, real estate agents, and stock brokers. Disintermediation. This extra level of communication provides and extra layer of market efficiency. Travel agents traditionally matched a customer's travel interests with the available plane, train, and bus schedules. Much of that is now being done by the consumers themselves over the internet. Because it does not include any middlemen, this effect of information systems is known as "disintermediation".

Making electronic markets. Cyber-intermediaries. Remote retail (8.12.5). Auction sites. GLG. Selling apps. Customer aggregators.

The Internet allows application of human effort to tasks that are otherwise difficult. Human mediated internet tasks (Fig. 8.47). Another example of social computing and crowd-sourcing. Mechanical Turk for question answering by billing. Geographically distributed problems like the Red Balloon challenge. Recursive motivation mediated through social media. Coordinate individuals to contribute.

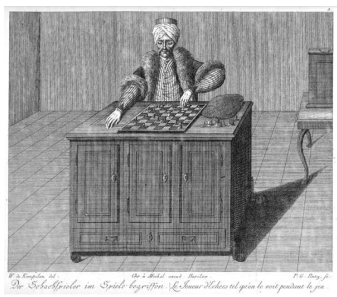


Figure 8.47: The Mechanical Turk was actually manipulated by a human being hidden in the case. There is an analogous service which support a human-mediated Internet task completion. (check permission)

Clickworker. Brokers and agents.

8.7.3. Money

Originally, people exchanged goods by bartering — one farmer might exchange a pig for another farmer's corn. Eventually, people began to exchange "money" rather than goods. Money is generalized representation of work and resources. Originally, money had a tangible value: A gold coin was worth a certain amount based on the amount of gold that it contained. An intermediary step in the evolution of money came about when the money itself no longer possessed any intrinsic value, but was worth a fixed amount if exchanged; U.S. paper dollars used to be exchangeable for a dollar's worth of gold or silver, and the U.S. Treasury was theoretically unable to print more money than was backed up by gold in its coffers. Now, however, money is not valuable in itself, it is merely a representation. People accept money because they have confidence in being able to exchange it for goods or services. Money is more flexible barter, and thus is better for facilitating exchange. Today, money has become electronic. As it becomes more virtual, it increasingly – though still imperfectly – represents work in society that others are willing to pay for. Prices set in a common currency establishes an equivalence of value for many types of goods and ultimately, the money must be backed by goods and services. In short, money is a representation system.

Converting recognition and other resources into money is termed monetization.

Electronic Money

The management of electronic money provides a distinct set of tradeoffs for information system design compared to other types of content. Any electronic system for managing money must maintain strict control over the security of that money. Just as banks used safes and steel bars to protect cash, so to must electronic financial and information systems use security measures to protect "digital money".

People's trust in electronic money services is important because the adoption of information systems by the financial industry has driven down their costs considerably. Social conventions associated with money. Security (7.10.3) and attacks on the finance system.

Increasingly, even cash transactions are being implemented with digital implementations such as DigiCash (Fig. 8.48).

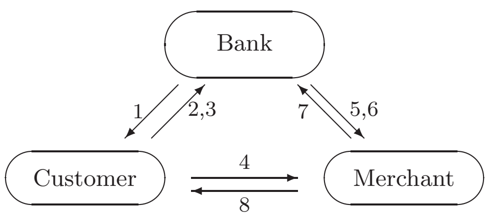
Alternative Currency and Virtual Currency Bitcoin.

Moreover, we increasingly have alternates to cash such as frequent flier miles, as competition for government-issued currency.

Addressable Money Addressable money.

Micro-banking and Micro-payments Micro-banking.

Micro-payments could be an alternative to advertising or subscriptions for funding low-cost internet services. Moving funds from a checking account. Mobile payments.



1. Customer requests a token from the bank.
2. Bank transmits bound token to the customer.
3. Remove binding to obtain signed token.
4. Customer requests merchandise and sends token.
5. Merchant verifies token with bank.
6. Merchant deposits token.
7. Bank confirms deposit of token.
8. Merchant transmits item and receipt to customer.

Figure 8.48: A collaboration diagram for the DigiCash model. A token, which has been approved for a fixed value, is obtained by the customer from a bank. It is then passed to the merchant who can "deposit" it back to the bank [41]. (check permission)

How PayPal works.

FireCredit Card Transactions

Bitcoin

Accounting, Financial Records, and Financial Institutions

Detailed records for capital. Double-entry book-keeping. Cost accounting. Return on investment (ROI). Financial records (5.3.4). Accounting practices as a social activity. Transaction processing.

The monetary system allows the ebb and flow of money across the economy. Financial institutions.

8.7.4. Macroeconomics

It is common to distinguish between microeconomics and macroeconomics. Macroeconomics concerns the behavior of the entire economy while microeconomics (8.8.3) considers the way individuals make economic decisions. The economy is intertwined with other parts of society. This is an example of a highly non-linear complex system. Some complex non-linear systems are stable within a range of conditions but most such systems, such as the economy, become unstable as conditions change. These systems often become unstable and chaotic (-A.10.2).

While many factors need to be balanced, many factors affect the essentials of a healthy economy such as the rate of savings and investment in new business.

Interplay of large financial institutions such as banks and large companies.

The economy undergoes fluctuations, periods of growth followed by periods of stagnation and recession which are collectively referred to as the business cycle (Fig. 8.50). Complex systems often develop

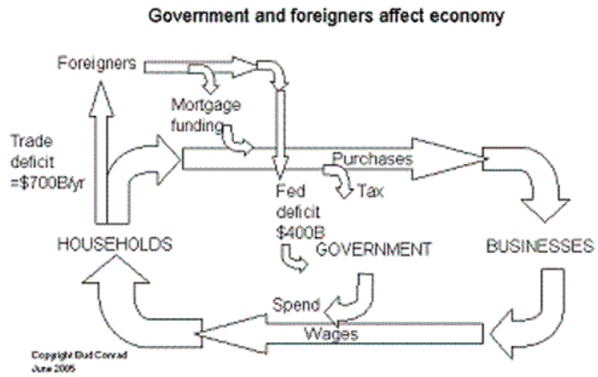


Figure 8.49: The macro-economy is a particularly complex adaptive system. A small example of an equilibrium model for components of the economy. The entire economy is more complex and includes many non-linear components. Even in this relatively simple example there are many possible complex interactions. For instance, creating a new agency or new law may change the flow. (check permission)

oscillations when something changes in their environment. During the growth phase solid investments are increasingly difficult to find and eventually they collapse. This is typical of complex systems. An example of downswing the business cycle is the dot-com boom of the nineteen-nineties and the recession that followed it. In the extreme, these are bubbles. Knowledge economy (8.13.2).

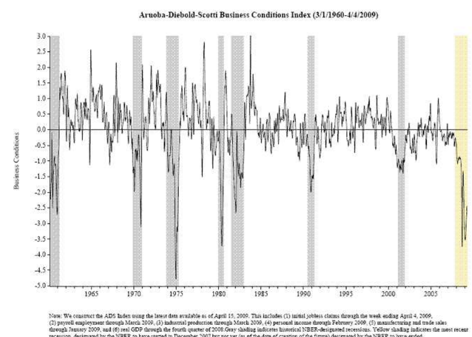


Figure 8.50: This chart shows This type of oscillation is typical, indeed it probably inevitable, for complex non-linear systems.

Monetary System

Many large effects in the economy are easy to predict. However, the details are often complicated and attempts to manage the economy often has unintended consequences. Nonetheless, to attempts are made to model economy. Input-output models describe the interaction of many components in the economy. On one hand, models are very helpful to even begin to understand the interplay of complex economic factors (Fig. 8.49). On the other hand, these models are rarely entirely accurate and can be seriously wrong because there are so many non-linear interactions. Changes in the price of gasoline affect many aspects of the economy in unexpected ways. A model of how the components of the economy fit together can be helpful to predicting the effects of changes in the price of gasoline.

8.8. Economic Activity

Restructuring the economy.

8.8.1. Productivity

Suppose a craftsperson builds a chair by hand and that normally takes four weeks. If the carpenter gets a new set of electric tools they may be able to build the chair in one week. Assuming the quality doesn't change, the electric tools improve productivity. If people work more efficiently and their output increases, then productivity should rise. If we give workers across the workforce improved tools, then more goods can be produced for people to use and the entire economy is more efficient. Information can also improve productivity by making workers more efficient. Corporate productivity. The relationship between IT and productivity is complex. it seems that IT increases output but not ROI. Increasing productivity can also have an effect on unemployment.

8.8.2. Technology and Economics

The laws of supply and demand are pervasive in a market-driven society, extending to and driving technological innovation (9.4.4, 9.4.0). Moore's Law, which states that the data density of a computer chip doubles every 18 months (1.5.2), demonstrates how public demand for ever more computing power effectively drives innovators to come up with ways to supply it. This innovation has maintained an increasing supply of computing power (keeping supply elastic), thereby allowing its costs to drop (keeping its price elastic), but there may be limits to this trend if physical constraints prevent the creation of computer chips with greater data density. Disruptive technologies.

An organization needs both social and technical components. The relationship between society and technology within an organization is like that same relationship within society as a whole. These systems which include contributions of both social and technical aspects are known as "socio-technical". [19] (8.8.2).

Productivity and Technology

In itself technology-based productivity seems like a good thing. The result is that there are more goods to go around. Eq. 8.1 shows the standard method for calculating productivity across the entire economy; it is the ratio of the Gross Domestic Product (GDP) divided by the number of hours worked. This is generally reasonable, but there are several difficulties with this definition. Many service activities, such as teaching and housework, are not well reflected as contributing to productivity. Indeed, much knowledge work is difficult to measure and may not be reflected very well. Personal productivity.

$$Productivity = \frac{Gross\ Domestic\ Product\ (GDP)}{Total\ Hours\ Worked} \tag{8.1}$$

Technology allows workers to produce more for the same amount of labor. Industrialization and technological advancement had a profound effect on productivity throughout the 19^{th} and 20^{th} centuries. This enriches society since there is more overall wealth. Facilitating production and technological development. How much of the surge of productivity was due to the Web?

Figure 8.51: Productivity rates in the U.S economy from 1870 to the present.

Productivity and Employment

Mixed results.

Education level of workforce.

Effects of robotics on employment.

Technology and white collar employment.

8.8.3. Microeconomics, Incentives, and Behavioral Economics

Microeconomics concerns how individuals make economic decisions. Much of this is based on the economic decisions of individuals. We have already discussed many aspects of microeconomics such as processes for choice (4.3.4) and general principles of human cognition (4.3.0). Organizational behavior and supply-demand curves. Determining value and utility. Ultimately, some values are based on fundamental biological needs such as health, food, and family (4.6.3). Incentives. Incentives need to be matched to objectives.

Behavioral economics. Economic decisions in everyday life.

A further dimension of tasks is the incentive. We do some things to directly satisfy biological needs. Some other things people do seem to accomplish these goals indirectly. Managing incentives effectively. Incentive-centered design can include the efficient use of information. Dissonance and large incentives. Economic mechanism design theory extends game theory analysis.

Economics and everyday decisions. To a surprising extent, understanding the true contingencies in a situation seems to affect the many everyday decisions people make. Thus, these decisions reflect economic choices[4]. Everyday information seeking. Designing incentives.

> The economics of drug dealing, includes the surprisingly low earnings and abject working conditions of crack cocaine dealers.

Figure 8.52: Even illegal activity seems to follow economic principles[4]. (validate quote)

The Notion of Economic Rationality

If it's cold outside, we would think it is rational to wear a sweater or jacket. If you had an abnormal medical test, you wold say it is rational to get a follow up check-up. Or, if someone hasn't eaten all day, it would be rational for them to look for food. Suppose you could earn either $10 or $20 for the same task. Presumably, you would take the $20. Indeed, we would say that's the rational thing to do. Similarly, we all tend to prefer choices which take less physical or cognitive effort and which give greater rewards.

In economics, a rational decision is one which meets your needs. However, this definition depends on a person's understanding of what their needs are. While people mostly focus on meing their own needs, some actions are clearly altruistic. Moreover, a person many not clearly understand what is in his/her self interest. Sometimes emotion may cloud choices, but the model would suggest that rational choice are made without affect.

Thus, economics does not claim that people are always rational. Rather, it attempts to describe the nature of interaction when they do behave rationally.

Indeed, a person might think hard about how to accomplish a goal with less work. That is, they might be provide you with reasons for their actions to accomplish their goal. This is not to say that every decision is optimal or fully rational[70]. Rather, the economics would claim that decisions will tend to be rational.

People can't know everything about the implications of choices they make, that is their rationality is bounded by their knowledge[71]. The wide availability of information broadens the information on which decisions can be made. Another possible explanation for seemingly irrational behavior is that a person may not have sufficient cognitive resources to determine the optimal response (4.3.3). Psychological processes and rationality (4.3.4).

There are examples of altruism and there is an evolutionary advantage for altruism (-A.12.2). That is people may sometimes forego narrow self-interest for the social good, but this is fairly unusual. Similarly, people act seemingly irrationally. They show emotion or simply do not know all the relevant information about a given problem. Nonetheless, people tend to be risk averse. Expected utility.

Prospect Theory [15] addresses the problem that people are not able to make good estimates of payoff and utility.

Law of unintended consequences.

Rationalization. To provide reasons for an action which would explain why it is rational. In some cases, these explanations can become causal stories and may or many actually be rational.

Rational choice theory. vs. “Practice” (Bourdieu) [?].

8.8.4. Economics and Information Policy

Intellectual property (8.2.0). Effects of Telecommunications Act of 1934 [?]. Open access publications. Net neutrality. Businesses and IP (8.13.3). Most social policy questions have an economic component: patents, copyright, information management.

8.8.5. Controlling and Managing Complex Systems

Infrastructure studies. Information intrastructure (1.5.3). Social infrastructure. Government.

Supply chain (8.12.1). Operations research. Epidemiology. Climate.

Instabilities and Disruptions

Many interesting phenomena are complex adaptive systems. Complex systems are susceptible to discontinuties (1.3.2). Effects of trying to manipulate the economy. Changing one thing excessively often has broader consequences. Financial crash.

8.9. Information, Globalization, and Development

Freedom of information. Political reform. Arab Spring. Alternatives to low information environments. While many parts of the world are now highly interconnected by communications, many others are not.

8.9.1. Information and Communication Technology for Development (ICTD)

There are many applications ranging from health and agriculture. For instance, farmers in remote areas can find more about prices in regional market centers. Using GIS data for development. Collaborative support for low resource environments. Often simple solutions work well.

Wireless Hypothesis. Priority in communication infrastructure. How important is technology compared to other human needs. (Fig. 8.53.) One-laptop per child.

Figure 8.53: The Wireless hypothesis proposes that development can be spurred by simply jumping to wireless systems. (ICTD) Here a set of rural health clinics in a developing country are connected by a wireless network because the landlines are unreliable. Here is a clinic in which some of the medical diagnosis is done remotely. (check permission)

Ultimately, the greatest gain may be in harnessing techology for efficient production.

8.9.2. A Flat World?

Information systems and changes in transportation are creating a "flat" world for interaction between nations.. The role of the nation state in a globalized world is minimized. As communication technology becomes improves, companies are seeking to maximize their profit by locating various elements of their business in different locations around the world, which may offer lower wage standards, fewer corporate taxes, and looser environmental regulations. This trend is commonly referred to as outsourcing.

The flat world also has many implications: English as a common language and globalization of World music. The expansion of the market-state to increased terrorist organizations[38] ((sec:netwar))and the globalization of criminal activity.

As noted earlier, information technology has created outsourcing[14]. In the global economy, this has become offshoring. Outsourcing can have positive effects for both in the country from where the jobs were shipped, and in the receiving country. Lower company operating costs generally translate into lower consumer costs for the people who buy the company's products, which means that people have more money to spend in other economic sectors, leading to increased growth, and an increase in the number of jobs. Also, if a company is able to lower their production costs and their product prices and thereby increase their sales, they will experience growth that will necessitate the creation of more (and often better jobs), which are often staffed in the original country. The country that receives these jobs will often find that the wages offered are higher than those of local industry, creating demand for more jobs of this type. This, in turn, often encourages political stability, leading to more higher paying jobs being located there, and raising the standard of living. Near-shoring. While there are certainly economic advantages to outsourcing — no companies would be doing it, otherwise — there are sometimes coordination difficulties and hidden costs. These can range from the mundane (different countries use different units of measure) to the extreme (some countries are not politically stable,. and a company can find itself in a country with a collapsed government).

Innovation (8.14.0).

8.10. Managing Infrastructure

Cities.

8.11. Management and Business Procedures

8.11.1. Management

Management is optimizing the optimal use of resources. How should the organization be run to accomplish its goals. Management should makes the effective allocation of resources to goals. Management keeps an organization aligned with its goals. There are many factors to juggle. Both people and processes. Facilitating processes with management. Task and project directed.

Managers make decisions regarding strategy and direction, strive to implement an organization's core philosophies, and organize and focus workers. Management is different than administration; administration simply carries out an organization's regulations, while management determines them. Within a large and complex organization, many elements at different levels need managing (Fig. 8.54). Routine management and flexibility. Learning and adaptation. Management and bureaucracy. Managers deal with scheduling, planning, and broken plans. Effective management can mean the difference between a growing company and a failing one. Ideally, management would be clear, direct, and informed. In this regard, information systems are integral to all areas of management, from strategic planning to day-to-day oversight. Organizational leaders should work to spread a common or shared understanding among members of the organization, and work to build a consensus on the decisions to be made. Dealing with policy and planning.

Management as coordination. Managers are intensive users of information. Management information systems (MIS) (7.3.2). Management can try to affect outputs, behavior, and culture. Scenario development as part of management. Management teams and building consensus. Coordination (3.5.3).

Strategic Management	Aligning activities with long-range plans and policies.
Planning	Determining long-range directions.
Front-line Management	Aligning daily activities with specific plans. A particular issue is project management.
Administration	Implementing routine procedures.

Figure 8.54: Some types of management activities.

Businesses, organizations, and the technologies that are used to manage them have changed considerably over the past decade. Niche oriented knowledge-intensive industries have enlarged their presence in the market. Not surprisingly, there has been a proliferation of small firms to conduct business. Information systems have facilitated this shift because they allow people to work more efficiently. Members of an organization or business can come together on a particular task and work more efficiently by pooling or allocating resources and knowledge. Information systems that facilitate interaction among different components of an organization allow the formation of project-specific dynamic work groups within organizations. However, these ad hoc alliances are flexible enough to allow resources and responsibilities to be allocated to individuals very quickly. This adaptability and organizational learning helps organizations to operate in dynamic environments (7.3.4). This can be facilitated by Web Services which allow organizations to obtain just the information services they need.

Managing People

Management Style

The management style an organization adopts should be appropriate to the task(s) it needs to accomplish. The classical hierarchical structure (5.7.0) is still the most common management style. It is stable, is quite suited to many industries, and it allows for clear and direct control. Some industries or tasks, however, are dynamic and changing, their requirements do not fit neatly into a department, and are time sensitive. Organizational structure (5.7.1). These types of tasks could benefit from another management approach known as "matrix management" (Fig. 8.55). There are, effectively, two lines of management. This allows people to move in and out of a project according to stage and demand, and encourages the sharing of information across typical task boundaries. This style is most effective when there are several different types, categories, or stages of decisions to be made or tasks to be accomplished. In most cases, setting a positive and constructive tone is most effective but in a few cases intimidation many work.

		Location				
		Asia	N.America	Africa	Europe	S.America
Function	Design					
	Marketing					
	Engineering					
	Production					

Figure 8.55: Matrix management controls organizational activities from two dimensions. In this case, management is by function and location.

Management is not just a set of individual decisions, but should support a consistent set of strategies. The strategies themselves are often determined by "upper management" to maximize the opportunities of an organization. Management, overall, attempts to build an organizational structure. This structure should represent the activities of the organization as a community of practice. That is, the organization is composed of individuals who are practiced at accomplishing particular types of tasks using particular tools, knowledge, and techniques that are inherent to this community. Management structures and techniques should seek to utilize this latent knowledge to the organization's benefit, and not subvert the knowledge of its members. Knowledge such as this is generally hidden in the minds of the members of a professional community, but can be made visible by involving them in all stages of task completion. This is particularly true when utilizing decision support systems (3.4.2), which are more useful with more pertinent information.

Business Rules and Procedures

Business rules are policies and procedures for running a business or organization. They can be found in operational information systems as formalized rule configurations. Fig. 8.56 shows some examples; they can determine, for instance, how data is entered into a database which helps to ensure the integrity of the database (3.9.2). Rules for the allocation of business travel allowances are an example of business policies. These are the also types of procedures which should be captured by records management systems (7.4.1). Financial records. Business process engineering (8.11.2).

> Each ordered item line corresponds to one inventory type, and each inventory type can be referenced by one or many order item lines.
>
> An item may be placed into use upon its arrival or it may be stored. An item may not be stored at all. Some items such as printer cartridges, are part of a generic grouping and may be stored in more than one location. Therefore, some items may be stored in zero, one, or more locations. Each location may store zero, one, or many items.

Figure 8.56: Business rules may define policies for inclusion of entries in a database. (check permission)

Business activities.

8.11.2. Organizational Structure and Processes

Information and organizations are intertwined. Even organizations not typically considered to be information-based are, in fact. heavily dependent on it; for instance, the expertise necessary to run a steel mill and the data to tune efficient production are as integral to the mill and the materials used. Why do we form organizations? Theory of the firm. Process and resource based models of the firm. Industrial organization in relation to markets. Object-oriented design (3.9.3). Preservation of workflows (8.11.2, 7.4.1).

Information systems may have a profound effect on organizational structure. Traditional business is also feeling the pressure to evolve, and many businesses and even individual positions may have to "re-engineer" themselves to stay competitive[51].

The economic consequences of the development and improvement of information systems is hard to ignore. These systems have allowed organizations to streamline production processes, cull knowledge and information from various sources faster and with almost no overhead, and reduced almost to zero many of the costs that were long thought to be unavoidable, such as office rent. Indeed, many organizations have become virtual, with no centralized business headquarters and employees who have minimal, if any, physical interaction with each other. Organizational structure determines not just information flow, but also decision making and control. There may be formal structure or informal structures.

Arranging incentives within a business.

Enterprise content management (7.3.6). Organizing business information[80].

Information ecology and communication genres for business communication.

Business are information intensive.

Operations: sales forwcast

Control: Budget control

Planning: shop-floor scheduling.

Structuring a business around a database and data that can be collected.

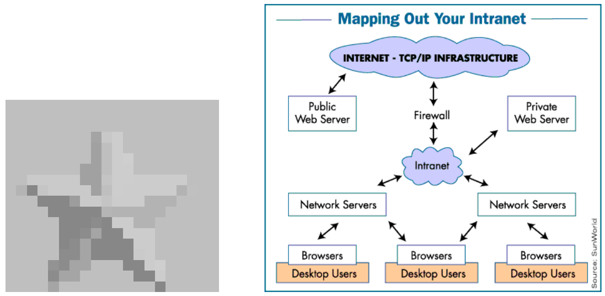


Figure 8.57: Corporate communication and intranets.

Core Competencies of a Business

To re-engineer organizations, there has been an increase in functional specialization in companies, with one result being the tendency of organizations to focus on "core competencies". "Core competencies" are the primary, or fundamental services that the organization exists to provide. This often means the elimination of superfluous operating elements; many non-primary or supporting functions are outsourced to independent companies that specialize in providing particular services. Fig. 8.58 shows how the basic structure of an organization might be divided into competencies. If the organization is restructured, it can then focus on its "core" competencies. Because information systems allow organizations to be decentralized, these virtual organizations can have a minimal structure. The detailed structure may be determined with object-oriented design (3.9.3). But, there is also more external information. These are socio-technical systems because they depend on both technology and social information.

Management of virtual organizations. This often means management of project teams. Use of online resources and use of open source products to avoid lock-in with specific vendors. Flexibility in the face of disruptive technologies.

Resource maximization

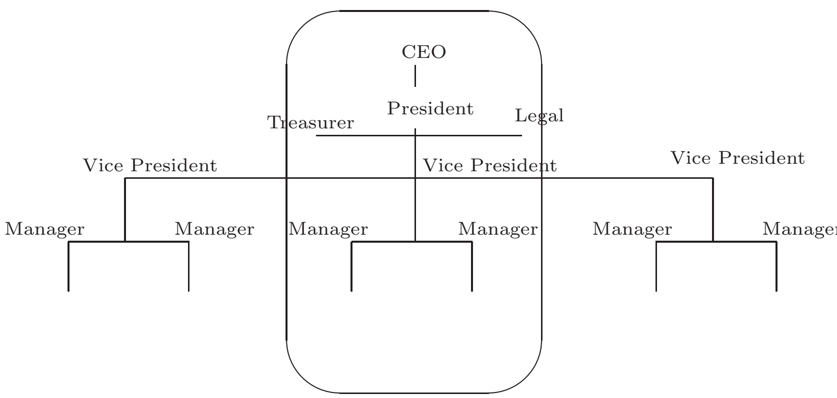


Figure 8.58: Information systems contribute to the fragmentation of monolithic organizations. The core business activities (inside the box) might be kept and the remainder outsourced.

When two organizations need to work together these issues and considerations can be difficult. The introduction of technology is not solely a technological endeavor; it is groups of people who will be using it, and every group is unique in the way that it will approach and adopt technological change. This phenomenon is best explained by "adaptive structuration theory," which is an extension of basic structuration theory and illustrates the idea that technology and the groups that utilize it are constantly and systematically changing due to their reciprocal interactions[45]. There are often coordination difficulties between the established processes of the individual organizations. Through adversity, however, innovation is often born; a merger can be seen as an opportunity to re-engineer two organizations at once, and introduce a new information system technology on a relatively blank slate. These factors are summarized with the Technology Acceptance Model (7.9.6).

Organizational Process Engineering and Re-Engineering

Rather than focusing on organizational structure, it's often helpful to emphasize processes. For instance, this can be helpful in developing and re-designing organizations. This may include the following steps: (a) Analyzing existing processes. (b) Determining what could be improved and (c) propose and implement how to do that. Requirements specification (7.9.1). Requirements models which include goals. Object-orented design (3.9.3). Dependency graph (Fig 8.59). Optimize quality by managing processes.

From re-engineering processes to re-engineering the corporation.

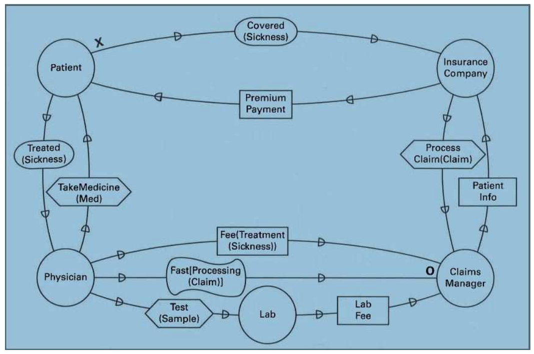


Figure 8.59: Dependency graph (from[46]). Diagramming the flows can facilitate organizational engineering. (redraw) (check permission)

Introducing an updated information system into an existing organization may require re-engineer processes to optimize workflow. This is often associated with the introduction of information systems. They may benefit from system analysis (8.11.0) and specification of activities. At the "front end" of this re-design, information can be targeted to the individuals who are responsible for it without having to be assigned down the line through management. As the traditional management control structures become unwieldy, knowledge management systems become more influential in aiding decisions such as these (7.3.1). Technology, such as knowledge management systems, can also help with the documentation and enforcement of business policies. Capturing tacit organizational knowledge (7.3.4). Group thinking by managers in determining business process engineering can facilitate acceptance of those models.

Each company must find the way to operate within the various structures that are made possible by information systems. An organization's particular business strategy must be considered when attempting to integrate an information system. Introducing a complex automated phone tree does not make sense if a company's strategy is to maximize its relationships with customers. Workflow. Coordination Theory (3.5.3). There are often inconsistencies of organizational processes. Business environments change rapidly. Business process mapping. This may use UML activity diagrams (3.10.2).

Management for Quality

Poor quality products can be very costly. It is generally better to prevent bugs and failures than to fix them later. These factors are acknowledged to result in more efficient and capable workflows. Capability Maturity Model Integration (CMMI), rates organizations on their ability to manage and complete large software development projects. The rating system utilizes a scale of one-to-five, indicating the level of an organization's procedural development. The CMMI indicates that the ideal organization is adaptable to unique and varying situations and requirements. As such, certain production and quality control approaches, such as TQM (Total Quality Management), can be overly rigid. Information system utilization and management of post-production information can greatly enhance an organization's ability to not only anticipate and adapt to new situations, but also to do so in a way that ensures a high level of product quality.

8.11.3. Projects, Project Teams, and Project Management

Management of specific activities towards a specific goal. Coordination theory (3.5.3). Flexible organizations are often structured around projects. Beyond simple meetings there is a spectrum of increasingly structured coordinated group activity [8]. In the extreme, the organization can be refocused around projects. Projects are time limited and goal oriented and often cross organizational boundaries. Having a set of people dedicated to seeing the project through from start to finish ensures that they do not become mired between groups or departments. Projects are difficult to manage because each project is relatively unique, although many of the same skills are utilized. Project management can be facilitated by object-oriented design (3.9.3) because the expected tasks are clearly specified. Organizing workloads into projects allows an organization to be adaptive, and to plan, schedule, and control organizational activities to reach a goal. Quickly and accurately assess a situation as well as the risks and opportunities it presents. Fitting constraints and a budget. That said, a project plan should often be flexible and adaptive. Project management as managing dependencies. Coordination (3.5.3) in management. Project libraries.

Composing the team with individuals of different skills. Every individual on the team has roles, responsibilities, and tasks that need to be accomplished for the team as a whole to succeed. There may be more than one team and project going on at the same time; coordination and communication across projects and project teams can ensure that all available knowledge is being utilized, and no efforts are wasted.

Centralized control of all projects happening at one time can be useful when there are a lot of complex activities that need to be coordinated. Multiple project managers, each responsible for their own team, will all report to one project leader. This is often the case for large, complex projects, where multiple teams may work on small portions of a large project whose stages need to be completed at the same time. Coordinated information is essential to the efficiency of these tasks, and information systems play a large role in the management of these types of projects. Indeed, information systems themselves are generally developed in this way.

Centralized decision making and centralized information processing depends reaching one correct response. Different perspectives and approaches may allow alternate solutions.

Judging the risk of various alternatives. These evaluations benefit from good information and there is a substantial risk the result of not having accurate information.

Project managers are responsible for maintaining continuous parallel streams of activity at all times to ensure maximum efficiency. A project manager may have to manage multiple, often conflicting schedules, balance and determine costs, and set and push for the completion of goals[12]. Even modeling these activities can be difficult. Processes and methods for doing this do exist, however, and should be in place before a project begins. Process documentation.

Collaboration in large-scale projects (Fig. 8.60). Collaborative project management tools.

Figure 8.60: Large scale project management is needed in complex projects such as the construction of the Oresund bridge [?].

For managing specific activities that need to be accomplished. Another method involves Pert charts, which are a common tool for task scheduling (Fig. 8.61). Pert charts are useful for modeling processes that have a definite order of operations, such as when one stage cannot be started until previous stages have been completed.

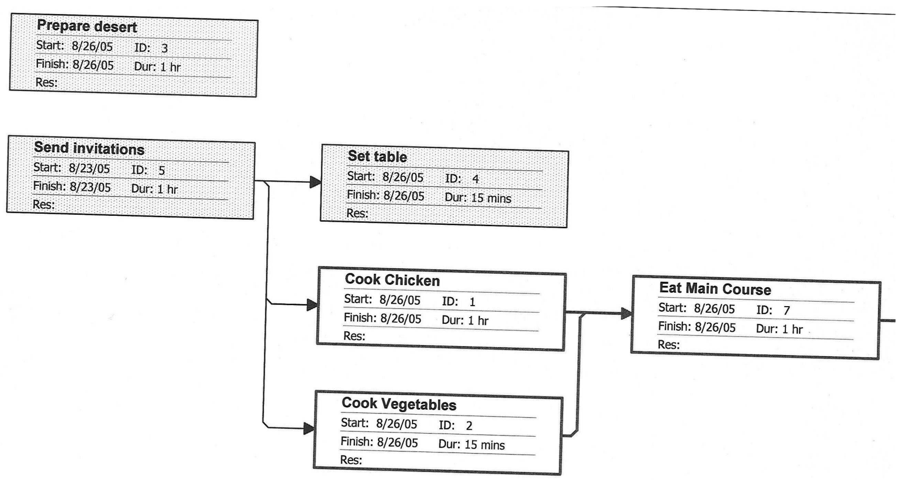


Figure 8.61: PERT chart for cooking dinner. These are they same tasks as shown in the Gantt chart above.

Individuals often have discretion about their work environments and develop strategies for organizing their work. Learning about the organization or work through apprenticeships.

From task models to workflow[78]. Workflow shows tasks to be completed. The Gantt chart (Fig. 8.62), shows parallel timelines or processes. This actually implements a simple workflow system ((sec:workflow1)).

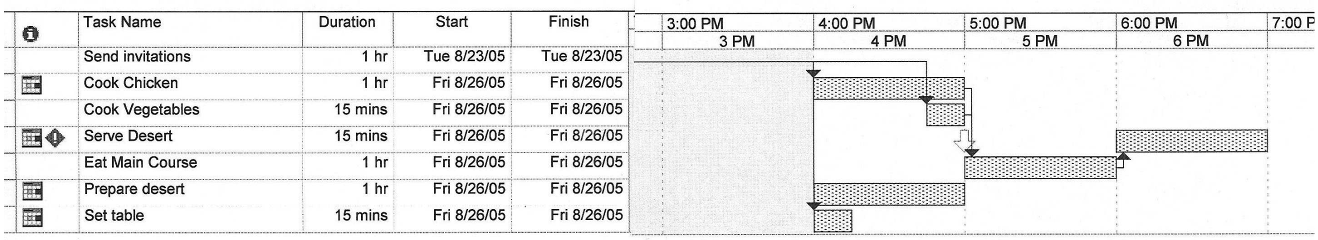


Figure 8.62: Gantt chart with a simplified set of steps required to cook dinner.

Operations research supporting logistics (8.12.1).

The critical path [2] is path through the tasks that will take the longest time. Thus it is particularly important for the project manager to keep those activities on schedule. For each stage of the critical path, a completion-time range for each task and sub-task can be determined. Given at least some probable dates within a project's schedule, the "slack" (Eq. 8.2) can be used to extrapolate the remaining times. The schedule can be further enhanced by considering the probability of completing each stage according to the schedule. Given that information, the schedule can be modified to consider the costs of different scheduling options.

$$slack = (earliest\ start\ time) - (latest\ start\ time) \quad (8.2)$$

When scheduling a project, plans should be as adaptive and flexible as possible. It may rain, the mail could be lost, the boss could get sick; despite detailed planning the unexpected will occur, and schedules need to be revised. Chance and the unexpected are the perpetual thorns in the side of strategic planning[63]. Contingency procedures and plans should be developed and put in place. Obviously, not all circumstances can be foreseen, but with pre-developed fall-back plans, knowledge redundancy, and adaptive management systems, procedures and schedules adapt to almost any situation. Assessment of risks (7.10.3) for the completion of a project and management of those risks is a critical skill for the project manager. Workflows and management.

Standards

Standards set uniform practice. Standards allow coordination between companies and organizations. Information systems are full of standards ranging from formats such as HTML, to protocols such as TCP/IP, to hardware such as standard plugs.

These standards are so pervasive that they are barely noticed but they do have pros and cons. They allow complex activities to be completed efficiently and safely and they support interoperability.

Standards are often set be the organizations which are likely to employ them. In many cases, this works well. However, it is also possible there they may be developed to limit competition from members outside the group.

Accreditation. Model curricula.

8.11.4. Business Models

Efficiency of production. Businesses are commercial organizations which emphasize production. Earlier, we focused on information in organizations. Here, we consider management, production, and commerce, and how information interacts with them. Each of them has distinct needs for information management. One of the major difficulties is simultaneously handling complexity efficiently and being adaptive to new conditions. Produce things which people want. Free as a business model.

Any organization needs to determine its strategy for managing it resources. This strategy is known as a "business model". A business model should not be confused with an organization's micro-strategies relating to specific products or services — a business model is a grand plan, outlining broad concepts and methods. There is no "one size fits all" business model; various models are appropriate for different products, markets, regulations, and economic climates. Every sound strategy takes into consideration the nature of the entity at hand, its strengths and weaknesses, and the competition that faces it (and their strengths and weaknesses). The business model includes the way in which the proceeds from the company can sustain the process.

Type	**Description**
Advertising	Draw attention and deliver messages about other products.
Brokerage	Facilitate transactions for a fee.
Infomediary	Collect and organize information of value to others.
Manufacturer (Direct)	Make products.
Merchant	Provide products in a convenient environment for the consumer.
Subscription	Pay for regularly delivered materials.
Utility	Provide services at a fixed cost.

Figure 8.63: Some broad categories of business models[3]. (check permission)

Companies are a specific type of legal entity. Generally, they are organized with by-laws.

Business models help in determining an organization's growth and revenue potentials. These two factors are related, and changes in one will have an effect on the other. Growth potentials indicate how large a company can expect to grow given its product or service and the market in which it operates. Growth potentials can change, however, and the initial projection can be influenced by factors such as economic or technological developments and the fluctuating cost of the product itself. Revenue is the gross amount of money that an organization takes in, without considering operating costs. Revenue potential is the projected amount of money that an organization will take in, based on its growth potential, the cost of its products or services, and other factors. An organization's actual growth and revenue can be much different than its projected growth and revenue — changes in management, the economy, and technology can all affect the numbers. It is typically the actual growth and revenue that investors look at when deciding whether or not an organization is sound (Fig. 8.64).

		Revenues	
		Low	**High**
Growth	**High**	Question Marks	Star
	Low	Dog	Cash Cow

Figure 8.64: Given revenue and growth prospects a company will usually prefer a business with high revenue and high growth[31].

Mission statement to articulate the goals of the organization.

Senior management team. CIO, CTO, COO, CEO.

Handling crises.

The business model is implemented by the allocation of corporate resources. Thus, there needs to be a financial model. Financial models help to predict the future. IT investment in businesses.

8.11.5. Social Infrastructure of Businesses

Effective business depends on a stable monetary system, legal system, education system, and trained professionals. Economics (8.7.0). Trained workforce. Stability. System of record keeping.

Legal System: Enforceable Contracts

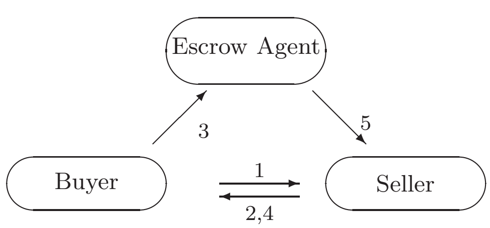
A contract is a binding commitment to action based on offer and acceptance between two or more parties. Contracts require a mutual exchange. Simple example of a contract. Such as "If you bring me a sandwich for lunch for a month, I will pay you $100."

Software agents may be designed to enter into contracts.

Promises. Deontic logic. Ontological design for commitments.

Disputes may arise when one party honor the details of the contract before the other party must honor theirs; after the first party receives what they want, what prevents them from reneging on their portion of the deal? In situations such as this, when a transaction requires the exchange of funds but the parties do not trust each other, a third party may be required to transfer the funds i.e., in "escrow" (Fig. 8.65). While escrow accounts have existed for a long time in traditional business models, there was no system capable of handling these types of demands over the internet. It was necessary for the growth of ecommerce and the continued viability of the Web to develop a system whereby individuals could securely enter into un-trusting transactions. Contacts and commitment. Contractual drafting. Contract should specify explicit actions required of both sides. it should focus on those actions.

Legal aspects of corporations.



1. Buyer requests information about products.
2. Seller provides information.
3. Buyer deposits funds with a third part (escrow agent).
4. Seller transfers product to buyer.
5. Third party moves funds to seller.

Figure 8.65: Escrow facilitates trust in online transactions where either the buyer or seller may not have enough of a reputation to be trusted.

8.12. Functional Units of Businesses and their Use of Information

Knowledge management (7.3.1). Structuring organizations and roles. Danger of silos (7.3.6). Although there are many types and structures of businesses, they can be decomposed into functional units such as manufacturing, retail, and engineering. Administration. Financial records. Personnel.

Business activities. Business services. Capturing those. Records management (7.4.1). Organizations use information in coordinating the interaction of all these components. Traditional components of business: Finance, Technology, Marketing.

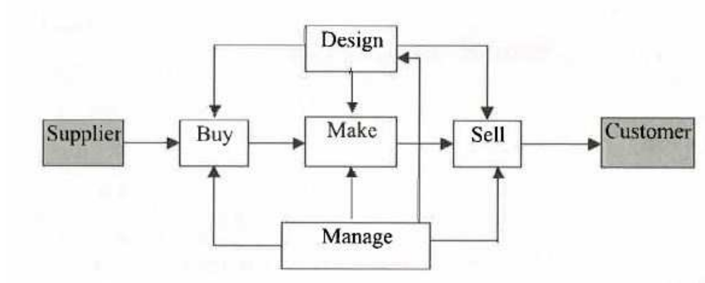


Figure 8.66: Business activity model[61]. (check permission) (redraw)

Structuring businesses to take advantage of information. Redesigning the business to take advantage of record keeping capabilities, customer interaction, automated inventory and fulfillment, and metrics for performance.

Business Classification Systems

Systems of taxonomies, such as the North American Industry Classification System (NAICS).

8.12.1. Manufacturing, Production, and Services

Compare to business based on services. There are several possible configurations for production activities. Manufacturing vs knowledge organizations. Henry Ford developed sequential production in 1913. This manufacturing design process uses sequential steps to rapidly construct a product, and for 75 years it has been the industry standard. However, due to changes in the marketplace, consumer demands, and production times, a successful company can typically no longer support sequential production techniques. Recently, there has been a push to develop more efficient and flexible processes. Integrated production, or concurrent engineering, has emerged as that efficient model. The model can be a unified vision incorporating concept, design, production, marketing, sales and maintenance, among others. Manufacturing learning curves reduce costs along with economies of scale. Business models for knowledge and information based organizations (8.13.8). PLM: product lifestyle management.

Efficencies in factors from information systems. Automated naufacturing with robotics.

New models of manufacturing with distributed printers. Distributed manufacturing. This can be based on personalized designs for mass individualization such as with 3-D printers (8.12.1).

Managing the Flow of Material: The Supply Chain

In manufacturing, the parts needed have to arrive at the same time. A supply chain is the path from source to destination that goods, materials, and products follow (Fig. 8.68). In its entirety, a supply chain describe from where, and how, an organization gets the materials that it needs to create its products, and how those materials are utilized. Optimization of a supply chain improves productivity, and lowers costs (8.8.1). Delivery and shipping time is increasingly important. The more general problem of managing inventory and supplies in many locations. This may include warehouses and transportation time. This is a type of coordination or articulation. Plan, source, supply, deliver.

Information is crucial to managing a supply chain. Keeping track of inventory such as who owns it and

Figure 8.67: Consider all the items that must be stocked and available at a moment's notice in a hospital emergency room. (check permission)

who has it. Management of physical products can be tracked and facilitated by location technologies. Moreover, supply chains can be integrated with inventory, shipping, and retail management. A tightly optimized supply chain, just-in-time manufacturing, could almost entirely eliminate inventory. When conditions are stable, it is fairly easy to manage the flow. But, uncertainty and changing conditions can create uneven flow. To maintain maximum efficiency, it is important to prevent any interruption of output, which means preventing any interruption to the input of necessary materials. Because supply chains are so integrated, and changes in one environment can have unforeseen changes in another environment, the supply and demand of materials and products is dynamic, and it is often necessary to alter the parameters of a supply chain fairly quickly. Articulation work (5.6.2). Modeling supply chains with Petri Nets.

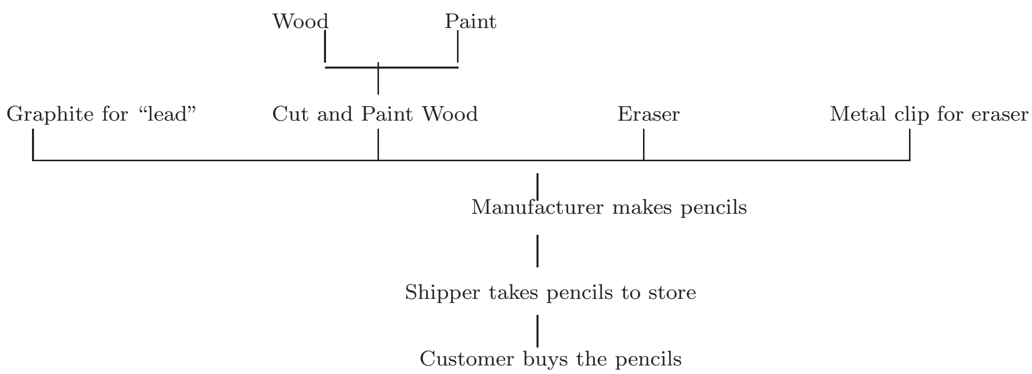


Figure 8.68: Schematic of a supply chain for producing wooden pencils. Without any one of these pieces, the pencil would not be complete. The delivery system will be much more complex if there are cross-links.

Timely information and accurate forecasting (3.4.2) such as these systems provide make a business much more efficient. When the demand for a product or service is constant, predictions are relatively simple — the average historical demand adjusted for demographic changes is an effective model. Moreover, inventory ties up resources and, indeed, often requires considerable handling and space. Many production environments, however, are dynamic, with sometimes unpredictable demands. Production systems must be designed to be much more flexible, and forecasting programs must be able to predict demand using incomplete information. Programs utilizing system dynamics modeling techniques often used in the design of production systems, many are already formalized (-A.10.2).

Related to B2B. Demand-pull economies.

One of the variables used by forecasting systems are current orders. These are the defining element of current demand. By utilizing systems that automatically upload electronic orders into forecasting software, on-the-spot calculations can be made. However, purchase order and invoice automation systems are essential[43] in and of themselves. Very long supply chains may minimize perceived responsibility.

Highly predictable environments are required for long supply chains to be effective. In the extreme, the issues become related to managing outsourcing (8.9.2).

Manufacturing

Because they operate in real-time, when linked with other advanced productions techniques they allow "mass customization" of products. Blue jeans can be produced to perfectly fit a customer's measurements.

Information systems are also useful for maintaining logistical and transportation models. Whereas the supply chain illustrates what materials come from where and where they go, logistics describe exactly how they get where they are going. In most production settings, this involves transportation schedules, supplier operating times, load values, costs, and shipping times. Information systems can help to coordinate and plan schedules using all of this disparate information. This allows more precise analysis of material arrival times, and hence, eventual production time. Using all of this information along with values, such as organization operating hours and average production quantities, and average daily production amounts can be calculated.

In a factory, custom jobs must be scheduled. Operations research. Scheduling algorithms ((sec:schedulingalgor)).

Managing activities so similar processes are completed together.

Figure 8.69: Factory floor scheduling optimizes the use of resources (including worker's time) in manufacturing. (check permission)

After facilitating the flow of pre-production information systems can facilitate process control. Different models of production have been designed over the years, often reflecting the requirements and constraints of the environment in which they were developed. That basic process was improved and made more efficient with Just-in-Time manufacturing, which used more advanced information and planning systems. When a customer places an order, the necessary supplies for that specific order are requested and injected into the production line almost immediately. Logistics – production schedules and times, and replacement supply orders are re-calculated — and the supply lines in and out of the organization are never broken, but no excess product is produced. Obviously, highly integrated information and control systems are required to coordinated these variables with any accuracy. This process has been combined with mass customization to maximize efficiency on the supply side while ensuring end-user satisfaction on the demand side. However, even preservation of the design for the product not be enough. For complex systems the entire manufacturing sequence is designed.

Object metadata. Design rationale (3.8.7). CAD and design representation.

Semantics of processes. Basic machines (levers, incline plane, etc.) Controlled vocabularies and describing processes. Filter and flow[13].

Records of manufacturing processes.

Mass customization.

Desktop Prototypes and Manufacturing CAD. Design libraries. 3D printers. Direct manufacturing. One-offs and low-volume reproduction. Rapid prototyping for R&D. Fig. 8.70. Personal fabrication.

Figure 8.70: Desktop manufacturing can be personalized and just-in-time. Rapid prototyping. For instance, a prosthetic leg can be produced in different styles. (check permission)

8.12.2. Distribution

Logistics. The flip side of supply-chain (8.12.2).

8.12.3. Research and Development (R&D)

Research

Innovation of novel products and processes. A research environment needs to encourage innovation. However, managing a research organization is a challenge because effective research is not easily planned or structured. Research and Development (R&D) have inherently non-routine activities. (8.12.3) often have special challenges moving ideas into operations and production[25]. Physical proximity and research productivity. Role of information resources in research and innovation. Universities (8.13.2).

This "technology transfer" is a particular challenge for organizational culture. It is also one component of organizational knowledge creation. Indeed, research in some organizations is not attempted and the organization evolves by acquisition (8.14.2). Innovation (8.14.0).

In many cases, a learning organization (7.3.4) simply shifts it emphasis to take advantage of opportunities. But, in other situations the organization evolve to disruptive environments. Indeed, some organizations attempt to institutionalize the development of new products. Organizational R&D is a cornerstone of those organizations which are oriented to change. The products and processes need to adapt to those changes [25]. R&D beyond the organization encouraging staff to participate in professional societies ((sec:professions)). However, there may be deep conflicts between a research organization and other parts of an organization [6]. Also, coordination with universities. Societal support of technology and research (9.4.0).

Product Design and Development

Design (3.8.0). Production. Project management (8.11.3) and engineering informatics. Design automation.

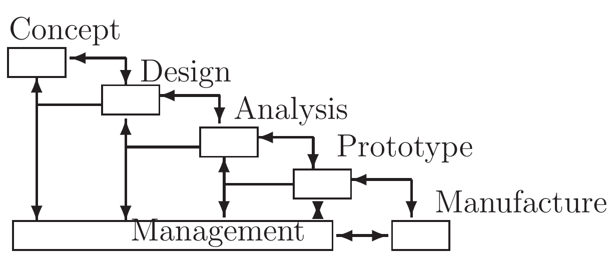


Figure 8.71: Product design development flow in a traditional engineering organization. Note that very little physical product moves across the organization; rather, only product descriptions move. (redraw) (check permission)

Reusable designs. A library of fabricated shapes[68]. There are several aspects of objects that need to be defined (Fig. 3.50)[74]. Issues for describing behavior: very context dependent. This is useful for identifying replacement parts. It is analogous to describing the behavior of software objects. Interactive Computer-Aided Design (CAD) is often part of very large engineering projects. Ways to describe shapes. Index of shapes. Searching shape properties. Shape similarity[36] (Fig. 8.72). Shape repository [18]. Representation of shapes: Functions versus data sets. Preservation for engineering records. Legal need for archives of airline engineering drawings.

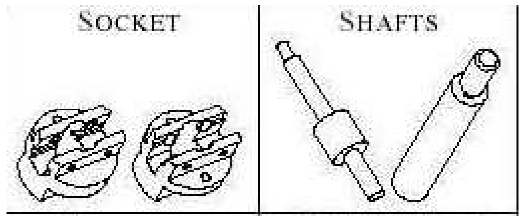


Figure 8.72: Samples for determining the similarity of machine parts[36]. (different picture) (check permission)

Coordination among design teams. Exchanging artifacts such as CAD across design teams. As different experts participate in different projects, libraries of CAD objects, situations, and designs can be built. All of this expertise can be harnessed to produce interactive representations and simulations that can be used to try out different designs or styles to see how they react to the environment for which they are intended. This represents the fusion of analysis and design, which significantly contributes to an increase in the speed and quality of design, and a decrease to its cost. After that, there needs to be product lifecycle management.

8.12.4. Business-to-Business (B2B) Services

Ecologies of business. Business have a "mutually symbiotic" relationship; each prefers the other to be doing well economically, as this means more business. Similarly, it is in the interest of all businesses to develop ways to allow them to interact with the most efficiency and least cost. Business-to-business (B2B) services allow businesses to interact. they all reduce marketing costs and allow buyers and sellers to easily view what the other has to offer. This not only increases sales, but also helps to optimize supply chains. The Internet greatly facilitates B2B interaction. Frameworks for online markets, such as auctions (8.7.2), have further optimized the benefits that businesses can have for one another. However, despite almost every organization and business having at least some web presence, there is a need for both a standard language for describing content and even more clearly defined marketing frameworks.

This mainly involves two areas: classification and record keeping. Record keeping is important in this regard because it allows other companies to clearly see not only what it is that another organization does, but also how they do it. Business records can illumine an organization's capabilities and history (7.4.3). Records, however, are only useful if a searcher can find what they are looking for. Business Acceptable Communications (BAC) seeks to permanently link certain business records and transactions with metadata that describe those transactions[32]. This makes record searching possible. B2B in the media industry may include supplying content to distributors.

Perhaps more importantly, facilitating business interaction is the development of a common interaction language. This allows organizations to communicate with one another, to describe their products, for example, in a consistent fashion. The most obvious method would be to develop web-services (7.8.1). One such system has been termed the business reporting language, or XBRL. This is an XML-based language developed to facilitate financial reporting between organizations. It is a web-based financial record exchange service, and can be used by organizations to distribute financial information about themselves to clients, competitors, or market regulators. Another useful language is ebXML (electronic business XML).

8.12.5. Commerce and Retail

Information Systems for Commerce and Retail

Commerce is the exchange of goods and services. Information systems affects many aspects of commerce including catalogs, funds transfers, accounting, and even the transfer of the goods themselves in the case of digital content. Wal-Mart uses a sophisticated inventory tracking system that automatically synchronizes a global inventory database. When a Wal-Mart customer in Columbus, Ohio buys a toaster, that purchase order is logged into a central database that not only monitors how well all toasters are selling in Ohio and how well that brand of toaster is selling across the country, but also automatically orders a new toaster from the nearest distribution center, and a new toaster is ordered from the manufacturer. It maintains virtually no inventory and each of its computers are built to order. Reliable measurement (9.3.0)for selling goods.

Accumulated data about the purchases of an individual can be used in many ways.

Trusted eCommerce sites.

Retail records. Managing retail inventory. Bar codes environmental tags. Weights and measures. Loyalty cards and personalization. Managing large data sets or customer records (9.6.3).

Order fulfillment. Warehouse distribution.

Market basket analysis.

Figure 8.73: Loyalty cards give discounts to customers but they also collect data about the customer's preferences.

In ecommerce, Internet sales with search engines allow greater awareness and easier access of low-frequency items. Lots of used books are now available. This is also known as the "long tail" [27] (Fig. -A.87). The Internet makes a more efficient market therefore not as much of the tail is truncated.

Figure 8.74: Demand for products generally follows a power law. The most popular product a very popular but there is a "long tail" of demand for a great many products. Traditional (bricks-and-mortar) businesses are limited in the physical inventory they can stock (dark area) but the Internet allows a virtual inventory. (redraw) (check permission)

Sponsored search (10.8.0). SEO (8.12.5). Log files (-A.14.2). Data management (9.6.3). Predicting preferences based on personal information. Privacy preserving data mining (9.6.5).

Point of sale system.

Figure 8.75: eCommerce distribution network.

Marketing

Marketing is presenting a product to a market. Although marketing is sometimes thought to consist only advertising, there are many aspects to presentation, such as pricing, demographics, positioning, and advertising. Indeed, marketing is information intensive and may even include developing models of the markets. Marketing intelligence is the information required to make effective marketing decisions. Marketing can also be seen as a social networking activity.

Segmentation of the market is a basic strategy, for optimizing interest. That is, to find users with different needs and tailor versions of the product to them. Business are constantly seeking to better specify and differentiate their products. Information systems help in this process by dividing customers into groups and differentiating prices. Airlines have found they can divide the business traveler (upper line in Fig. 8.42) from the recreational traveler (lower line) by requiring a Saturday night layover. Without information technology, this was not possible.

A well-marketed product creates a brand, which comes to be an inseparable identifier of that product. That brand must then be managed, always preserving its image while repositioning it to capture more users (5.2.2). Ad buys on tradiional media but, increasingly, social viral marketing by word of mouth from person-to-person association in a social network (5.1.0). Social media (5.1.4). Online product reviews and recommendations.

Futhermore, the social media platform with likely return data to the advertiser about the users. Tie into data analytics. Persuadability.

Customers

Customer relationship management (CRM) Customer relationships are often one of the most expensive parts of retail. It can, however, be partially automated and supported with information systems. Service management theory: identification, commitment, bonding, customer relationships, retention. Customer relationship management (CRM) software and programs are used by businesses to help maintain a sense of connection between customer and business while increasing efficiency as much as possible. These systems may perform services ranging from auto-completing a returning customer's order form to making recommendations about what movies they would like. Furthermore, customer service can be facilitated with several information system technologies such as voice interaction and searching. Call centers. Product community. Managing collections of customer complaints (tickets) to give satisfying interaction.

Figure 8.76: Mining discussion groups for customer reactions about a product.

Daily deal sites and correlated activity with other information services. Deals services.

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Figure 8.77: Mining discussion groups for customer reactions about a product.

Online Retail

Augmented reality viewing of products to minimize returns.

Product Information and Product Reviews

A business has to provide information about its products to the consumer. This can be done in many ways: websites, customer service representatives, conventions, and advertising. Many consumers do research — often using the internet — before making major purchases, and if they do not, or cannot, find information about a product they may skip buying from that company. This trend acts as an incentive for businesses to not only advertise their products, but also to provide information about them. The most detailed information will often be found on the company's website, as this is the most cost-effective way of presenting it. Further information can generally be obtained by calling a customer service representative.

Some systems publish subscriber reviews of products or services. In addition, quality ratings of the reviewers themselves are also published, which are based on comments from other subscribers regarding the typical usefulness or accuracy of the published product review. If several "highly reviewed" people seem to think another person's reviews are generally sound, the odds are that they are a good source of information. The more links or associations to your virtual identity there are, the better or worse your ranking, and the more trustworthy you appear to be. Example shown in the discussion of opinion mining (10.5.3).

Advertising

Advertising typically serves two purposes; it disseminates business or product information, and it seeks to convince. Advertising for ecommerce businesses is different from traditional advertising, particularly because of the way that it can be targeted to small groups of people, and in a sense, even to individuals (4.10.2). An agency advertising a particular product on television must predict, broadly, what type of people are going to be most interested in their product, and on what station at what time those types of people will most likely be watching TV. Although advertisers have become quite adept at doing this, internet advertising can be much more specific. Commercial search engines may match particular advertisements to particular search queries, guaranteeing that the individual conducting the search is at least mildly interested in what the ad is selling. Ecommerce user profiles allow for more personalized shopping, including personalized pricing, which can limit advertised products to a finite price range. This user profiling allows businesses to target individuals for advertising. Many agencies specializing in online advertising guarantee a minimum number of transactions or views (click-throughs) by placing their ads in areas of high traffic, or coordinating their advertising with multiple targeted ad services (8.12.5).

Advertising and attention (4.2.2). Tracking eye movements of people viewing a screen.

Advertising rhetorics. Social media and advertising. For instance, by building online communities. The effects of advertising can be monitored with searches. Searches reflect people's awareness of topics. Indeed, searches on specific products rise following even non-Internet based advertising campaigns. Search engine marketing (SEM). Advertising campaign. Impressions and presentations of advertisements on search return pages. Cost per impression (CPI). Click-throughs. Auctions for position.

Search engine optimization. Because many users are led to Web pages by search engines, some Web site designers who want their sites ranked by those search engines add spurious text to Web pages that will be picked up in Web indexing processes. This is known as “keyword spamming”. A variety of techniques have been developed. Such as link farms and content farms. Adversarial IR.

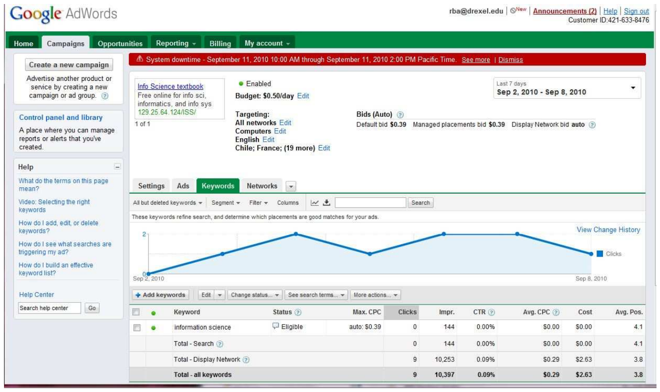


Figure 8.78: Google Adwords interface for managing a targeted advertising campaign.

Micro-targeting advertising.

Keyword auction for setting prices.

Commercial data brokers.

Data profile even without facts. Working with probabilities.

Search engines have rapidly moved from research to a major commercial force. The search is generally supported by advertising. Business models (8.11.4). Search engine business model (10.8.0). Presenting advertisements associated with searches. Personalized advertising (4.10.3). Auctioning advertising space on the search engine results page (8.7.2). Click-throughs. Click fraud, Separating ads from content. To maintain the confidence of users, the search engine company needs to be neutral in selecting sites to be returned by the search. Second price auction.

Giving people what they want in search results versus giving them an overview of the available literature.

Measuring the Quality of a Web Page or Web Site

Quality score.

Business Strategies for B2C

In general, many of the same business strategies that have been used for decades in traditional business environments can be applied to ecommerce businesses. Many businesses employ a hybrid strategy, which include physical locations as well as virtual businesses (i.e., “clicks-and-mortar”). This business model does not alienate any group of potential customers. Even physical purchases are affected by customer research online. In a well-integrated system, the online system can extend the physical displays by making unusual, low volume products available.

Shopping and Consumer Transactions

Process of shopping. Finding and evaluating products. Pay-as-you go, subscriptions, shareware.

Commerce and the transactions that constitute it are processes. They may be more or less complicated, depending on the specific type of transaction. While there are many facets to a commercial transaction, most can be broken down into stages or templates, which are useful in modeling automated forms of those transactions. low-chart of the various transactions that make up a particular activity. Haggling.

Decision to Purchase

Consumers make decisions when purchasing a product. Product information as interpreted by the individual's awareness of the product and analysis of its benefits. The decision to buy, or not, may depend on how the purchasing transactions are managed[22]. If the process is complicated and there are many different steps, people may be disinclined to make a purchase. Or, perhaps, a particular wording may increase or decrease a customer's desire to buy. Product and service reputation (5.2.2).

Businesses attempt to highlight all those factors that have a positive impact on purchasing probability, and eliminate those that have a negative impact. To understand and analyze what effects the purchasing process has on customers, dynamic data models are gathered from a customer's interaction with a Web site. Fig. 8.79 shows a click data analysis from an online store that registers four million accesses per day. The various levels represent differing degrees, or specificities of information; this is reflected by the increase in the amount of data. An analysis such as this can be used to determine, for example, at what point in the transaction process the majority of people decided not to purchase a product. By analyzing the "click level," a business can determine what most of their potential customers are interested in and what particular information they are seeking. This is related to data warehousing (7.4.4) and data curation (9.6.5).

Level	**Description**
Customer Level	General information about customers.
Session Level	What purchases were made in the session.
Click Level	Details of all user clicks.
Presentation Level	What is presented on each screen for each customer.

Figure 8.79: Levels of data about user behavior in a large online retailer. The amount of data increases by about an order of magnitude at each step. (check permission)

Habit analysis. Predicting consumer behavior.

8.13. Information Economics, Information Goods, and Knowledge Markets

We have already considered basic economic principles (8.7.0). Economic decisions are greatly affected by information. We have already discussed the effects of information on economic decisions (3.4.1); in this section, we consider the economic aspects of information and information resources themselves. This definition of information as the reduction of uncertainty is particularly applicable for economics. Legal and social frameworks for information distribution: publisher, broadcaster, distributor, common carrier.

8.13.1. Value of Information

Value of information in use versus value of information in exchange. There is a direct value for some information. Information has value either in itself (such as music or software) or because of its value for facilitating predictions. It can also have an exchange value.

Systematically determine valuation by: Accuracy, completeness, availability.

Organizations which manage personal information.

Three ways to value information: Market value, Income value. Replacement value

Measuring the value with "valuation". Each of these components can be extended. Management of personal private information.

Management of the asset of information.

Difficulty of extracting information from people. This is the problem of tacit knowledge that we have considered earlier (7.3.4).

8.13.2. Knowledge Institutions

Media, publishing, and now search engines (8.12.5), are part of the knowledge economy. Manufacturing is less of a factor for the post-industrial society. There is a shift from manufacturing to a service and knowledge economy. Creating values for encouraging innovation such as encouraging research and higher education [79]. Universities and libraries overlap with and often function as cultural institutions (5.9.3). Intellectual property plays a key role in a knowledge economy. Creating virtual organizations (5.7.3). Entrepreneurship versus detachment in scholarship. Economic impact of universities and other knowledge institutions [44]. The use of knowledge in society [52]. Subverting information institutions. Academic integrity and reputation.

Knowledge businesses and profits.

Figure 8.80: Andrew Carnegie donated library buildings to towns across the world. Here is a Carnegie library building which is part of the New York Public Library system. (check permission)

Earlier, we considered memory institutions and cultural institutions such as museums (5.9.3). Here we consider institutions which facilitate knowledge creation and dissemination such as universities, museums, and libraries.

Information policies for knowledge institutions. Determining the value of libraries (7.2.1). Research universities.

Universities

Information creation and transmission. Scholarship (9.0.0). Scholarly communities (9.1.1).

Supporting systematic and neutral discourse. Universities are known as highly political environments, some origanizational structures may reduce the politics and encourage scholarship and teaching.

Universities generally realize that scholars need to be able to explore ideas that may be unpopular so they allow latitude to explore ideas under the heading of academic freedom. Debates about the appropriate scope of academic freedom.

Scholarship should be grounded in the world but also separate from the pressures of political agendas. Political issues inside and outside the university.

While scholarship is considered integral with teaching at high level, some universities focus especially on research. Universities as research and development centers. It is often felt that university-level teaching should be coupled with research. In some cases, universities have become primarily research institutions which include some teaching. Traditionally universities are institutions which promote and protect scholarly values (9.0.0).

Quality control and policies which lead to strong universities. Avoiding inbreeding by avoiding hiring their own graduates.

Figure 8.81: The University of Bolgona was one of the world's first universities. (check permission)

Academic Libraries

As centers of information use and creation information management is central to universities. Traditionally, that role in the university has been carried by the university library. Typically, these provide specialized information resources. Management of scholarly literature. Liaison librarian.

While information management is still essential for universities, the role of libraries is changing.

Academic libraries and institutional repositories.

The institutional policies might define requirements for data storage.

Academic Disciplines

Universities are typically organized around disciplines. Such discipline a particular viewpoint of perspective literally a discipline for analyzing the complexity of the world. Disciplines maybe based on differences of models (e.g., chemistry versus physics) or differences of methods (sociology versus social psychology). This way of organizing academic knowledge is also related to the organization of the Dewey Decimal Classification system. It is generally, believed to be based on emergent concepts though it is also possible to argue that the categories are arbitrary. Some other disciplines such as computer science are based on evolving technologies and business which serves a particular constituency. Professions (5.8.2). Disciplines and levels of emergent properties (1.3.2).

Practitioners of a discipline form a discourse community (5.8.2). They are slow to change and have developed an institutional momentum. Multidisciplinary and interdisciplinary work. Emergence of new disciplines. Universities provide a home to representatives of different scholarly communities (9.1.1).

8.13.3. Businesses Based on Intellectual Property

One of the justifications for intellectual property rights is that they encourage innovators. Here we consider two examples. Balance of factors.

The distribution music has dramatically changed from CDs to downloads over the past few years. Despite the copyright laws, it was too easy to copy music files from the CD. Now, most music sales are from downloads of individual songs which are low cost and relatively easy to manipulate.

Cloud music.

Sentiment analysis. Fan metrics by blog analysis (10.11.2).

A patent protects the commercial use of an idea for a limited time (8.2.2) in return for making that public. This is an example of science policy (9.4.0). It is possible to build an entire business around one or a few key patents. Typically, businesses that are formed around patents have a high investment in research and development, but relatively low production costs. Pharmaceuticals may cost several hundreds of millions of dollars to develop and test, but once they are approved they can be produced relatively cheaply (Fig. 8.82). Although it might seem logical for a patent holder to implement their idea, The patents are not always used directly. Sometimes they can simply be used to block competitors from developing along the same lines.

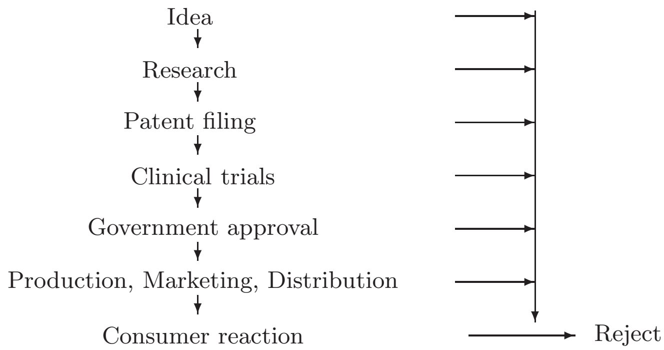


Figure 8.82: Simplified path for approval of a new drug. Even with a very careful research effort, each step is costly and has a high rejection rate.

By comparison to the pharmaceutrical industry, information technology and information systems companies often have interlocking patents portfolios.

Information resources are powering much of the world's economy. This trend is likely to continue. Traditional business models must evolve to incorporate the new technological realities that they face. Failure to do so will most likely mean they will become outmoded and be replaced. The management and review of patents can be complex; indeed, specific information systems have been developed for managing patent portfolios. Moreover, because of the value of patents, there has become a great deal of gamesmanship in their processing. Reverse engineering. Patent trolls.

Information goods have supply, demand, and production costs. Not only do information systems, which manage this commodity, affect traditional businesses, the information industry itself is growing rapidly. Typically, these are non-rival goods (8.7.2) and in many cases, they are perishable goods.

The value of information, like other goods, is dependent on the demand. An algorithm that can predict stock market changes would have a huge demand, and hence, would be extremely valuable. The same can be said for a hit song. Typically, however, information goods have a high cost of development and a low cost of duplication. This alters their value, in the economic sense. Information goods are different from many physical goods, such as a food or an automobile, in that they can be replicated. It is difficult to sell a good if that same good can be had for free — duplication limits the amount of money that can be made from information goods. In terms of information systems, In terms of the dimensions of goods we discussed earlier; information goods can be "excludable"(8.7.2). It is often possible, though in many cases difficult, to control access to them.

Information goods can be exchanged in "knowledge markets". That is, knowledge can be traded between people. Given the fact that anyone seeking out an information resource for a particular subject is not going to be an expert in that field (else, why seek it out) or have the time to become one, a certain amount of trust is required. Information providers such as newspapers, universities, and Web sites may try to create a reputation for quality information (5.2.2). Scholarly publishing and the exchange of information (9.1.1).

Markets work best when when both sides have full information about the products and services. A buyer of a used car rarely knows as much about it as the seller. That is they have asymmetric information. One result of this is that the price of used cars may be less that their true value because the buyers are cautious. It's also the case that buyers are sometimes fooled and buy a car with many problems.

When only one organization controls information, there is an information monopoly, it can be provoked by an individual or an organization within a knowledge market. If it is more profitable to retain information than it is to share it — for example, in the case of asymmetric information for negotiation (3.4.1) —- then the information may remain hidden [9]. Knowledge markets are also accompanied by knowledge gamesmanship which may, of course, include deception (5.3.3). Signaling provides an indication of confidence for contracts, such as an indication of educational credentials Limited use content such as music and book downloads. Fits with genres. Linked to production of information resources ((sec:informationproduction)).

Figure 8.83: Ecosystem of information resources.

Value of general knowledge versus factual knowledge. There are often several ways of learning something so some of the advantage is convenience. Related question of the value of an education.

8.13.4. Publishing and Distributing Information Goods

Content is valuable. There are several ways an information good may be disseminated but the most typical traditional business is through publication. For many media types. Media industry. Book industry.

Publishing is literally making a work public — in the information world, to share is to publish. There are many models for the profitable publication of information, and more are devised every day. We will discuss several of them. Publishing is a social institution that goes beyond simple distribution. It also implies quality because the publisher puts its reputation behind it. Some publishers will publish anything for which they are paid. Because individual of use this type of publisher when their material doesn't reach the quality standards of other publishers, these are called vanity presses.

Publishing is changing, dramatically. The cost of distributing digital information is small compared to traditional methods of distribution. As a result, the distinction between formal and informal publications is breaking down. It is now, in a sense, possible for everybody to be a publisher — the threshold, economically at least, is much lower. The role of traditional publishers is declining; however, traditional information resources can also reap the rewards of lower costs. Digital convergence encourages multi-channel distribution of content the combining of traditional text publishing and new media. The information industry has spurred the growth of large media companies, such as cable TV and newspaper businesses, that can take advantage of this digital convergence. There are many business models that can be utilized to offer high-quality publications that are researched, created, reviewed, and designed by professionals, all for a competitive price. Managing intellectual property. Production asset management. Digital supply chain services. Magazines. Constraints and implications of media business models.

Publishing Platforms

Beyond libraries, data linking has been proposed across the broader Web. Open data (9.6.4). Wikipedia and related projects such as Wikimedia and Wikidata.

Semantic Publishing Semantic descriptions of content can be useful for organizing the material in web publications.

One of the keys is the description of distinct entities. URI FOAF can be used for a personal URI.

Micro-formats. RDFa.

Structuring layouts.

Example vCard and hCard formats. Rich snippets. Advertising.

Web-based publishing platforms. Workflows for web publishing.

Reusing content works better than re-use of code.

Standards for annotations across platforms.

Applicable to scholarly communication ((sec:scholarlycommunication)).

8.13.5. Business Models for Publishing

Dissemination of information, but also a business.

One common method of securing payment for an information resource is the subscription-based publication model. Simply put, a person orders a subscription and issues start to be delivered after the bill is paid. There is a finite term length involved in the subscription-based model; by paying a predetermined fee, a customer is entitled to utilize the service for a predetermined amount of time. This method can be applied to digital content as well by providing the user with a password that is licensed for a specified period. Paywall.

Another method that publishers of all sorts are using capitalizes on the fact that authors and creators want their materials to be seen by the public. In this model, the author and publisher share many of the costs of publication. An author may pay page charges for things such as color, excessive complexity, or open-access. An author may also pay for the entire publication process in exchange for access to the publisher's already established marketing infrastructure and experience. The author would then be reimbursed on a per-view basis, with the publisher receiving a portion of the profit. This requires the formulation of a "cost per access" rate for the publication in question. The demand for publications, however, is often elastic; that is, setting the per-view cost too high will discourage people from accessing it (8.7.2)[64].

The recording industry has also been coping with similar changes in distribution. It is easy to make perfect copies of digital objects such as MP3 songs and videos on DVDs. Consumers are being confronted with the choice of paying money for material that they can obtain for free by file swapping. This is transforming the music industry much like electronic publishing is transforming the publishing business.

One response has been to try to strengthen digital rights management (8.2.4) and prosecute those who violate the established law. Other responses include limited licenses, or the voluntary relinquishing of certain rights normally associated with copyright. This allows artists to choose the level of copyright that they deem desirable. The copyright to some material is owned by larger organizations such as movie studios or record labels. It remains to be seen in what direction these entities will move to adjust to the development of new technologies. In general, there appear to be two general options available to these industries: the first is to attempt to enforce the existing interpretation of copyright law, and to monitor and control the development of new technologies. The second way is to revise the copyright law and artist contracts to reflect new business models.

Sometimes free distribution of content can stimulate interest by heightening awareness. Bands such as the Grateful Dead and Phish typically did not focus on protecting the intellectual property of their songs, instead allowing free copying and distribution of their material in order to widely disperse their music and build a loyal base of fans. Most of the revenue for these bands came from concert ticket sales and other merchandising endeavors. Music linked to advertising.

Other information resources revolve around information brokering, or the collection (not the creation) of existing information and its distribution. Aggregators are information distributors that collect information from many different sources and provide access to it through a single portal. Search engines are information brokers. Others might develop a "shopping model," which makes a direct connection between the producer of the product and the consumer. Because so many of these services are offered for free, it is difficult to charge for their use. Most information resources of this type obtain money in two ways: sponsorship and advertising. Some free services may be offered, or partially sponsored, through a larger organization. This gives the larger organization publicity, and associates their name with a commonly used service. The other way that services is through advertising. Companies will pay the service to run advertisements on their website. These may be based on a flat rate or counted per-click. Copyright is inter-twined with traditional publishing but, perhaps, fundamental changes are needed.

Focused advertising.

Scholarly publishing (9.1.1). Open content initiative. Open access is one part of that. Value to research from availability of open-access materials.

8.13.6. Books, Printing, and Print Culture

Printing

Medium of information presentation. Earlier revolution in information transmission infrastructure. Bibliometrics (9.1.3).

Figure 8.84: Scroll to codex to eReader. (check permission)

Many coordination widgets (2.5.5) have been developed to support access to the contents of books. Page numbers, tables of contents, indexes. Using table of contents and indices.

Communication and diffusion among printers and intellectuals through letters and books. This is a type of social network.

These changes are somewhat analogous to the extend of changes we are experiencing today with the introduction of digital technologies. The changes in printing technology also had a number of less obvious impacts such as changes is the significance of authorship.

Generations of print technology. Publishing (8.13.4). (Fig. 8.85).

2400 BC	Earliest surviving papyrus scrolls.
295	Alexandria Library founded.
c. 370	Rome estimated to have 28 libraries.
1041-48	Movable type from an amalgam of clay and glue developed in China.
1373	Bibliotheque Nationale founded in Lyons.
1456	Gutenberg prints Bible with metal type.
1702	First daily English newspaper, Daily Courant. Survives 30 years.
1709	Copyright Act limits terms of copyright protection in England.
1812	Koenig perfects first steam-powered, flat-bed-and cylinder press.
1959	Xerox markets first xerographic photocopier.
1975	IBM introduces first laser printer.

Figure 8.85: Timeline of some significant events in printing and publishing. (check permission)

Printing changed culture. Originally, printing was primarily used for the Bible, to novels, to paperbacks. Reading aids added to books. [1]. Books and the rise of science. Laws surrounding the distribution of boooks and newspapers also changed.

Non-fiction. Recording and sharing ideas[47]

Indeed, there was an extended series of changes. Page turning in books.

eReaders and Structured Formats. Combine content and systems. Social reading and reading on mobile devices. Architecture of the WWW. Links, Anchors, Mappings. Difficulty of adding annotations to an eReader. Coordination widgets (2.5.5).

E-book standards. EPUB. Content licenses and library business models. Interacting with eBooks. Coordination widgets.

Print Culture

Fan bases for other types of media such as games (11.7.3). Culture associated with the printed word. Although rare books appear almost entirely in library, their preservation is related to archives.

Document communities (5.8.2) such as bookclubs. Social implications of printing. Media conservation. Book clubs. Film groups. Comicon.

Reading experience records. Bibliophiles are people who love books. Typically, this includes not only the content but also the craftsmanship of the book. Type face. Preservation of books and of Web pages (7.5.5). Online reading communities.

8.13.7. News

Figure 8.86: Generations of news media: A) Town crier, B) Newspaper, C) Television, and D) Twitter. (check permission)

News gives people a view of what goes on in the rest of the world. It helps individual relate to their world. Publishing news is a special publishing business. Dissemination of news via the particular advertising model. online newspapers and news searching (10.11.2) and news publishing. In a complex society, there is a need to disseminate current events. News functionality versus news distribution. Text processing of news (10.11.2). News as entertainment. News as empathy (5.5.3). News and newspapers.

Ecosystem of systematic information production.

Word-of-mouth from friends. Perhaps from social media.

Structure and organization of news. Broadcast news versus interactive news. Diversity of opinions.

News focuses the public's attention on issues. However, this focus can also create a bias.

News versus newspapers. Newspapers are rich reflections of their community.

News frames and the impact of news on public discourse (8.4.3).

Novelty scores for news. Personalization and recommender systems. What new over what you did not know before.

Policies for Journalism

Principles: Journalistic style. Citing sources.

News reporting. Investigative journalism.

Neutrality versus advocacy.

Silencing journalists for political advantage. News collection and dissemination has changed dramatically.

Greater emphasis on taking a political stand in contemporary. There is a suggestion that this may be due to newspapers shifting place in the news ecosystem. By line and opinion pieces.

Yellow journalism emphasizes sensationalism.

Social structure which supports the news.

News organizations and responsible behavior. Presumably, the details need to be specified better.

Role of the editor.

Journalistic Practices Covering a range of perspectives.

Anonymous sources.

Difficulty of providing object reporting (1.6.2).

Credibility is important for most publishers. Reputation (5.2.2). Reputation for providing unbiased information. Trusting the credibility of a publisher.

An honest broker has no stake either way in the outcome of a transaction. Honest broker of information.

Some of this is due to professionalism of the journalist. Reports should have multiple independent sources of news for confirmation. There is a need for independent observations. For instance, this helps to uncover corruption and abuse by government and organizational officials. Less investigative journalism because it is expensive and traditional news is being challenged by Internet publishing.

Nonetheless, news is subjective and news media have a great deal of influence over public discourse (8.4.3). Newspapers also serve a community information role beyond news reporting.

Policies and practices are helpful for effective freedom of the press [?]. Shield laws protect journalists from having to reveal their sources.

Journalistic ethics. Report conflict of interest.

Reporters may be told about an event but they generally can't be confident without additional evidence. Usually two sources are required. As an additional step in quality control, even simple assertions are double checked before are article goes to press.

Figure 8.87: There is some feedback about the accuracy of political commentary such as these indicators from politifact.com. Such fact checking itself is subjective. (check permission)

"Errata" also serve to establish good practices by showing allegiance to accuracy rather than image, and a desire to acknowledge mistakes in an effort to avoid them in the future.

Errata example.

Authority of sources. Reporters notes.

Political operatives posing as journalists.

Citizen Journalism

Citizens rather than professional journalists. Citizen journalism. Levels of integration of citizen journalism with traditional newspapers. Investigative crowd-sourcing. Hyper-local news blogs. Function of news. Providing information to citizens in society in a cheap way.

Blogs are commentary. Social media journalists.

Hyper-local news blog. Networks of local news blogs. Revenue sharing of blogs.

Bottom-up news stories. News and other content, generated by search.

People often turn to micro-blogs for updates about fast-breaking news stories.

Processing and Searching News Text

News is distinct from other types of content. Characteristics of a news search engine. News search (10.11.2). The content to be searched may change rapidly. Indeed, the reader's expectations about what should be returned by a search may be changing as the story develops. Very different from

Personalization of newspapers.

Figure 8.88: Media-space map for news. (check permission)

Production and Distribution of News

Newsroom workflow.

Effect of information technology on news. Twenty-four hour news cycle. The allows for a different type of access by viewers. Rather than accessing a newspaper once a day, the users can sample the news stream when they can.

News business models. News, many other mass information services has been supported by advertising. However, Internet distribution of news has changed the parameters of that model.

Broadcast news often does not handle complex issues very well. Video news release.

Writing stories to be highly ranked by news search engines.

Paper production versus electronic distribution. News provides information that can be of both personal and community interest. News services usually deliver data as soon as possible after the events they report occur; some content, such as daily cartoon strips, is of lower priority. News also has a social context. We depend on news outlets to maintain at least some objectivity in their reporting, based on the standards of journalism that have been established (1.4.3).

News agencies.

Streaming and morphing into content.

News as an example of dynamic content. Importance of news media that is independent from the government.

Preservation of news.

Business models for news. Paywall. Aggregators and search engines. Many-to-many distribution model.

8.13.8. Software Publishing and Distribution

Software is similar in many ways to other information resources. Like other information goods, it generally has a high fixed cost of development, low incremental costs (updates), and is easy to duplicate.

Apps as software distribution.

Software Licensing and Contracts

Software is a type of intellectual property and commercial software generally licensed. Beyond sales, software vendors have developed a strategy of selling a base system that needs customization. Thus, they get ongoing income from that customization and from are likely to improve lifecycle management.

Software may be protected by copyright and this is often used as the basis of software licensing agreements. Software companies use patents to protect their intellectual property (8.2.2).

Most commercial software is also protected by contracts when it is sold. A contract may allow one user at a time to access the software, or it may be a site license, which permits use by an entire facility. Digital rights management (DRM) (8.2.4). A variety of new mechanisms for accessing software are being developed. In a networked environment, software may be downloaded from the network as needed and may even be charged for on a per-use basis. This is determined with an End user licensing agreement (EULA).

Software development is techniques are described in (6.5.2). Locked down development platforms versus open development environments.

Open-Source Software

Open-source software goes beyond freeware in providing access to the source code. This makes it easily customizable. Because the software was distributed free in the first place, its creators (and all those who have modified it) wish to prohibit any one person from making a profit from it, To guarantee it remains open source, most open-source software has a license (Fig. 8.89) and this is similar to other types of commons movements (8.2.2, 10.3.2). Libre software and the four freedoms Fig. 8.90.

> You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program. You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

Figure 8.89: The first part of the GNU open-source software license and Gnu project open-source project logo. (check permission)

Free and open source software (FOSS). Open source software can be less vulnerable to bugs or embedded malicious software because each component of it can be inspected and discussed but it may have a slow and unpredictable development of new features. Non-monetary incentives. While this is an appealing

1.	The freedom to run the program for any purpose.
2.	The freedom to study how the program works, and change it to make it do what you wish.
3.	The freedom to redistribute copies so you can help your neighbor.
4.	The freedom to improve the program, and release your improvements (and modified versions in general) to the public, so that the whole community benefits.

Figure 8.90: Four senses in which software may be free [?].

model in many ways, it is impractical for complex large scale or time-critical projects. Some companies contribute their employees time to develop open source software. There is often some mix of open and closed software is projects. Ultimately open source may drive out closed-source software for some applications.

Indexing Software

Difficulty of finding code in a repository. Software libraries (7.9.3). Indexing software[54]. Reuse.

Software preservation (7.5.5).

8.14. Innovation

8.14.1. How Startups Work

8.14.2. Innovation Networks and Ecosystems

Innovation ecosystem. Silicon Valley as a culture of entrepreneurship. Silicon Valley. Based on entrepreneurship.

Entrepreneurial commons. Sharing ideas and resources in innovation. It has several aspects that make it unique. Accumulated know-how, infrastructure, and resources. This is also related to a industrial commons which is based on manufacturing. Concentration of parts in in a supply chain region.

Research and development (8.12.3).

Innovation is often motivated by competition. User-centered innovation groups. Role of a stable legal framework such as intellectual property. Business to develop ideas. Incubators and knowledge sharing.

Effects of factors such education and government support on innovation.

Role of information for encouraging innovation.

Synergies, specialization, and patents. Role of information resources. Bibliometrics on patents for telling us about innovations.

Open innovation. Management of innovation. Organized research laboratories. Supporting hunches.

Cities as Innovation Hubs

The world is not entirely flat (8.9.2)in terms of innovation. Some areas still have a distinct advantage. Specialization provides distinctive expertise and that allows for productive collaborations. People tend to be more collaborative in cities. The social networks are tighter. Can networked collaboration substitute for proximity. Critical mass.

Science parks, Communities of practice (5.8.2).

Innovation in emerging markets.

Entrepreneurship: Building a Business

Many businesses are built primarily with an idea which identifies a market niche and then hard work. Growing businesses, or businesses with grander ambitions often start with a business plan. Many information-based businesses are supported with venture capital. Building a business is a different challenge from running an ongoing business. Collecting resources. Return on Investment (ROI) Analysis of costs and return.

Fast fail.

Competitive advantage. Information systems have allowed the development of many new businesses. Being the first to develop a new product can give a "first mover advantage". For instance, there can be brand-specific training. However, being a first-moved is not always a great advantage because it often expends a lot of resources. Economy of scale. Protection of intellectual property (8.13.3). Introducing new products. Installed base.

Small business. Evolution of the business. Agency theory. Stewardship and succession.

Information entrepreneurs.

8.14.3. Creativity

People in innovation environments.

Serendipity (3.2.3).

8.15. Media

We have encountered aspects of media throughout this text. Like many other terms we have encountered, the term "media" is ambiguous. We will explore the transmission of information by different media in later chapters but here we consider general principles which apply across media. Information resources and entertainment. This is certainly not intended as an exhaustive overview of the topic. Media policy.

Media disseminates culture (5.8.2). Media spreads cohesion. We have already encountered many aspects of media such as the discussion of media and violence, (5.9.4) and media and imitation [67], and media business models. Media in this sense often refers to commercial media. Analyze the media industry (8.13.4).

Media focuses attention and amplifies individual messages. Persuasive power of the media. In part, this simply by the physical properties of the delivery medium. The relationship between the "medium and the message" [62]. Hot media. Surfing. Global village.

Media systems and the relationship between news media and the political systems in which they exist [**?**].

Why are people entertained by media. Infotainment. Media entertainment theory [10]. Coordinating and controlling publicity. The role of media in shaping public discourse (8.4.3).

Demassification of Media. The development of new information technology, particularly that of the World Wide Web, has increased citizen participation in media. It is now possible for a single individual, through their webpage or Blog, to reach an audience of literally millions of people every day. Conversely, it is also possible for a single person to access virtually any type of information source, from any location in the world. The "mass media," as it is commonly known, is a reference to the big media outlets. Traditionally, these organizations have competed with one another to be the main source of information for the country. This competition led to a particular type of demographic targeting — that of the "average" person.

The competition offered by the internet's ability to access a virtually infinite number of disparate news sources has led some to speculate about the decline of the mass media. While this decline may well have begun the mass media is still the primary source of news and information for most people. This is an aspect of "mass personalization". There are many ways of communicating to an audience, rather audience members can interact. Customization.

8.15.1. Media in People's Lives

Information Storm. Obsession with apparently trivial news items.

Television. Synergy of Internet and television Time shifted TV. Interactive TV services.

Syndication of TV shows.

Engagement with content.

8.15.2. Creativity and Content Ownership

Music. South Park.

Direct internet delivery.

Exercises

Short Definitions:

1^{st} Amendment, U.S. Constitution
4^{th} Amendment, U.S. Constitution
Academic freedom
Administration
Affordance
Aggregators
Auction
Business cycle
Business model
Business-to-business (B2B)
Case law
Cease and desist
Censorship
Clicks-and-mortar (retail)
Collusion (business)
Common carrier
Contract
Core competency
Copy identification
Critical path
Customer relationship management

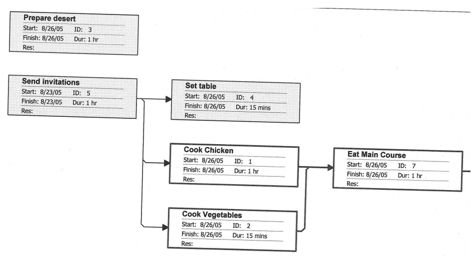
Derivative work
Digital Encryption Standard(DES)
Digital rights management
Disintermediation
Due process
Economies of scale
Elastic price
EULA
Externalities
Fair use
First sale
FOIA
Fraud
Freeware
Intellectual property
Information disaster
Infringement (copyright)
Just-in-time manufacturing
Knowledge economy
Knowledge market
Libel
Logistics
Macroeconomics
Market
Matrix management
Micro-payment
Moral right
Network effect
Open-Source Software
Orphan works
Parody
Piracy
Privacy
Productivity
Public domain
Public good
Public-key encryption
Public sector information systems
Rationality
Regulatory creep
Return on Investment
Reverse engineering
Royalty (copyright)
Slander
Social protocol
Steganography
Supply chain
Transaction cost
Watermark
Work-breakdown structure

Review Questions:

1. Do current U.S. intellectual property laws allow people to own facts? Explain. (8.2.0)
2. What are the four legally protected types of intellectual property in the U.S.? (8.2.0)
3. If you invented a new type of computer hardware, what type of intellectual property protection would be most appropriate for protecting it? (8.2.0)
4. What parts of a movie based on a traditional fairy tale can be copyrighted? (8.2.0)
5. Distinguish between plagiarism and copyright violation. Is every case of plagiarism a copyright violation? (5.12.3, 8.2.2)
6. How are intellectual property rights related to "terms and conditions" of use. (8.2.4)
7. Distinguish between "privacy" and "anonymity". (8.3.1)
8. Distinguish between "identification" and "authentication". (8.3.4, -A.13.1)
9. Describe some of the potential problems in electronic voting systems. (8.4.3)
10. What are some of the pros and cons of direct democracy? (8.4.3)
11. Describe your school's policy on the Internet access for students. (8.5.1)
12. Explain how "policy" is different from "law". (8.5.1)

13. What are some of the ways that information affects economics? (8.7.0)
14. How many combinations or pair-wise communication links are possible for a set of 10 people? (8.7.2)
15. Give additional examples for each of the cells of Table 8.45. (8.7.2)
16. Explain what we mean by different "types of money". What would happen if you couldn't trust any banks? (8.7.3)
17. (a) How do Web-based map and route finding services help to increase productivity. (b) Can you estimate how much they improved productivity? (8.8.1)
18. What is the productivity of a country for which the GDP is \$10B and 100M hours are worked per year? (8.8.1)
19. What are some ways information systems might improve productivity? What are some of the obstacles to getting potential productivity benefits from information systems? (8.8.1)
20. Are emotional responses rational? (4.6.0, 8.8.3)
21. Is everything a person does rational? After all, anything that person does can be taken to show subjective utility? (8.8.3)

22. Is rationality an ideal to be achieved or a description of what people actually do? (8.8.3)
23. Read a standards statement and discuss those pros and cons. (8.11.3)
24. What management strategies (8.11.1) might you adopt when
    a) you are developing a piece of software. b) merging two companies with different organizational cultures.
25. Would it make sense to run an automobile manufacturing plant with project management techniques? (8.11.3)
26. Calculate the slack time for the project shown in the following PERT chart: (8.11.3)



27. Distinguish between "management" and "administration", and "governance". (7.10.0, 8.11.4)
28. Describe some of the ways that information systems can streamline business processes. (8.12.5)
29. How is "marketing" different from "advertising"? (8.12.5)
30. Why is it important for a newspaper to clearly distinguish between news and paid advertisements? (8.13.7)

Short-Essays and Hand-Worked Problems:

1. Some countries seem to believe that economic development can occur without democracy. What do you think? (8.1.0)
2. To what extent would the following be protected by freedom of speech in the First Amendment? (8.1.0):
   a) Disrupting a speech by shouting down the speaker.
   b) Handing out leaflets inside a shopping mall without approval of the owner of the shopping mall.
3. Give an example of harm done from too tight control of information. Give an example of harm done from too lax control of information. (8.1.0)
4. Can a new dress design be protected by our current intellectual property laws? (8.2.0)
5. How are notions of intellectual property similar to or different from our notion of physical property? (8.2.0).
6. Describe what might happen if ideas, rather than the expression of those ideas, were allowed to be copyrighted.(8.2.2)
7. Take a position pro or con on the following statement: The duration of U.S. copyright protection should be extended from 100 years to 150 years. (8.2.2)
8. What are the difficulties in using copyright to protect novel computer chip designs? (8.2.2)
9. Find an example of an apparent copyright violation and judge it by the criterion of "fair use". (8.2.2)
10. In a recent case, a trademark was claimed for the phrase "fair and balanced" with respect to a news program. The claim was withdrawn. Why might that have happened? (8.2.2).
11. What are the pros and cons of compulsory licenses for copyrighted materials? (8.2.2).
12. How do privacy policies affect the information management in your organization? (7.3.1, 8.3.1)
13. What are the policies of your university or company regarding the privacy of your electronic communications and Web site access? (8.3.1)
14. List as many different databases as you can find in which your name included. (8.3.1)
15. Contrast the definition of privacy as "any unwanted intrusion" with the legal protection given by the Forth Amendment to the U.S. Constitution. (8.3.1)

16. What are some of the privacy concerns in the protection of medical records? Specifically, what privacy requirements would you want for patient data on a doctor's PDA? (8.3.1)
17. If you worked for a large company where you ran a server and you had no ethical or legal concerns, what data would you want to collect about a person's Internet usage to help you sell products to them? If you did have ethical concerns, what data would you collect? (8.3.1)
18. Because it is so easy to collect electronic information, it has been proposed that all information should be made public. Do you agree? (8.3.1)
19. How will you conduct a security audit of an electronic voting system? (7.10.3, 8.4.3)
20. What are some steps that you might take to enhance the chance for the acceptance of a policy? (8.5.1)
21. Describe how you would go about developing a policy managing the following information resource (8.5.1):
    Confidential plans for a new product to be developed by your company.
22. List four reasons in support and four reasons opposed to the following policy statements (8.5.1):
    a) There will always be inequality among people so the digital divide is inevitable.
    b) Information systems are a foundation for a modern society, therefore it should be a priority to introduce them in developing societies.
23. Are the following effective policy statements? Why or why not? (8.5.1):
    a) Automobiles should pay per mile for highway use. This should be accomplished with GIS-based location technologies.
    b)
24. Describe a Web page (or Web site) which would provide legal information for ordinary consumers. (8.5.4)
25. Is demand artificially distorted by advertising? (4.3.4, 8.7.2)
26. What are some of the ways freedom of information facilitates the elimination of political and economic corruption? (8.1.0, 8.4.1, 8.7.2)
27. Give an example of how supply and demand affect the value of information. (8.7.2)
28. Compare credit cards payments with micro-payments. (8.7.3)
29. If you were the manager of a corporation, what procedure would you adopt to determine the optimal level of spending on information systems? (8.8.1)
30. What are the difficulties of analysis of system as the sum of its components rather than as whole? (8.11.0)
31. How is "leadership" different from "management"? (8.11.0)
32. What are some of the advantages and limitations of matrix management? (8.11.1)
33. What documentation would be most useful for project management? (8.11.3)
34. What kind of organizational structure would be most appropriate for the following projects (5.7.1, 8.11.3):
    a) Research and Development.
    b) Manufacturing.
35. What types of information are conveyed by product branding? (5.2.2, 8.11.4)
36. What techniques would you employ to protect and develop a brand name? (5.2.2, 8.11.4)
37. What is the business model for a private university versus a public university? (8.11.4)
38. Why can supply chain management be difficult to implement effectively? (8.12.1)
39. Develop supply chain diagrams for (a) a light bulb and (b) a newspaper. (8.12.1)
40. Analyze B2B XML tools as socio-technical artifacts. (8.8.2, 8.12.4)
41. A project management effort requires a project team. If you worked for a bank, who would be logical members of a team to develop a lessons-learned database about problems with customer service requests? (8.11.3, 8.12.5)
42. Describe the considerations for a customer relationship management tool. What are some of the tradeoffs required? (8.12.5).
43. Suppose your job was to provide information resources for your workgroup. Investigate and report the licensing costs and conditions (8.13.3) for: (a) an online encyclopedia, (b) financial data that would be useful for competitive intelligence, (c) a digital library.
44. Public libraries in the U.S. are traditionally paid for by taxes. How could you measure whether there is a fair return on the taxes? What other strategies might there be for funding libraries? (7.9.0, 8.13.5)
45. A library fine for a traditional lending library serves to discourage patrons from keeping books out too long but too high a fine can eventually discourage a patron from returning the book at all. What would you argue is the level for a library fine in your town public library? (8.13.5)
46. Compare the way three different newspapers report a news story. What accounts for the difference? (8.13.7)
47. Why is metadata even more useful for software libraries than for text libraries? (2.4.0, 7.9.3, 8.13.8)
48. Why are "networking effects" important in software publishing. Give an example. (8.7.2, 8.13.8)
49. What policies are needed for a software company to manage different releases of its software. (8.13.8)

Practicum:

1. Establish business plan.
2. Describe the information flows and services in your own organization.
3. Pick a standards document. (a) Describe the standard it proposes. (b) Describe the possible pros and cons of the standard.

Going Beyond:

1. How would you measure the level of "freedom of information" in a society? (8.1.0)
2. Compare two countries in how they control information. (8.1.0)
3. Does freedom of information in markets necessarily lead to freedom of information in political systems? (8.1.0)
4. Although it allows some anti-social statements to be made, freedom of speech seems to lead to a stable society. Why is that? (8.1.0)
5. Should the concept of "first sale" apply to digital copies such as downloads of songs? (8.2.2)
6. What is optimal duration for copyright? (8.2.2).
7. How does the notion of copyright serving as an incentive to creativity fit with the number of years granted for that copyright? (8.2.2).
8. The concept of "fair use" is complicated when applied to electronic materials. Separate publications could apply fair use for distinct parts of the original work. These could then be re-synthesized back to the original document. Should the fair use provision be modified? (8.2.2)
9. Is a dress designer protected by intellectual property laws if somebody else makes a "knock-off" of a dress design?(8.2.2)
10. What would the implications be for consumers in the uncontrolled use of trademarks? (8.2.2)
11. It has been proposed that the principle of first sale should be abandon because it is so easy to make copies that the owners are likely to copy and resell a resource – effectively short-changing the creator of the resource. Do you agree this problem needs to be fixed? (8.2.2)
12. Explain how fair use could be managed by a digital rights management server. (8.2.2, 8.2.4)
13. Conduct a patent search. (8.2.2, 8.13.3)
14. Describe a digital watermark scheme. Implement it. Describe what sort of attacks it would prevent. (8.2.5)
15. Give an example of the need to balance between privacy and security concerns. (8.3.1)
16. How would society adapt if "privacy is dead"? (8.3.1).
17. How are principles of privacy affected by cultural traditions? (8.3.1)
18. In the United States, private companies can intercept the email of the employees but cannot tap the employee's telephone. What do you think the right balance should be? (8.3.1)
19. Given a budget of $50, determine how much personal information about yourself you could find on the Internet. (8.3.1)
20. Are video surveillance cameras effective at deterring crime? (8.3.3)
21. What is social justice? What is economic justice? (Give a definition, not an example.) (8.4.1)
22. Until about 1985, the U.S. Government tried to control encryption technologies. Why did it do that? Why did it stop? (8.4.1, -A.13.1)
23. In electronic voting the identity of the person who casts a ballot needs to be hidden. How can the be reconciled with the need to track and audit the system's performance? (8.4.3)
24. Write a statement for the use of the Web by your children. (8.5.1)
25. How can the regulatory process be corrupted? How can that corruption be minimized? (8.5.1).
26. Compare the efficiency in distributed computation and distributed control in economic systems? (7.7.1, 8.7.0)
27. How is speculation different from investment? (8.7.0)
28. Is economics a science? Do you agree with the economic principle that people act primarily in their self interest? (8.7.0, 9.2.1)
29. Relate the discussion of information system management to the application of externalities. (1.5.2, 8.7.2)
30. Does the stock market accurately reflect the value of companies list on it? (8.7.2)
31. Do markets encourage honesty in companies to encourage the trust of investors? (8.7.2)
32. If markets are facilitated by freedom of information, what are the economic consequences of authoritarian governments which control information. (8.7.2)
33. The government is generally not as efficient as commercial businesses. Why is that? (8.7.2)
34. Should all tickets for entertainment events be sold by auction (8.7.2)
35. What has the effect of the Web been for travel agents? Has there been a similar impact on real-estate agents? Why is there a difference? (8.7.2)
36. Should money reflect social value? How could it be made better at doing this? (8.7.3)
37. Identify and explain a digital payment system *not* described in this book. (8.7.3)
38. How important in a stable economic system for individuals? What factors make the system stable? (8.7.4)

39. Find the productivity rates for three other countries than the U.S. Propose why you think there are differences. (8.8.1)
40. Is it rational to be altruistic? (8.8.3)
41. How is the management of for profit businesses different from the management of not-for-profit organizations? (8.11.0)
42. Explain how procedures for managing complexity apply to organization design and re-engineering. (7.7.1, 8.11.2)
43. Compare the procedures and strategies of BPM and TQM. (8.11.2)
44. Develop a business model for an information service or Website. (8.13.5)
45. Print, read, and comment on an end-user software license. (8.13.8)
46. A popular business model for software companies around 1990 was to stimulate demand by giving away one component (e.g., a web browser) and then charge for the server. Compare the success of Adobe and its distribution of Acrobat and Netscape with its Web browser. (8.13.8)
47. What are the pros and cons of the open-source software model? (8.13.8)
48. Open source software appears to violate profit-oriented business practices. Why is that? (8.13.8)
49. If the knowledge economy is robust? How concerned should we be about to decline of manufacturing jobs? (8.13.8)
50. Should universities ever block content on the Web from students and staff? (8.1.3, 8.13.2)

Teaching Notes

Objectives and Skills: The chapter introduces social and policy issues that relate to information systems. These include a discussion of business models and intellectual property.

Instructor Strategies: This long chapter could be split into two sections: social policy and issues (Sections 8.1 to 8.4) and economics (Sections 8.5 to 8.9)

Related Books

- Alvarez, R.M., and Hall, T. *Electronic Elections: The Perils and Promises of Digital Democracy.* Princeton University Press, Princeton NJ, 2008.
- Anderson, D.M., Ed. *The Civic Web: Online Politics and Democratic Values.* Rowman and Littlefield, Lanham MD, 2002.
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- Burns, E. *All the News Unfit to Print: How Things Were... and How They Were Reported.* Wiley, New York, 2009.
- Camp, L.J. *Trust and Risk in Internet Commerce.* MIT Press, Cambridge MA, 2001.
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- Friedman, T. *The World is Flat: A Brief History of the Twenty-first Century.* Farrar, Straus, and Giroux, New York, 2005.
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- Perez, C. *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages.* Edward Elgar Press, Cheltenham UK, 2003.
- Razgaitis, R. *Valuation and Pricing of Technology-based Intellectual Property.* Wiley, New York, 2003.
- Schon, D.A., Sanyd, B., and Mitchell, W.J. *High-Technology and Low Income.* MIT Press, Cambridge MA, 1999.
- Steiglitz, K. *Snipers, Shills, and Sharks: eBay and Human Behavior.* Princeton University Press, Princeton NJ, 2007
- Sullivan N.P. *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy.* Jossey Bass, Indianapolis IN, 2007.

Chapter 9.
Scholarship, Science, Simulation, Scholarly Data Sets, and Domain Informatics

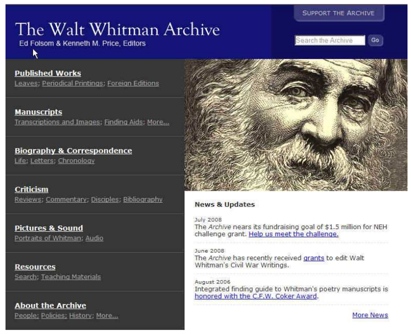

Figure 9.1: Walt Whitman Digital Archive (just upper portion) (check permission).

Scholarship is generally based on thoughtful, systematic investigations. Such reflection can appear overly dry but it has a role in ensuring carefully evaluation of complex issues. It uses a cumulative body of knowledge to develop new interpretations. Content-specific issues dominate. Science is one approach to scholarship which we examine in the next section. Formal information seeking everyday or citizen information seeking. Personal scientists. Data management as a type of library. This is how society captures knowledge. Institutions for collecting and organizing knowledge. Domain informatics.

9.1. Scholarship

Scholarship and science help get the right answer to difficult problems. Potentially, it can detect and understand broad trends. Both depend on systematic development and management of information. This can be thought of as critical thinking (5.12.0). Knowledge institutions especially universities (8.13.2). Although scholarship is often described as an ivory tower, it generally does aim to have an impact on societal issues. STS (9.4.0) and the social context of scholarship. Scholarship often comes with particularly high standards for identifying challenging problems and for evidence that addresses them.

9.1.1. Scholarly Communities and Communication

Scholarship can be solitary but the results of even individual scholarship eventually need to be disseminated to the broader community. Indeed, solutions to many complex issues are probably possible only by an ongoing scholarly discourse. Scholarly communities are communities of practice (5.8.2). Indeed, because scholarship emphasizes the value of ideas many scholarly communities have a norm of minimizing other marks of social status.

They are also particularly information intensive and focus on documenting their work through scholarly literature. The nature of scholarship, that of an empirically based presentation of intellectual work, requires a rigorous presentation and also a relatively free exchange of ideas. The publication of this work, by institutions both public and private, is at the same time the culmination of individual scholarship and the motor that drives it. Scholarship, be it in science or the humanities, is a highly collaborative endeavor. It is rare (and perhaps impossible) for scholarship to be completely new, and to not use assumptions or facts based on the work of past or present colleagues in the field. No document stands on its own — it is only by referencing the work of others that any validity is conferred. Published scholarly work contains footnotes and citations that link to previous relevant findings. Publish or perish.

Although the creation of scholarly material may be done alone, when it is completed, it is shared with a community. In that community, scholarship is a cultural value. Associations of scholars are known as "learned societies". Scholarly communities can uphold ethical and quality standards. They may encourage data sharing but this must be balanced by constraints such as intellectual property rights and security. Scholarly organizations support the values of the profession (5.8.2).

Specialized descriptive systems and catalogs.

Academic honesty. One example is plagiarism (5.12.3). Scholars have ethics. These may range from citing previous research to not stealing other researcher's findings.

Universities' role as a knowledge institution (8.13.2). Scientific disciplines have different cultures.

Characteristics of Scholarly Publishing

Scholarly literature seeks to promote the scholarship of a given field. Thus, it needs to be clear and to reflect the standards of the scholarly community. Scholarship is cumulative; it builds on recording and sharing previous work. Scholarly publishing is the traditional approach way for sharing knowledge. Thus, there is a cycle of production and distribution of knowledge. Value proposition in terms of how literature supports future research. One of the main goals of scholarly activity is to disseminate advances in the field. Thus, scholarly conferences and publications are an integral aspect of scholarship. Reuse of scientific results.

Scholarly articles are summaries of the major points about research.

Range of types of communication: From classes to presentations to dissertations to books to research reports. Academic libraries (7.2.1).

Style: Maximize clarity. Avoid philosophy.

Even scientists are often less that forthright about admitting the limitations for their research.

These publications are often distributed as "proceedings" or "communications". to the work of "epistemic communities" [26]. Digital resources in scholarship. Academic libraries (7.2.1).

Contributions to scholarship should be original work which make a new contribution. The data speak for themselves, the paper should use a neutral tone. For instance, avoid honorary titles. That work would be published is published in the primary literature.

Who owns the copyright and publication in multiple venues such as arXiv.org

Scholarship and publication is confounded with implications for tenure and job security.

Standards of authorship. Inclusion as an author implies that the person has made a substantial contribution to the work.

Expectations for scholarly work to be published. Substantial contribution, original, novel. Nonetheless, there can be incorrect information but replication of the procedure can detect that.

Scientific commons. Scientific social media. Scholarly annotations. Systematic policies.

Controlling the community of editors to an extent. Published but not peer reviewed. Supporting scholarship with scholarly commons. Alternatives to peer review such as community reviews.

To a surprising extent, there are differences in the conventions in scholarly communities. Physicists use online publishing but chemists use journals. There are distinct norms within the different scholarly communities.

Beyond the traditional research report, there are many other types of scientific writing. Secondary Scholarly Literature magazines, textbooks, encyclopedias. As with journalism, for this material, the reputation of the publisher is in selecting quality material even its technical content is not reviewed

Figure 9.2: SSRN and arXiv are two well-known pre-print repositories.

There are also, unpublished works such as grant proposals. If publications are are written for a non-official purpose or destination and not peer reviewed, they are considered "gray literature," and are not accorded as much trust as peer-reviewed literature.

Material which has not been formally reviewed is known as gray literature although that distinction is becoming less distinct as more publication options are becoming available.

Scholarly Publishing and Scholarly Digital Libraries

Acceptance for publication confers status on a publication as being an important contribution. Content selection is based purely on merit. There should be no financial consideration. If advertising appears at all, it should be clearly separated from the text. These are derived from the core values of scholarly communities. Electronic resources may have more impact because they are more widely available.

Prior to publication most formal scholarly literature is reviewed Or refereed by independent readers. Reviews check that a scholarly contribution is made. Fig. 9.3. The most common approach is blind reviewing in which the author is known to the reviewers but the reviewers are not know to the author. In some cases, double-blind reviewing is used. In this technique, neither the authors nor the reviewers are supposed to know each other's identities. However, it is often easy to guess authorship of technical work even if the authors' names are not included. Systems to support reviews.

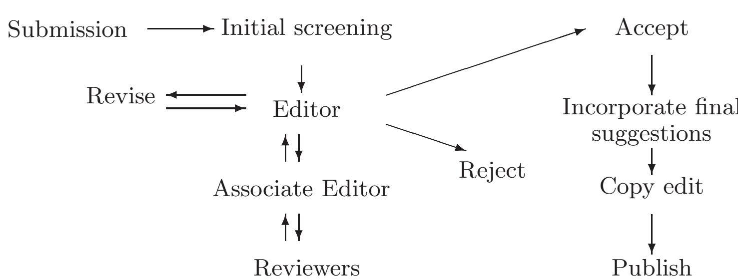

Figure 9.3: Schematic of a typical peer-review process for a scholarly publication.

Trust in a publisher's brand is often a factor in acquisition and use of an information resource. In a brader sense, the review process is a system for certification by the scientific community. It is often difficult to find expert reviewers for highly technical work because there are only a few experts. As a result, the only competent reviews are other researchers — the peers of the scholar — so we say that the work is be peer reviewed. While there is sometimes criticism of peer review because it appears that a small club is rewarding itself, there seems to be no better way to make these decisions. Group consensus and gaming detection mechanisms.

HIVE project[37].

Business Models for Scholarly Publishing and Digital Libraries The business models for scholarly publications are changing rapidly. Information systems have dramatically changed the production and distribution of books. Because of the costs of production have been reduced so dramatically that prices are reduced. On one hand, scholarly research is generally created in response to the expectation that scholars will communicate their research. On the other hand, its distribution may be restricted by copyright. Open Access Publishing. Make scholarly, especially scientific, reports freely available to the public. One example is the Public Library of Science (PLOS) which employs an "author-pays" business model (Fig. 9.4). Earlier, we discussed business models for publishing (8.13.5). Feedback to publishers for the design of publication. Difficult to evaluate the value of scholarly research. Information economics (8.13.3). Alternative sources of value from one's knowledge work.

Figure 9.4: The Public Library of Science (PLOS) is an open access collection of medical and biological articles.

Evidence for long-term viability of open-access publications. Because scholarly literature supports scholarly communities, it can be thought of as a type of knowledge commons.

However, some publishers also require transfer of the copyright from the authors. And, increasingly, articles are only available online as part of publisher's digital library. The costs for access to those articles can be very expensive.

Scholarly communities and community-run journals. This collaboration serves to create an extensive community of practice, as scholars share ideas, give commentary, and suggest possibilities for more research. They are also useful for education. Publishing authors begin to develop a niche for themselves within their larger field. Sometimes that niche becomes polarized by two vying epistemic communities with competing theories. Other times there is a sort of community consensus about what lies within the norm of current thought, with each publication building from those that have gone before it. This ubiquitous and extensive interconnection of articles and ideas can provide intriguing insight into a given discipline or topic.

Scholars Workbench. Query management system.

Scholarly communities and publications exist in the context of institutions such as universities and libraries.

Is there a citation advantage for materials which are published in open access, online repositories?

9.1.2. Citations and Citation Analysis

Scholarship is cumulative. Scholarship requires providing evidence for claims. That evidence is provided by citations to prior work.

There are many reasons for citations but at some reflect the author's decisions about the orientation and emphasis of the research. Taken collectively, citations across the works in a field can characterize the values, influences and directions of that field. Analysis of the scholarly literature. It provides context and continuity for new contributions. It also provides us with a view of community.

There is a strong similarity between citations links and Web links (2.6.3).

A "citation index" can be particularly effective for researching a complex topic — the report could list all studies published in the past two years that contain a particular reference. The importance or impact of an individual work can also be determined by analyzing the number of times it has been referenced, similar to the ranking of Web pages on the Internet (2.6.3). [80] [18]

Citations support literature searching which we discussed earlier (3.3.1).

Citations are used by authors to indicate the intellectual foundations for scholarship. Citations link scholarly articles to previously published articles on related topics. However, the judgment about what citations to include is somewhat subjective; thus they may reveal something about the process and logic of science. They can show who is publishing in what fields and reveal communities of scholars who are doing related work. The existence of these communities of practice notable in peer-review.

Scholarship is cumulative and citations in articles provide links to documents published in the past. Citations can be an indication of similarity of documents. A better strategy for analyzing citations compares works which are cited together. This provides much richer data than simple citation analysis [?, ?]. Another strategy also includes links among authors. This leads to author co-citation analysis as compared to document co-citation.

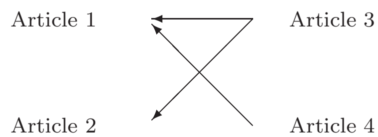

Figure 9.5: It is helpful to have a measure for how similar two articles are to each other. One way is by analyzing citation links. One measure is similarity is bibliographic coupling. Article 1 is cited by 3 and 4 so we say that 3 and 4 and similar. Articles 1 and 2 show a co-citation relationship with Article 3 It turns out that the co-citation measure is better than bibliographic coupling. (under construction)

Citation roles and types.

Citation analysis looks at the reference lists of published academic articles to determine if there are inherent patterns to what is cited, in what subject area, and with what other references. Analysis of this variety uncovers relationships between whole academic fields as well as specific subject areas. Citation analysis is related to bibliometrics in that it seeks to quantitatively study a vast bulk of information.

Citations and social networks[81]. Citations may also be used as an indicator of the rich social network in science. Co-authorship as an indication of collaboration. Small-world networks for co-authorship. Citation context can suggest relevant local information[66]. Author-topic models.

Citations across disciplines (8.13.2).

Finding Undiscovered Public Knowledge

Presumably, there are many important findings remaining to be found by combining knowledge which is recoded in books and journals. Typically, a researcher creates a hypothesis by being familiar with the current state of research in a given area of study. This requires familiarity with the literature. which in no way excludes the other, is by being familiar with that area's research literature. The development of automated data-mining techniques has revealed important, but previously unnoticed, relationships among concepts. An unsuspected relationship between magnesium and migraine headaches[76] was determined entirely from citation analysis in the literature. This connection was confirmed by subsequent medical research. These are bibliographically disconnected literatures.

The first step could be identifying important concepts (10.5.3). Without full knowledge extraction, we may still be able to make some useful inferences from factors such as patterns of citations. As an example: Fish oil. Undiscovered public knowledge (Fig. 9.6). If we find evidence in the literature which suggests that there is an association such that A causes B and B causes C then we may believe it is worth investigating whether A causes C.

9.1.3. Bibliometrics

Bibliometrics is, literally, counting things about books and other information resources. It often deals with characteristics of the authors or publishers. It can include counts such as circulation for printed materials or hits on web pages. Scimetircs ((sec:scimetrics)).

Figure 9.6: There may be "undiscovered public knowledge" can we actually merge facts from one domain into another. In a classic example, research about the effects of calcium on headaches can be applied to the hypotheses about the effects of magnesium (which is chemically related to calcium) on headaches. (Magnesium as a calcium blocker) (check)

h-measure.

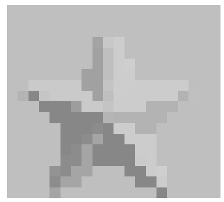

Figure 9.7: Google Scholar.

Measures derived from collections of citations may have several implications. For instance they are often used as indicators of scholarly productivity and impact. Zipf's Law.

Bibliometrics is often used to analyze trends within a discipline, or even the emergence of a new field. Mining citations.

Impact Factors

Impact factor. Who are the most commonly cited authors? Bibliometrics can also provide measures of the cohesion of scholarly communities (cf., -A.3.5).

Measuring impact of research with the number of papers which cite it. Counting citations. While citations are generally a positive indicator of quality, they are not satisfactory as a primary indicator. Citation counts are not very effective at predicting Nobel Prize winners among scientists[68]. Indeed, some papers which turn out to be highly influential are often not widely cited when they first appear. Citation counts have been proposed as a measure of quality of linking but they are not clear predictors. This raises the broader question of what are valid metrics of scholarly activity.

Earlier, we discussed the rate of change of individual documents. Bibliometrics can provide an indication of the evolution of a scholarly field. We may see changes in citation frequency. Note the pivot points (Fig. 9.8). Transition points between networks sub-graphs of the network. Rapid development in a field and the stability of co-citations[2]. Time-series visualization. Network Visualization. Pathfinder networks. Citation analysis and topic tracking (10.11.2). Burstiness as a sign of the rate of change in a field. Cumulatively, citations should be able to tell us about the intellectual underpinnings of a field. Interactive visualization tools. Citations can become symbols for concepts. Visualizations to support literature-related discovery.

Scholarly journals are the main path for distributing scholarly work. Some scholarly journals consistently have more impact than others. With a limited budget, we would prefer to access those publications with a high impact. We would like indicators of these publications' impact (Eq. 9.1). While we would hope that journal impact is related to broader societal impact, that is often not the case.

$$Journal\ Impact = \frac{number\ of\ citations\ to\ the\ journal\ from\ all\ sources}{number\ of\ articles\ published\ by\ the\ journal} \tag{9.1}$$

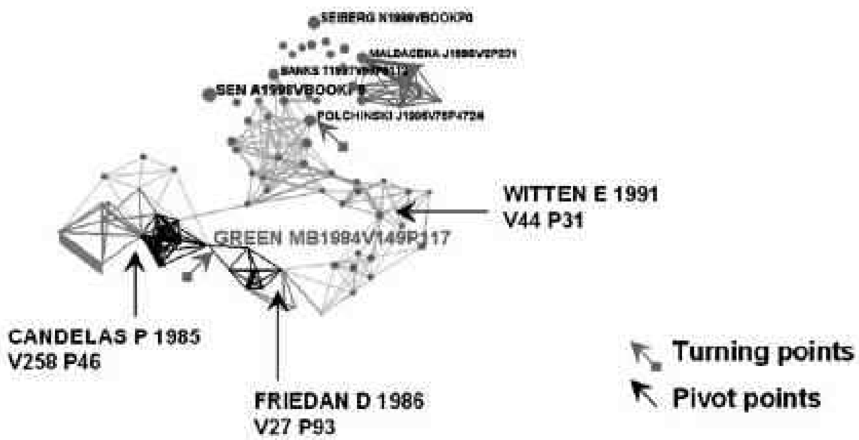

Figure 9.8: Citations networks can provide maps of a scholarly field. Networks of citations can suggest the evolution of a scholarly field[27]. Here we see clusters of research and transitions to new areas of research. (check permission)

Furthermore, there is a decreasing value of journals for a given researcher. Bradford's law. It is similar to the PageRank calculations for determining the importance of Web sites (10.10.2).

9.1.4. Research Space

Managing digital scholarship. Commons.

RDF triples for explantions.

9.2. Science

Science as a outcome or as a process. Science is a specific type of scholarship. Science develops statements about entities in the world and relationships among the entities. Furthermore, it applies specific criteria to those statements. Statements should be as general as possible but also as simple as possible. They should also be consistent with other scientific statements and falsifiable. Finally, they may be supported by interference but ultimately by experimental evidence. These properties give science distinctive characteristics. For instance, history also tries to make causal statements but there is no way to replicate the phenomena it studies. In addition, the activity of science should be distinguished from the informal use of the tern science as the theories that have been developed rather than about the process of discovering and modifying them.

Values of science activity[50]. Encouraging communication of results. Conflict of interest. Increasingly, politicians seem to be manipulating but the public's perception of science and even the reported science.

Science as practical art. Science allows us to manipulate the world.

9.2.1. The Scope of Science

Natural Science

In natural science, it's common to assume that the most valid observations are based on our senses. Models are built based on those sensory experiences and ideally, the models are tested by further observation. Thus science is distinguished from faith which is not confirmed by observation. Integral to the "Age of Reason".

Behavioral, and Social Science and Humanities

Natural science has been particularly effective in developing models and abstractions for the physical world. Behavioral science is based on consistencies in behavior. It has been less effective for describing human social behavior. As we have discussed, social phenomena are much more complex and adaptive than natural systems. Indeed, social phenomena can be considered as an emergent and not readily derivable from the underlying natural processes.

The value of social science in relationship to natural science is has been the subject of so-called "science wars"[57]. One possibility for social science is to develop grounded theories[35] rather than trying to do hypothesis testing. Separation by levels of complexity. Social science has many epiphenomenon. Social science hypotheses sometimes do not allow falsification. Social science as understanding the nature and patterns of complex social systems. Nature of social science constructs. Increasingly, science includes understanding and modeling complex systems.

Thus, it is much more difficult to capture regularities for social systems. For instance, economics is sometimes called a "dismal science." Certainly, social activity appears to be very different from natural phenomena because human beings are highly adaptable and often unpredictable. As we have seen, many aspects of social systems are mutable. There is a debate about whether social science should attempt to identify isolated causal factors as compared to factors which are part of a broader milieu. Is the notion of causation in social science socially constructed?

Is an empirical social science possible? Causation in social science[64]. Moreover, its very difficult to do experiments in the same ways they are done in natural science. Social science addresses the variability in human behavior by trying to focus on those situations in which human behavior is relatively consistent and even then by statistical analyses[23]. Thus, explanations of human social organization need different sorts of models. Typically, social science is based on statistical testing.

Social science described with activity theory. Qualitative research. Subjective vs. intersubjective evidence.

Unlike areas of humanities such as history (5.13.0), science depends on the replicability of its effects.

9.2.2. Scientific Knowledge: Properties, Laws, and Models

There are many ways we know things, such as listening to others but science supports a more systematic investigation. Perhaps we also develop models of the world (4.4.4). Science generally tries to develop conceptual models of the phenomenon under investigation. A wide variety of phenomena are under study. For instance, medical science models complex processes and systems. On the other hand, systematic science-like analysis is applied by detectives. A paradigm is a body of scientific knowledge, not just one model. Standard theory for science. Science as developing new frames.

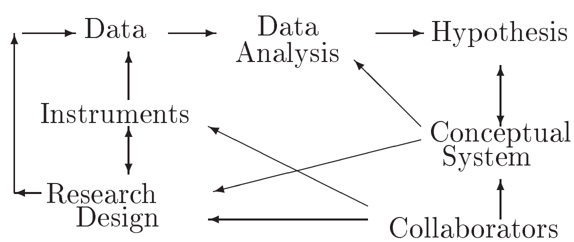

Figure 9.9: Many factors contribute to effective scientific inference (adapted from[79]). (check permission)

Scientific Laws and Models

Science as developing descriptions about entity classes. This often means developing models. Models are not reality. Scientific explanations. Discrete or continuous models. Entities/Systems and Interactions/Processes.

Laws are regularities with a broad application profile.

Accepted scientific explanations may change. Isaac Newton's models of gravity were replaced by Einstein's (Fig. 9.11) as described below.

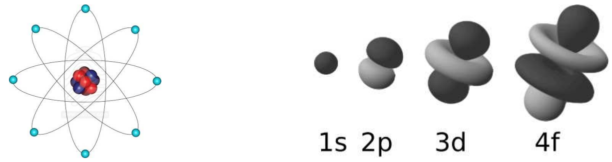

Figure 9.10: Two conceptual models of atoms: The Bohr model (left) and the quantum model (right) which is derived from quantum equations (redraw) (check permission)

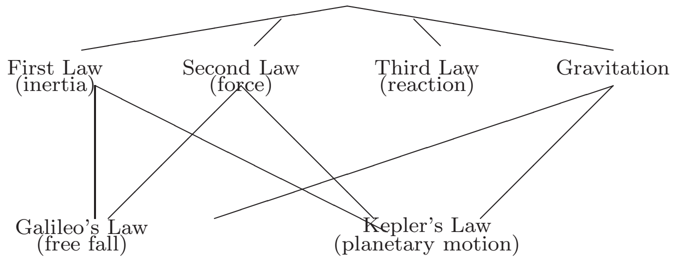

Figure 9.11: Explanatory coherence for Newton's Laws (from[78]). The set of Laws neatly covers commonly observed phenomena. (check permission)

Models may provide conceptual frameworks and science depends on developing conceptual models. These are often causal models. Models are also be useful for formulate new hypotheses (Fig. **??**).

Describe the entity classes and the relationships among them. Theories, Laws, and Models. Conjecture, Hypothesis, Theory, Law, Constants. Not all research is hypothesis testing. Because they are at the highest level, scientific laws (constants) do not have an explanation; rather, they are assumed to be true. Pre-causal models.

Equations and logic as models. For instance, Newton's F=MA

Process Models for Science The development of new scientific models is a creative activity. Cognition and the development of models such as reasoning by analogy (4.3.4). There has to be a base of knowledge and experience in a field. In other cases, models develop from a systematic search for evidence.

Reductionism proposes that complex phenomena can be described by appeal to low-level underlying processes. A reductionist would explain biology entirely in terms underlying chemical and physical processes. Reductionism avoids appeals to emergent phenomena. Minimize the number of assumptions.

Science attempts to develop more detailed and also more general models. Science as sense-making. Increasingly, rich and inter-related models are preferred over separate, equally adequate models. This is a principle known as Occam's Razor. However, there may be disagreement about what is superfluous. Indeed, scientific paradigms are often composed of complex interlocking assumptions and there may be an ongoing debate about them.

Scientific Explanations

Explanation versus modeling versus causation. Explanation (6.3.4).

Abstractions and generalization. Role of causality in exaplanations. Causation versus mechanisms. Science explanations as building models for abstractions. Different from explanations of history (11.3.3).

Explanations based on laws.

Functional explanations.

How do we decide what is pseudoscience?.

Is causation needed for scientific explanation? Problem of explanation and quantum theory.

Semantic technologies are also relevant. Importance of how entities are defined and how they relate to models. This is seen directly in taxonomy. Analogical models can be helpful (4.3.4).

Hypothesis generation. Undiscovered public knowledge (9.1.2). Mining scholarly literature text and citation linkages.

Causation in Science

9.2.3. Evidence for Science

What is adequate evidence to accept a theory?

Examples of accidental discoveries. Even more subtly, we might try to develop metrics for the quality of science.

Experimentation. Antropology. Astronomy,

Research designs versus research methods. Scientific research methods are often aligned with given disciplines (8.13.2).

Scientific research reports as creating a research space and staking a claim [75]. Science as deduction vs as argumentation (6.3.5). There are aspects of both. Operational definition. Testable hypotheses. Science is based on evidence and potentially every scientific generalization is disconfirmable[58]. Negative results. Fasifiability. How much evidence is needed to disconfirm especially if a finding does not match a popular model. Acceptance requires replicability.

Thought experiment. However, counterfactuals can get convoluted. For the purposes of developing models. Reasoning about expectations. Retrodiction.

What is a plausible relationship between data and a hypothesis. Depends on the paradigm. Handling anomalies. Fig. 9.12

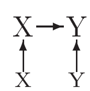

Figure 9.12: Causal model with observations. The observations do not perfectly reflect the actual concepts.

Scientific method. Scientific induction. Induction and abduction (-A.7.1)/ Abduction, for instance about the fossil record. Statistical tests of hypotheses.

Bacon and experiments. Fisher and randomized control.

Volunteers collecting observations and networking the results of those observations. Citizen cyber-science.

Science is a human activity, as such it is susceptible to human frailty. Scientific fraud. Systematic attacks science by publishing and promoting dubious research.

Scientific explanations. Could something happen versus does it explain a given situation. Amount of variance accounted for by an effect

Science is never settled. What does it mean that a model is accepted. How much proof is required. Acceptance of some scientific theories is often a matter of consensus, sometimes by scientific review panels, but in other cases it simply the judgment of individuals. Indeed, the norms of science encourage the minimization of social gamesmanship in the interest of letting data stand on its own (9.2.0). For instance, the use of honorary titles may be discouraged.

Using the Scientific Literature

This is an aspect of scientist information behavior. Science and information systems. Tacit knowledge in science (7.3.4). Collaboration among scientists (9.2.3). Scientist's use of journals (9.2.3). Scholars and scientists are demanding users of information resources. As we have noted, scholarship and science are interactive activities. Many scientists spend hours reading[77]. Keeping up with field. Examples of information use (1.4.3). Science-related information tasks [**?**]. Current awareness (2.5.5). There are marked differences across disciplines in the patterns of using information.

More broadly, supporting discover.

Bench science. Laboratory life[44]. Collaboration in scientific groups as a community of practice (5.8.2). Workflow in science. Scientific process automation. Virtual laboratories typically provide platforms for access to data sets and tools often associated with those the domain which the data represent.

d

9.2.4. Scientific Collaboration and Communities

Science is a social activity in several senses. This is reflected in multi-author and often, multi-institution, publications. Joint authorship in citations. Co-citation networks may show schools of thought (9.1.2). Scientific communities are a type of scholarly community (9.1.1). Social structure of science research. Distributed research teams. Aspects of science communication[45]. Scientists from various fields differ considerably in their willingness to share data with colleagues.

Scientific Communities

Disciplines. Interdisciplinary interfaces.

Conceptual revolutions are generally changes of conceptual frameworks. There often seems to be a tipping point where many scientists change the conceptual models they apply. Such tipping points have been termed paradigm shifts. However, it remain unclear whether such paradigm shifts are the result of a rational consensus, or generational changes. Indeed, are many cases in which paradigm shifts are led by older scientists.

Scholarship evolves as new ideas are introduced. In some cases, that evolution seems to be the result of a paradigm shift[41]. We can see the transitions in the visualization of citation networks. One way to analyze the patterns is to analyze how scholarship is done. Scientific thinking evolves. Sometimes rather than gradual changes, there are dramatic paradigm shifts[41]. The shift in physics from the Bohr atom to the quantum model. Or the shift of psychology from field theory to computation models of cognition (4.5.2). Bernoulli principle and airplane flight. Thinking in physics changed dramatically from Newtonian determinism with the acceptance of quantum mechanics which is probabilistic. Causes of ulcers.

Scientific models follow trends in information processing[25].

Scientific Communication and Publishing

The primary goal of scientific publishing is the dissemination of findings. Science writing should present a clear description of the claims persuasion but maybe this should be viewed as persuasion by logic.

All scholarly publications have standardized discourse structures, but these are especially pronounced for scientific publications. Discourse in science articles (6.3.2). The most common Genre Template is Introduction, Methods, Results, Discussion (IMRD)[75]. Scientific argumentation versus deduction and hypothesis testing. Discourse in academic lectures. Research genres.

Functional units of language and tasks CARS model for introduction to scientific articles [**?**]. Applied by the author to persuade the reader. Linking to entities and to models. Module reuse in scientific publishing. Model-oriented scientific research reports[20].

Coordinating vocabularies across disciplines.

Scientist's workbenches. Tools to understand research fronts. Exploratory search.

Collaboratories

Research groups can be tightly interwoven collaborative teams. Indeed, the tacit knowledge of procedures in often difficult to transplant. It is often most efficient for a member of the team to move from to a new laboratory. Exchange of samples, methods, and data among researchers. However, there is also competition.

Teams may collaborate on complex scientific problems. Facilities which support collaboration are sometimes called collaboratories (Fig. 9.13).

Figure 9.13: Astrophysics Simulation Collaboratory Portal.

Citizen Science

Citizen data collection. Crowdsourcing science. Concern with data quality.s

Increased public information and computational resources means that significant data analysis can be done by citizens. Moreover, individuals may also have strong motivation to conduct research (for instance a parent may have a child with a disease). This gets to the question of who is qualified to do science. There are issues of the reliability of data and sophistication of the analyses.

9.3. Measurements and Instrumentation

Recall that in science, it's common to assume that most valid observations are based on our senses. This is not to say that our senses can't be fooled

For science and commerce. Testing laboratories. Certification of testing laboratories.

9.3.1. Measuring Things (Metrology)

Metrology is the study of making measurements. Accurate measurement is important in areas such as business and science. When you buy gasoline or meat at a butcher you rely on the scales.

Scaling (-A.11.2). Accuracy and precision.

Sensors (-A.19.0). Data collection from instruments and calibration of those instruments to ensure accuracy. Measurements are inherently inexact.

Standard weights and measures.

Tracability.

Measurement theory and scaling for social science.

9.3.2. Instruments

Technology has a great effect on the advancement of science. Instruments for basic measurements. Should be consistent across environments. easy to use. Thermometer. Record keeping for calibrations and settings. Social science instruments such as surveys.

Role of networking in coordinating data from different instruments.

The availability of instruments to collectn data in specific ways helps to shape the focus of research and, thus, the nature of knowledge. Highly distributed sensors as a new type of measurment instrument.

Figure 9.14: Thermometer (left) and beam balance (right). (check permission)

Science often requires measuring unusual properties in unusual conditions So, special instruments need to be developed.

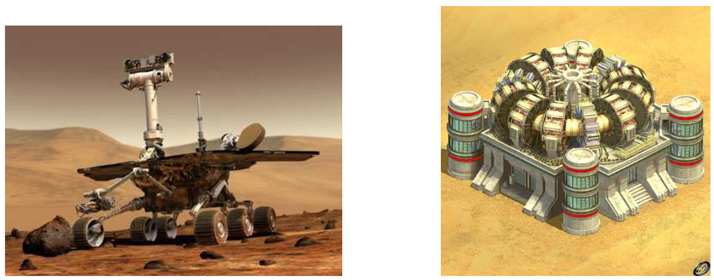

Figure 9.15: Advances in instrumentation often lead to advances in science: Mars rover (left) and supercollider (right). (check permission)

Automating exploration of a large space of parameters.

Sensors as instruments.

9.3.3. Laboratory Notebooks and Integrated Research Data Management

Laboratory notebooks. Notebooks and open notebooks. Tools to help scientists manage their data (9.6.0). Records, audits, and preservation. Ensuring patent right. Laboratory notebooks as part of an ecology of information genres for scientists.

Scientific workflow provenance.

Open science. Open notebook science Fig. ??. Laboratory notebooks as blogs.

9.4. Science, Technology, and Society

Science and technology interact with society. Among other things, science often studies things which are socially important. Development of socially important knowledge.

9.4.1. Science and Society

Science generally serves social needs. Science is a social activity [28] [45]. Science and technology have transformed society. Boundary between politics and science. Science education (5.11.5). More than a socio-technical system.

Social construction of scientific knowledge.

Within scientific disciplines ad hoc groups may emerge to address more specific issues. These are effectively communities of practice (5.8.2). they emerge, develop structure, assign roles, and use language through stages [?]. Medicine.

What social structures lead to the a science-oriented society. The Age of Reason. The Enlightenment.

Broader social value of science and of the other hand, the problem of not having data available. How social values may determine scientific frameworks [**?**]

Society and social science.

Using unsettled science not only for policy but also to sway public opinion.

Because science can be highly effective it can be persuasive. Indeed, we have many calls for "evidence-based" However, the results of science may take a while to be settled and social science results are often particularly contentious. Moreover, individual scientific results may be grabbed by the media as though the were settled and widely accepted.

9.4.2. Science and Technology Policy

Science and technology are so integral to society that science policy is developed. Encouraging commercialization. Ideally, patents (8.2.2) encourage development of commercially valuable technologies. Incubators. Innovation.

Images of computing technology. Technology and humanity.

Funding for science

Funding agencies.

Report possible conflict of interest which might bais research outcomes. There are a variety of mechanisms for science funding and feedback into societal needs.

There are large differences in funding for different areas of science. Presumably the funding is prioritized to social needs such as eliminating disease. The funding model should require that the results should be independent of the results obtained. Otherwise, there is a bias and science loses its value. Some funding models present challenges to academic freedom.

Scientific debates often go on for years without resolution. However, funders would like evidence that their money is being spent on areas where progress is being made and where it is able to be made. Science metrics (scimetrics) attempts to determine the interaction of science and society. Measures such as bibliometric impact factors (9.1.3) and the number of patents to determine the quality of a research program and thus to set overall funding.

ICTD (8.9.1). Disruptive technologies.

On one hand. science is useful when it helps to resolve policy debates. On the other hand, it can often easily be distorted when caught in the middle of a political discussion.

Political and scientific controversies and what research gets done. Lysenko. There are also many examples of scientists who ignore social pressure.

Science is a social activity [46]. Scientists communicate scientific ideas to the public. Many scientific areas overlap with policy. Increasingly, scientists are being expected to make complex assessments of risk [54].

While many early scientists worked alone with modest funding, some areas of science require substantial funding. There are still many areas in which individuals new ideas and clear thinking can have a big effect, but there are also areas where large infrastructure is required. Ideally, science would be independent of social pressure but that often does not happen. Big science. Large projects with many people involved. IRB.

Social needs for research often implies support by public. Government funding of science both directly and indirectly. Difficulty of government funding research. However, because government is a fundamentally political, there can be difficulties in government funding science. Science funding by industry. For instance, drug companies may fund evaluation of the drugs they produce.

Research institutions (8.12.3). Pure research versus applied research (Fig. 9.16)[73].

Evidence-based initiatives.

	Useful	
Understanding	**No**	**Yes**
No	-	Edison
Yes	Bohr	Pasteur

Figure 9.16: Types of scientific research with examples of practitioners of each. "Pasteur's quadrant" is applied research[73].

9.4.3. Public Understanding of Science

Public understanding of science (PUS) [15]. Dissemination of scientific results. Society has become increasingly dependent on science but the public is poor at evaluating scientific controversies.

By the traditional values of science, a scientist should shun publicity because it might corrupt the neutral stance toward data. Increasingly, however, scientists are engaging on policy issues and some are actively seeking publicity.

Popularized social blogs. Science is the press. Science journalism. Public outreach by science.

As with other literacies (5.12.2), we would like citizens to know the basics of science and be able to apply basic science models in everyday contexts.

There are many complications in trying to base policy on scientific research that is not settled.

Many controversies are played out in the press. People often believe results presented in the form of science although the quality controls such as peer review may not be followed. Pseudo-Science. The tendency to believe causal chains (4.5.0). Belief in UFOs[62].

Science Controversies and the Public. The scientific community usually eventually reaches consensus about whether to accept evidence. However, there are many scientific controversies which are being evaluated in the court of public opinion. These range from evolution, to the causes of global warming.

Examples of manipulation of science on both sides of the global warming debate.

9.4.4. Engineering, Technology, and Society

Technology is the application of scientific knowledge to practical problems. Technology made dramatic changes in the living conditions in the Industrial Revolution and that rate of change continues with the developments in information technology.

Engineering

Engineering is the application of technologies for soling problems. Technology and engineering are very different from the scientific knowledge generation. Engineering as problem solving. Engineering is, typically, very pragmatic and outcome oriented with an emphasis on cost-minimization. Technology is the application of knowledge to practical needs. Applied science is often combined with engineering (8.12.3). Engineering and design. R&D. Concurrent engineering. Information engineering.

Difficulty of engineering very complex systems.

Large-scale engineering projects such as the design and development of a new appliance or a new building.

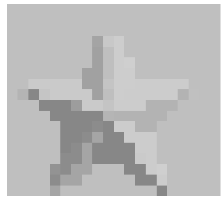

Figure 9.17: The Imperial Hotel in Tokyo survived a major earthquake because it incorporated adequate knowledge.

Figure 9.18: While Interstate highways have brought many benefits to society, they have also created new problems. In some places the highways divided neighborhoods. The “BigDig” tried to undo the effects of a major highway dividing the center of Boston.

Technology

Infrastructure as technology. Developing partial production methods based on scientific findings. Technology has provided society with a remarkable string of accomplishments. Technology is the application of scientific knowledge. Technology management. Technology and design (3.8.0). Technology transfer. Technology and social policies. Institutions and procedures as technologies. Socio-technical systems.

Technology shapes society. It is both agent and recipient of practical action.

Discourse around technologies. “Progress is our most important product”.

The relationship between technology and culture. From the perspective of culture, technology is that which disrupts culture and tradition. There are certainly social changes related to technology and, of course, technology does not always improve people lives.

Pasteur’s quadrant.

Technology has sometimes been portrayed as leading to an unalloyed benefit notion of progress. While science and technology have clearly allowed the human population to increase and for substantial advances in human welfare such as improved health, it not improved living standards for all people.

Technology as a double-edged sword.

Technology transfer to business.

Polygraph[14]. How much social shaping of technology is there?

History and Economics of Technology Technology and economics (8.8.2). Technological developed is greatly affected by the economic infrastructure. Clearly a system of intellectual property protection and encouraging entrepreneurship facilitates the development of technology. Patents are intended as incentives for technological innovation (8.2.2).

Technology development. Innovation (8.14.0).

9.5. Simulations

Large scale computer-driven simulations are increasingly common. They are found in sciences such as astronomy but also in policy arenas such economics and climate modeling. Indeed, we have encountered models throughout this text (e.g., (1.1.2). Models have representations. Conceptual models (4.4.1).

Simulations as information resources. Simulation documentation rather than metadata.

Here, we focus on the process of complex modeling with computer programs. A model of land use may forecast the extent of urban sprawl over a certain period given certain variables, such as growth rates, predicted economic changes, etc. An individual in the speculative real estate business may find such information useful, should they believe the model to be accurate. Therein lies the difficulty of predictive modeling: we tend to not need predictive models to forecast simple, or easily predictable events; they are most useful for complex situations that, by their very nature, are difficult or impossible to predict, whether or not we have a modeling program designed to do just that. A simulation then, is the output of the runs with one of the models. Business process models (8.11.2). Simulation for the purpose of education (serious games) versus entertainment. Models are difficult to validate across a broad range of cond

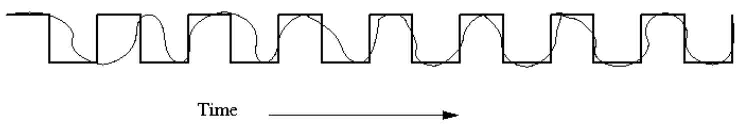

Figure 9.19: An adaptive dynamic model. Imagine a system that re-produces a regular pattern (dark line) (repeat figure)

Simulation is generative reproduction. It acts on a model to generate output.

Simulation as a thought experiment suggesting what is possible.

Simulated interactive environments as related to games.

9.5.1. Types of Modeling and Simulation

Different types of simulations are used for different purposes. Some types that differentiate simulations are shown in Fig. 9.20. Models are particularly useful as a representation for information systems (1.1.2). Modeling attempts to develop an accurate description of complex plans. That model is often used in simulation.

This sort of modeling enables a designer to see the overall picture of a project, and whether or not it satisfies its set of requirements before embarking on the time-consuming task of actually implementing the design. Mathematical models are more abstract examples of regular models, in which mathematical formulas are constructed to represent what sort of outcomes a particular set of input variables will produce (-A.10.0). Modeling for decision support services are particularly complex, as they typically involve many variables in a complex, or probabilistic scenario (3.4.2).

System dynamics (-A.10.2).

Representations. Mathematical models (-A.10.0).

Dimension	Description
interactive / non-interactive	Is there user interaction beyond setting the initial conditions?
deterministic / stochastic events	Does the simulation follow a set course or is it probabilistic?
discrete-event / continuous systems	Does the simulation run from beginning to end or does it pause for input following each event?

Figure 9.20: Some dimensions of simulations.

Finite-element analysis for simulation. Deterministic models. Models that show learning.

Simulations languages and tools. Domain specific.

Non-interactive animations could be implemented as simulations. Fig. 9.21 shows a frame from a computer generated animation in which the fluid motion of the clothing on a dancer is simulated.

Figure 9.21: An animation showing a simulation of clothing and hair moving while the character is dancing[4]. (check permission)

Some stochastic models, such as climate change models, predicting earthquakes, and turbulent flow are recognized to be extremely difficult to simulate (9.5.4). In part, this depends on the resolution of the calculations, and the probabilistic nature of the system being simulated. These systems cannot be "solved," and therefore a simulation is evaluated by how closely it conforms to the analogous process in the real world. These are said to be model-based simulations; that is, they are based on an existing model, though the details and effects of simulations run on that model may be unclear. The model becomes a metaphor for the simulated system.

Simulation-rendering - Alice.

Neural networks (-A.11.4).

Procedural Modeling

Agent-Based Simulations

Computer simulations can be constructed with independent agents. Understanding that many systems to be modeled involve various discrete elements that interact to create an overall effect, agent-based simulations attempt to re-create this scenario by constructing multiple "agents" that act according to pre-defined instructions in response to various stimuli; the net effect of all individual agents produces the desired simulation. These are autonomous agents, and their actions are not coordinated by a central control.

Multiple-agent, aggregate effect simulation can be applied to individual agents as well. (7.7.8).

9.5.2. Practicalities of Simulations

Composable and Multiscale Simulations

Ideally, simulations would be scalable. As for systems biology. Systems dynamics for supporting multiscale simulation. Many difficulties of composable simulations. Creating modular simulations that work together. Because the formatting and language is the same, "composable simulations" allow modules to be reused [?] and save designers time CAD (8.12.3).

Divisible modularity. At different levels, different processes dominate.

Re-use has been emphasized throughout. When models need to be re-used they need to be assembled.

Reuse and interoperability. Interoperability of simulations at different levels of details. Composable simulations can consist of hierarchical components. It is difficult to develop cross functionality between simulations if the simulations or events to be modeled are of a very different variety.

The evaluation of interactive simulations is more complex.

Parameters and disruptive events outside the model.

Interactive Simulations

Simulations are often a part of interactive virtual environments (11.10.2), and can greatly enhance their plausibility. Simulations, to be effective, often need to be scalable, in the sense of added information. New information — whether it be user actions, updated environmental data, or completely new variables or limits — have an effect on the simulation, and if agents are participating, will have an effect on that outcome. Interactivity adds an external factor – the actions of the user — to simulations.

This interactivity can be added to simulations in two ways: through feedback from environmental sensors, and through user interaction.

Simulations can be produce information artifacts. Another simulation support tool allows the addition of annotations to existing simulations.

9.5.3. Example: Weather and Climate Models

9.5.4. Evaluating Simulations

It is often helpful to have model for complex processes. These produce predictions of complex behavior. Malthus (Fig. 9.22).

Figure 9.22: Models have been used to make predictions about complex systems such as the use of resources. Malthus predicted that a population of animals would grow geometrically in the presence of adequate food. However, a limited food supply may be exhausted and the population will crash. (redraw)

However, minute changes in data and only minor miscalculations can lead to massive irregularities and inaccuracy when their effects are spread across and entire system. These models predicted the depletion of resources. Many of these predictions have proven to be unreliable. Complex systems such as the economy and the climate are notoriously difficult to predict. One notable example is the Club of Rome report on the effects of over-population[49]. They do not include the full complexity of these very complex systems.

Indeed, a nearly infinite number of models can be developed by adding parameters. Thus, we prefer models with fewer parameters. Free parameters. (-A.10.0). However, we also need to consider the generality of simulations. One strategy to improve accuracy in domain-specific modeling. Over-simplification by incompletely modeling the complexity of the system. Failure to consider critical but hidden factors. There is an ongoing debate about whether climate models incorrectly estimate feedback processes in the same way.

Climate models are often evaluated by testing seeing how well they predict historical climate changes. It is often helpful to couple climate models. That is, to run two different models simultaneously and to combine their predictions. While one model may be getting of track, it can be stabilized by the other model.

Some types of phenomena are famously difficult to model. The Butterfly Effect (9.5.4). illustrates how unpredictable weather can be. Cellular automata. Weather prediction. Time-step predictions.

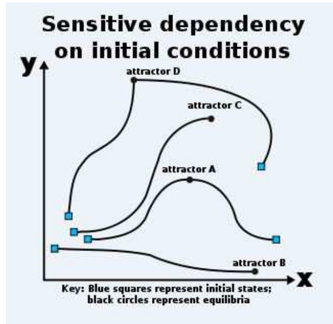

Figure 9.23: Butterfly Effect. (with permission)

Some models are so complex, that it's difficult to analyze these directly. Sensitivity analysis for empirically determining the impact of various parameters. How the output of the model is affects by different values in the inputs to that model. Fig. 9.24. Sensitivity analysis and risk analysis.

Figure 9.24: Sensitivity analysis.

9.6. Scholarly and Scientific Data Sets

A lot of data is generated by science, but there are also massive data sets from many other sources such as the government, corporations (7.4.1, 7.4.4), and from data such as personal medical records (9.9.0). Big data sets and mass personalization (4.10.3). Beyond data sets created specifically for scholarship, many other data sets are used in scholarship.

This surge in data is generated by a increasing array of sensors which measure attributes such as light, sound, temperature, and even magnetic fields. These are coupled with the development of data centers and networking for processing and communicating the data. A data set is a collection of related data.

Just as we describe APIs as a standard interface for one program to interact with another, we can say there is an API for data bases. If this is one the Web we might call it a Web Service. An API can be considered a type of representation for the component.

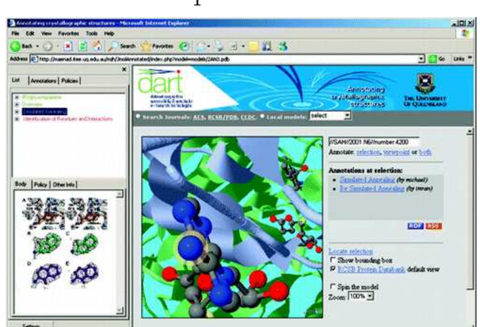

Figure 9.25: Visualization and annotation of scientific data sets (from[40]). (check permission)

Primary data. Is it reproducible or not.

Big data. Could also include big metadata.

Standardized metadata systems. Communities which define their metadata standards. Earthcube.

Data data model: collection, deliverable unit, manifestation, file. For data, preservation can be defined as the ability to be reuse.

Moreover, data sets may be linked into larger scale data-sets. Tools to support data analysis. Visual analytics.

High-performance information processing. Solving certain large scale problems.

9.6.1. Collections of Data

A data set in set of observations. It is similar to a work (2.4.3). Not only do they have a consistent structure but they are managed much like library content. Should we trust the data in the dataset?

Interoperability among different data sets. Difficulty of interoperability also has policy and social origins.

Live data sets may keep changing. Difficulties of dynamic records. Do we have to keep all changes and be able to reproduce the exact data set on which a given calculation was completed.

Data management institutions: FBI and fingerprints[6].

Figure 9.26: Fingerprint data set.

Data grid (7.7.2). Infrastructure for grid.

Figure 9.27: UN data.

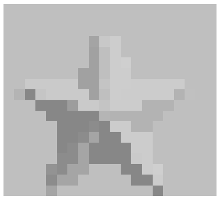

Figure 9.28: Sloan Sky Survey.

Gigaword corpus, Google Books. Social media data sets.

Data sets for decision making versus data sets for science.

eScience has an emphasis on large collections of data. Linking data sets to literature. We considered the conceptual foundations of science earlier in the chapter. Here, we examine data sets which are collected for science. Separation from hypothesis testing.

Standard data sets. Data for future reference - just in case it's interesting or because it shows an effect we know to be of interest. Reference works (3.3.2). New access for data sets such as the Library of Life

[8]. Data sets which are high quality may be cited by scientists to help validate a claim based on them.

Coordination and preservation of complex data sets.

Many sciences are becoming highly data driven. Collect a lot of data and then analyze it. Record keeping (7.4.1).

44000 terabytes of NOAA data.

Materiality.

Reference collections (7.6.2). Data authors as a type of information professional (5.12.4).

Scientists annotation of their own data sets.

Scientific publishing and data sets. Active publishing. For example, highly fragmented least-publishable units. Versioning.

Observing scientists and their use of metadata. It is not clear who will be doing this work.

Mashups for coordinating data from different data sets. This can be viewed as a type of data fusion.

Entity authority file for names of objects in a database.

Data sets in the real world are often messy.

Data cleaning. Data releases. FRBR and data sets.

Requires data specialists and extensive domain knowledge.

Annotation of data sets. Annotation with SWAN.

Figure 9.29: SWAN annotation ontology. (check permission)

Scientific Data Sets

Collecting some data without an immediate reason. Extensive Data sets have been fundamental to discoveries such as Darwin's theory of evolution. Instrumentation which obtains a lot of data needs to be followed my systems for the management of that data. Tyco Brahe was able to develop predictive equations for planetary motion by using the data tables developed by Kepler (Fig. 9.30).

Management of scientific data. Record keeping is essential for science.

Sensors and the ability to collect massive data sets makes systematic hypothesis testing less important and it fundamentally changes the nature of science. Still, the key is the interpretation of data rather than the collection of data.

Data retrieval from large datasets can be available on the grid. Mining data for research. Science and information systems are becoming more inter-twined. Open notebook science for confirming the procedure used to collect the data sets. Shared data which can be useful to everyone. History of how a data set has been processed. Are two data sets related?

FRBR for data sets.

Figure 9.30: Kepler (left) collected extensive data tables about the motion of the planets in the sky which Tyco Brahe (right) used to formulate equations. (check permission)

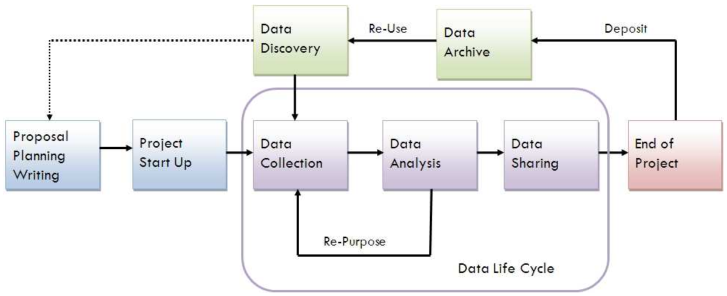

Figure 9.31: Research data lifecycle. (redraw) (check permission)

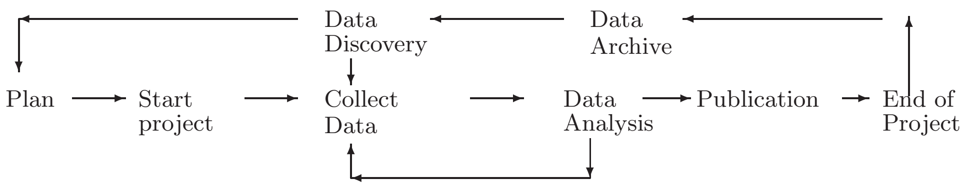

Figure 9.32: Research data lifecycle. (vs OAIS) Increasingly, also need to support publishing and reuse. (check permission)

Baseline collections such as large sets of shells which in science museums against which to gauge ecological changes.

Interoperability of data sets.

Automated filtering of data sets for low probability events.

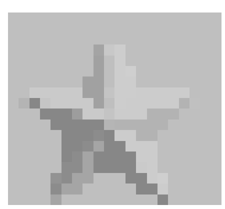

Figure 9.33: O-Ring failures. Challenger accident.

9.6.2. Applied Data Sets

Earth monitoring. Medical data sets.

9.6.3. Frameworks for Managing Data Sets and Data Curation

There are many similarities between the management of text libraries and data libraries. Data libraries are related to data warehouses (7.4.4). Data archiving. Linking to publications, DRYAD. Analogous to the approaches for archives. Data management planning. Coordinating and reconciling metadata and field names.

Just as policy was critical for libraries and archives, policy is also central for frameworks for data management.

The collection and management of data sets such as census, economic statistics, labor statistics, geographic data, and sometimes scientific data is a significant government function.

At the least, the data should be machine processable. This often means it is structured with XML.

Data Sets

Data set as a work.

What makes a dataset citable. Corpus linguistics.

Errors in Data Sets Outliers. Missing cells. Limits to resolution in measurement accuracy. Data cleaning.

Human-to-human communication around data. Storytelling about data. Data communities analogous to document communities (5.8.2).

Data Curation

Scientific data use often doesn't match the relational model.

Data reuse.

Trusted data. Data provenance[65].

The intermediate data products may be captured.

Difficulties of data analyses across different levels of a model. Such multilevel models are common in complex systems.

Many information systems need to manage large amounts of numerical data. There's a wide range of data sets. Data sets need to be managed as though they are libraries. Data curation is still fundamental. Coordination across data sets.

Data custodians and data managers.

Similar to many of the issues for libraries and archives (7.5.1). Trusted repositories. Risk analysis for content. Provides a cost-benefit advantage.

Data curation and data management[53]. Collection management issues are like those for digital libraries. Quality of the data. Identify new data used in an analysis. Should partial results be kept. In laboratory research, there is a lot of control over the quality of the data.

Curating data sets is similar in some ways to collection management (7.2.2). This includes consistent organizational commitment and continuity. Audit procedures (7.10.2). Security, information assurance, history of access and updates. Audit trails for determining the provenance and quality of data. tracking any changes that are made.

Narrative journalism.

Some of this is specific to science datasets but other aspects apply to all large datasets. Messy natural data sets. (3.9.2). In the sense used here, the curator is like a steward.

Semantic Web and ontologies are widely used for description of data sets. (2.2.2).

Representation information

Data Management Systems and Services

Managing petabytes (7.7.3) and scale. Some datasets are so large the the cannot be run across distributed networks. current data networks cannot handle them. Large scale data flows[21] (Fig. 9.34). We need systems for accessing large data sets across the network. The Data Grid combines features of libraries, archives, and knowledge management systems. As we saw for those applications, they can be described by the services they offer. (7.0.0). Federated data. XML format sports data. Many of the issues we discussed for cultural archives (7.5.1). also apply for preservation of data sets. Sneaker net. Moving data vs. moving computation to the data. Science DMZ.

Data :

Figure 9.34: Here is a data management map for CLEO which is a high-energy physics project based at Cornell. It includes hundreds of people and instruments. One of the problems of distributed data management is maintaining consistency when doing updates[21]. A workflow management system can be used to keep track of complex processes.

Derived data products.

Representing and reasoning about provenance. Grid transactions. Events in the user interface. Process documentation. p-query.

Federation of data grids. Coordination of policies for data grids. Data grid chaining.

Difficulty of moving large amounts of data around the data gird. Collecting data from instruments in remote locations. Data centers for scientific data.

Merging results from very different fields requires both coordination of data sets and also ultimately, coordination of the organizations which produce the data and analyses. Cyberinfrastructure for science. Implementing policies for science repositories. For instance, this might include IRB approval[51].

Data synchronization.

Describing Data Sets

Metadata and Semantic Web for describing the content of scientific data sets.

Metadata for statistical data. Standard descriptors for similar concepts across implementations.

Interoperability.

Classification of statistical data sets.

Common information model.

Gene ontology, (2.2.2). In some cases, some or all metadata about a digital object may be lost.

Interconnecting data sets with workflows.

This is particularly important since we need to know exactly what is in the data sets.

Machine-processable metadata.

Self-describing datasets.

Data format definition language.

Metadata for data libraries. Potentially a very large amount of metadata. Effects of scientific data sets on the way science gets done. Scientific metadata evolves.

Linking datasets and publications.

Data Preservation

Large collections of data may be maintained as data libraries. S.O.A.P. (Selection, Organization, Access Persistence) principles should also apply here. Each domain will have its own specific data structures but the background principles should be the same.

Loss of data sets can be very expensive and can set back research. It is expensive and sometimes impossible to recreate scientific data sets. Collecting and preservation data which might be useful sometime in the future. It is especially worth preserving scientific data when that data is unique or when it is difficult to reconstruct. Scientific datasets allow the user to go back to old data to see what has been recorded and what it shows. As with other types of digital preservation, formats and metadata are major issues (7.5.5). Preservation institutions and infrastructure. Importance of keeping data in the original format (Fig. 9.33).

Some data sets about phenomena such as records of earthquakes and volcanoes are not reproducible. Particular preservation of at risk data or data which would be particularly difficult to replace.

Trusted data. Data provenance[30].

Economic models for data collection and storage.

Figure 9.35: Frame from a reconstructed NASA video of the first step on the moon. The original was lost. (repeat)

Preservation data requires that the protocols used to generate the data are described. Importance of guaranteeing data quality.

Importance of information needs for data libraries. For instance, the astronomers need to be able to compare observations across time.

Federated data. Repositories of government data.

Structured browsing of the content of data libraries. For instance, a collection of data about ship wrecks could include data sets organized by the components of a ship.

. Data documentation initiative. Recent versions include details about the lifecycle and workflow. Lifecycle management for datasets. Archiving data sets. Data preservation. Sets of related materials for a certain objective. Text documents, images, data. Unlike some archives, only the values in the data set are important, the original appearance and format are generally not important. Data liefcycle issues in DDI-3.

Some data sets such as those generated for relational databases (3.9.0). Data cleaning.

Preserving Workflows and Contexts

9.6.4. Data Rights and Policies

Policies

As with other collections of information resources, there need to be both legal and institutional policies governing their use. One claim is that data from research which is funded by government grants should generally be made publicly available. Indeed, increasingly this is part of the terms of awarding a grant. Embargo for use of data collected by one researcher. We have considered the basics of records for commerce (7.4.1) but that is often focused on satisfying legal obligations. Here we consider scientific and scholarly records where there would be different types of issues. For instance, sharing data across a research community is often a major consideration.

Recognition for the creators of data sets. Issues around open data sets. Confidentiality in some social science data. Open data sets.‘ Open-source Project for a Network Data Access Protocol standard interfaces for visualization software. There's a cost to not having open data. Civic data.

Data cannot be copyrighted; it describes facts. Rights and responsibilities for data management. Language for specifying constraints on the use of data.

Beyond retaining data from individual experiments. Science is an accumulation interlocking results. Data progresses from collections of measurements, to edited databases and handbooks, to derived physical constants. The periodic table effectively summarizes a large amount of data from many observations. It is a very effective representation.

Aggregation of records from many sources. Re-identification of records in supposedly anonymized data sets.

Data Privacy. Corporate records. Security for managing privacy. Anonymize data to facilitate privacy.

Substantial privacy issues for some data sets.

Data Sharing and Open Data

Shared raw data sets (9.6.3) can supply more information about publications, especially when linking is provided between data sets and journal literature. Norms across disciplines for data sharing. Cost and business models for data sharing. Time-embargoed on data. Facilitating interaction among researchers. Open microscopy environment[12]. Tool sets and desktops (3.5.4). Data sharing and scientific collaboration (5.3.3). This is similar to the unwillingness of sharing data in organizations which leads to silos (7.3.6). Perhaps even mandatory posting of data. Collecting and managing the collection. Who controls data? Open data.

Policies to encourage access especially of government data. There could be considerable value in making data available. Data practices are human routines organized around data. Sometimes there is rapid sharing or data and in other cases, the data is hoarded. However, there are substantial differences in disciplines about this. Not just open data but follow the open data by open analysis.

9.6.5. Data Mining, Data Visualization, and Visual Analytics

The activity of science consists of a set of systematic workflows. Science data flow models. Design of laboratory notebooks should be based on scientists use. The model becomes an artifact showing the dataflow used in a given analysis and can be managed like other information resources. Indeed, the reliability of laboratory notes needs to be comparable to other trusted archival materials. Flow of the routine data analysis. Workflow. Providing an index of content, a friendly interface, and security. Workflow for the analysis of data. For instance, Kepler workflow (Fig. 9.36).

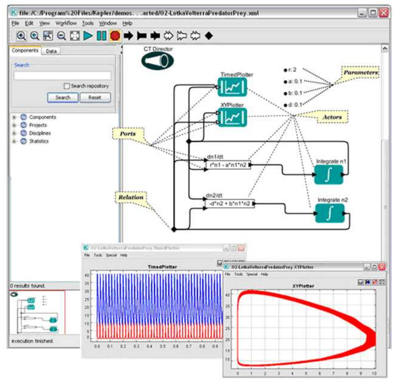

Figure 9.36: The Kepler data management system has a GUI dataflow for science and can provide provenance for derived data. (Workflow only. check permission)

Fig. 9.37[16].

Figure 9.37: Many-Eyes community data analysis. (blogging based around visualization tools)

Complex decision support (3.4.2).

Exploratory data analysis.

Large data sets can be extremely rich sources of information. Thus, their exploration and extraction of information from them is actively pursued.

Determining semantic structure of data sets. For instance, “data detectors”.

Information visualization (11.2.5) emphasizes quantitative relationships in data. However, we can also consider displays of quantitative, numerical relationships. Because this is often associated with scientific research, this is often called “scientific visualization”. This often allows for controlling perspective and coordinates. Data may also be presented with animated visualization. For instance, particle flurries identify on a sample of exemplary particles. The motion of typical particles can illustrate complex behavior such as flow through a blood vessel (Fig. 9.38). Data analysis environments versus workflows. These could, for instance, support decision making with DSSs (3.4.2).

Data analysis from secured data sets. For instance, maintain privacy.

Data analysis environments and workflow. Limitations of visualization.

Data behaviors as a type of information behavior. Query previews (3.9.2).

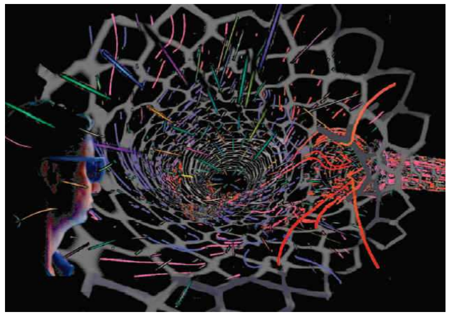

Figure 9.38: The flow of red and white blood cells can be illustrated with animations of particle flurries[13]. (check permission)

There are many possible applications: Visualization and statistical analyses. Clustering. Data warehousing. Information fusion (9.6.5). Visual analytics uses visualization to support analyses. Visualization data in a schematic of the environment from which the data was drawn.

Collaborative visualization. A visualization can serve as a conversational artifact. Virtual observatories.

However, there is mixed evidence about whether visualization is actually superior to other interfaces for information presentation.

Information fusion is combining evidence from many sources. For instance, from sensors, reports by humans, and historical knowledge.

Data mining. Privacy preserving data mining.

Data narratives.

Sensors in the name of science. Changes the way people do science and greater value in the analysis than in the collection of data. Need to reward collection.

9.7. Mathematics, Statisitics, and Logic

Although mathematics is generally paired with science, it is quite different. It can be quite abstract and in that sense, it seems far removed from typical information systems. The criterion for acceptance of a mathematical principle is consistency with the rest of the system of expressions. Mathematics is useful for science because mathematics facilitates the abstraction of some types of processes. Math can be thought of as a collection of languages. Mathematical knowledge and axioms[42]. Working with math[43]. Godel[36]. Teaching math (5.11.5).

Numeracy. Cognition and numbers[31]. Reasoning about probability (4.3.4). Clearly, math needs to be broadly defined to include statistics and probabilities.

Logic (-A.7.0)

9.7.1. Mathematics and Logic as Frameworks for Representations

Mathematics has been described as exploring the “relationship of relationships”[55]. Abstract procedures. State models and discrete math. The nature of mathematical proof.

Math as abstraction. Branches of mathematics: Topology, Graph Theory, Algebras.

Library of mathematics[29]. Coherency of mathematics. Proof development systems. Mathematical proof and certainty of knowledge.

Geometric objects as ideal forms.

Collaborative mathematical environments.

9.7.2. Structure of Mathematical Expressions and Mathematics Markup

Languages of mathematics. Geometry as a visual language. Equations in text such as $(a+b)^2$ can be presented with an extension of XML known as MathML[10]. As shown in Fig. 9.39, the format can be separated from semantics. Parsing equations.

```
<msup>
  <mfenced>
    <mi>a</mi>
    <mo>+</mo>
    <mi>b</mi>
  </mfenced>
  <mn>2</mn>
</msup>
```

```
<apply>
  <power/>
    <apply>
      <plus/>
      <ci>a</ci>
      <ci>b</ci>
    </apply>
  <cn>2</cn>
</apply>
```

Figure 9.39: MathML presentation format specification (left) and content format (right) for $(a+b)^2$.

9.7.3. Mathematical Argumentation

9.7.4. Automated Theorem Proving

Logical operations.

Proof verification.

Figure 9.40: Automated theorem proving.

9.7.5. Other Math Processing Tasks

Structured math documents such as math practice sheets.

Math searching[11]. Can I get the derivative of $\frac{1}{e^x}$ Math descriptive metadata.

9.7.6. Statistics

Exploratory Data Analysis.

9.8. Science and Informatics

9.8.1. Biology as an Information Science

"...modern biology has evolved into a science of information," – David Baltimore

There are several senses in which biology is an information science. Taxonomic classification has been an important theme for many years. Taxonomy based on evolution rather than, say, on structure.

There is a greater awareness of DNA as a representation. Biological systems have representations which model they world. Their representations are biological processes. While DNA represents the information necessary for making life is clear, the processes by which that representation gets expressed are also integral. Information polymers: DNA, RNA, proteins, and carbohydrates.

Biologically inspired systems. Genetic algorithms (-A.11.6).

Issues of representation are essential for biology. Bioinformatics. How do organisms grow and reproduce themselves. Partly the DNA but the entire context. Data management of biological data. Encyclopedia of life. iPlant. Brain science (-A.12.2). Spore is a game which simulates biological processes (Fig. 9.41). Intellectual property issues for genetic modifications (8.2.2).

Figure 9.41: Natural computing. (check permission)

Naming and Classifying Living Things

Since the time of the great Swedish taxonomist, Linnaeus, taxonomies and classification have been fundamental to biological[70]. Categorization and classification (2.1.2). As with other classification systems, there are problems with the definition of the attributes on which the classification is based. In the case of biological classification one question is what exactly is a species[82].

Biological taxonomies. Versus, say, agricultural taxonomies.

Originally based on physical structures and now similarity of DNA and, for that, models of likely evolution.

SuperTrees[9] (Fig. 9.42).

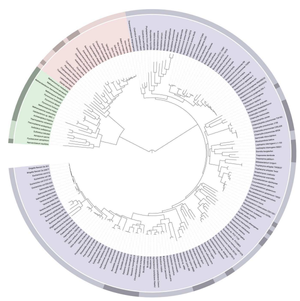

Figure 9.42: SuperTrees are cluster diagrams which try to link a very large number species[9].

Genomics and Proteomics

DNA carries the information essential for life. In effect, DNA is the representation of the organism though complex processes are required for expression of that representation.

Genome sequencing. Human DNA is 99.9% similar; 0.1% difference.

Diseases determined by mutations. Analyzing the function of gene sequences. HMMs for gene sequences.

Gene ontology. Dimensions of gene activity. Function, Gene annotation and entities[47]. This is an example of a collaborative information resource. Evidence codes. Re-sequencing.

Interestingly, the sequence of codes in DNA chains and proteins can be examined with some of the same techniques that we use for text retrieval. For instance, we may want to match a fragment of DNA

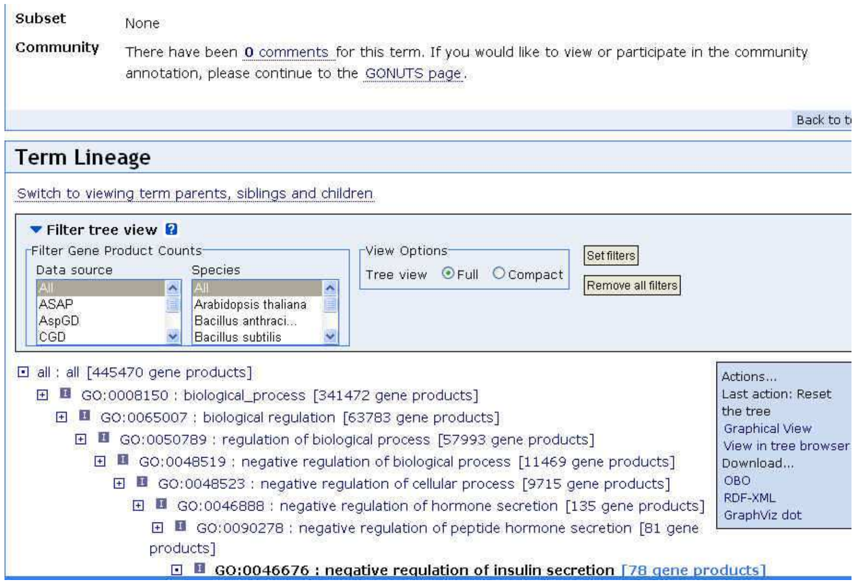

Figure 9.43: Gene ontology. (repeat figure)

to find the sequence where it belongs. Also, uses for proteins analysis. From DNA sequences to the 3-D structure of a protein is difficult. Protein folding.

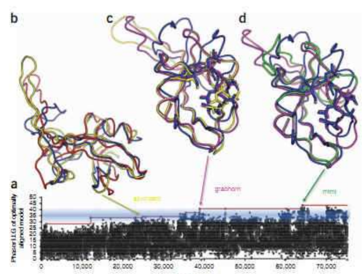

Figure 9.44: Fold-it is a crowd-sourced puzzle for solving the complexitiies of protein folding (from [?]) (check permission)

Searching Sequences with BLAST (Basic Local Alignment Search Tool) search aligns sequences. This makes DNA sequencing possible. Matching amino acid sequences in proteins.

MKLLQRGVALALLTTFTKASETALA

Figure 9.45: Fragment of an amino acid sequence in a protein.

Protein shape searching in drug development.

Translational medicine - from science to clinical impact.

Patents may be given, for genetically, modified crops.

Control of Gene Expression Design control in biological systems.

Personalized medical treatment by understanding individual gene sequences.

Genetic testing and personal genomics. Personal DNA screening. Genetic testing is a predictor of a person's health. It can lead to personalized medicines, health insurance, Personal knowledge about genetic conditions. There can be difficult decisions about having children with knowledge of genetic conditions. These tests raise ethical and privacy issues[5] Large data sets of personal genetic information are needed for research but are prone to privacy problems. (8.3.1).

Models of Biological Processes and Learning in Biological Systems
Systems biology explores how the components work together. Organisms can be considered as the complex combination of many interacting components. We can consider them as systems. Thus, some of the same tools we use for modeling information systems may be applied to modeling biological systems. For instance, biological systems may be modeled with UML (3.10.2)[33] (Fig. 9.46). Furthermore, we can use visualization to explore these models. This model could then be used to do the drug personalization. Semantic systems biology.

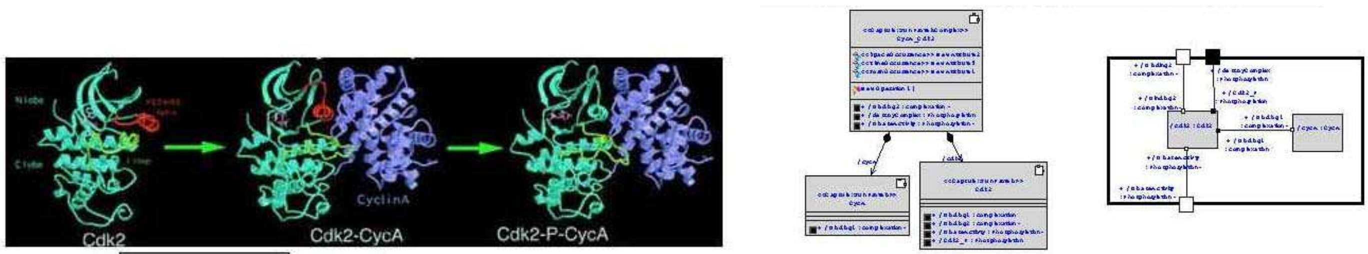

Figure 9.46: UML for systems biology. The transitions between molecules in a chemical pathway (left) can be modeled as states in a statechart (right). Specifically, the pathways of cyclin-dependent Cdk2 kinase are shown [?]. (check permission)

Evolutionary game theory.

Simulations and systems biology. In some cases, UML (3.10.2) is used for these simulations.

Learning is an aspect of information systems and we see learning in biological systems. The primary representation is DNA. Survival of the fittest. The species is an adaptive unit. Evolution of altruism. Evolution and game theory[56]. Cost-benefit ratio times the number of links.

$$B/C * K \tag{9.2}$$

Genetic algorithms (-A.11.6) are a type of machine learning. Natural Computing. Evolutionary systems.

9.8.2. Cheminformatics
Just as classification has been a cornerstone of biology, it has also been central to chemistry. The development of the periodical table of the elements was a major advance. Increasingly coordinated with biological informatics.

9.8.3. Other Sciences
Geology. Astronomy. Economics. Archaeology as a spatial scientific and cultural science.

9.9. Medical, Clinical, and Health-Care Informatics
Medicine and health-care are information and inference intensive. These issues range from principles of medicine, to the management of the entire health system, to the clinical treatment of individuals and patient involvement in decision making and Medicine employs many of the information management techniques we have explored. Many of these points echo discussions we have had elsewhere. Health care is information intensive. Thus, there are issues related to decision support, semantics, and data management.

Medicine would seem to be an area where progress is hard to argue with. Life spans have been increasing steadily. Translational medicine attempts technology transfer for medical discoveries. That is, it attempts to facilitate moving good ideas from the laboratory to practice.

9.9.1. Medical Concepts, Research, Scholarship, and Teaching

Scholarly publishing (9.1.1) for medicine. Medical scholarship. PubMed. Disease database. Low recall for physician information seeking[24].

Automatic monitoring of patients with semi-intelligent devices.

Open-Source Medical Research.

Over the years, many different medical description languages have been developed. Recently, many of the components of those languages have been unified into a single system, the Unified Medical Language System (UMLS). UMLS has attempted to create a umbrella which encompasses the different domains of medicine but it is unclear if it accomplishes that. Ontologies (2.2.2). UMLS is composed of three main parts: a semantic network, a lexicon, and a thesaurus, which combine knowledge representation with subject classification systems. From these components, UMLS has developed a framework describing the medical literature based on the concepts it contains. While medical publications are relatively formal, as with any natural-language descriptions, the concepts may be described with several different words. Indeed, each of those lexical units uses different string units. Fig. 9.47 illustrates the relationship of some of these concepts. UMLS has many applications; for instance, it is a type of query reformulation (10.7.2) with different terms. This is a relatively well-defined ontology but as we have noted for other attempts to exactly specify concepts (1.1.4) and to develop controlled vocabularies (2.5.3), here are still many vague terms.

Medical Searching

Use of medical literature (9.9.2). Medical question answering. The patients other have a lot of anxiety about their medical problems. Medical searching search engine as a specialized search. Evidence-based medicine (9.9.2). Clinical outcomes research. Characteristics of different searches.

Semantic types in UMLS. Text processing of medical content.

Difficulties of consistency in UMLS [?].

String (SUI)	**Lexical (LUI)**	**Concept (CUI)**
S0016668	L0004238	C0004238
Atrial fibrillation	Atrial fibrillation	Atrial fibrillation
S0016669	Artrial fibrillations	Artrial fibrillations
Artrial fibrillations		
S0016899	L0004327	Auricular fibrillation
Auricular fibrillations	Auricular fibrillation	Auricular fibrillation
S0016900	Auricular fibrillations	
Auricular fibrillations		

Figure 9.47: There are different levels of description. The Unified Medical Language System (UMLS) defines String variants (SUI), Lexical variants (LUI), and Conceptual Units (CUI). One concept, (C0004238), is expressed with several terms (L0004238 and L0004237) and each of those terms has several strings (S0016668, S0016669, S0016899, S0016900)[39]. (check permission)

Visualizations such as particle flurries (11.2.5). Augmented realities.

X-ray image processing. Indexing cell lines. Organizing information to protect meat supplies.

Medical training and medical simulation. Fig. 9.48 Humanoid robots may also be used for medical simulations.

Figure 9.48: An example of simulation for medical education. (check permission)

9.9.2. Clinical Health-Care Informatics

Information systems are being applied in medicine in many ways.

Decompose the complex activities into workflows. Many types of information are needed to make effective medical decisions. Information about the patients' condition and prior medical interventions. However, this is often not available.

Small search tasks in everyday activities. Select from many alternatives. Many reports.

Hospital. Doctors rarely have all of the information they need about patients when interviewing them. Major information management constraints. Siloed information organization. Supporting diagnosis and decision making. Supporting collaboration in medical settings.

Surgical workflows.

Safety and error prevention.

Care assistant.

Medical Diagnosis and Decision Making

Diagnosis is part classification and part causal modeling (4.4.5). Doctors[7]. Medical diagnosis can be particularly challenging to because of the complexity of the human body. There many different ways that medical symptoms can manifest themselves and there is the possibility that there can be multiple diseases.

Making decisions about individual cases. Medical inference systems. Diagnosis and treatment decisions about individuals.

Evaluation with positive predictive value which is similar to the notion of precision for evaluating search performance. Fig. 9.49

		Actual Condition		
		Yes	**No**	**Total**
Diagnosis	**Yes**	10	10	20
	No	20	60	80
	Total	30	70	100

Figure 9.49: The positive predictive value is the value of a diagnostic test.

Nosology is the classification of diseases. Especially contentious with respect to concepts related to mental health.

LOOK-DECIDE-DO There are many devices for information delivery such as PDAs. Consider the information needs of health professionals in an emergency room. Complex data and a stressful environment.

Medical decision support systems for making medical decisions. Clinical decision support systems. As with other decision support systems, the data presentation should be easy to understand. Computer-supported diagnosis helps to minimize errors from cognitive load. Medical diagnosis as cultural phenomenon. Low cost wide-spready medical testing. Diagnosis for all. Networked communication to support simple medical diagnostics. ICTD. Best practices for health care in a crisis.

Managing treatment. However, devices may affect physician workflow and this becomes an obstacle to their acceptance. Current versions often fail to take contextual factors into consideration.

Evidence in Medicine and Evidence-Based Medicine

There is often a substantial gap between research findings and applications of medical treatments. Medical treatments should be based on the latest finding but that often doesn't happen; that is, we should have Evidence-Based Medicine (EBM). There are several reasons for this gap. Doctors don't know all the latest research in every field and even if they do research on those finding, the research results are not readily accessible. Speed the time from literature to practice, a type of technology transfer. Making the literature clearer with narrative and systematic reviews. Also with structured abstracts which highlight dimensions which are particularly relevant to medical treatments. Rely less on human judgment which is often fallible.

Stepping further back, we can ask what is evidence in medicine. There is a lot of medical research but there also seem to be a lot of contradictory results. It is relatively easy to obtain correlational data but it is harder to do experiments. Randomized clinical trials (RCTs) provide stronger evidence than correlational studies. Generates large data sets.

Designing Medical Work Environments

Collaboration of a medical team in the trauma center. Social structure and communication of medical delivery teams.

Information in Health-Care Delivery

Information is essential in the health-care delivery environment. Hospitals are at once highly complex, highly traditional, and data-rich. Hospitals are among information institutions invented. Physician-order entry systems – for managing treatment. Management of costs. Effective outcomes. RFID. Sensor monitoring of health-care procedures and treatments. Information for preventative medicine.

Health gaming.

Medical images (e.g., Fig. 9.50) are very different from pictures of your vacation. Radiological images are often difficult to decipher And may require pattern recognition approaches such neural networks have been used for detection of tumors. Medical image modeling. Computational anatomy[3].

Teleradiology. Collections of digital images will have high space and network requirements.

Patient Information Behavior

Self-diagnosis. Hypercondira. Cyber-condria. Consumer health vocabularies.

Mobile medicine with apps. Patients collecting their data.

Issues for decision making. It is often difficult for a patient to understand all the implications of various treatment options. In some cases, it may be easier to have a physician or social worker talk through the choices and provide advice. Shared decision making (SDM) between patient and physician. Like other decisions, this will include information collection. Patient decision making.

Problem of patient conclusions. Quackery. Laetrile.

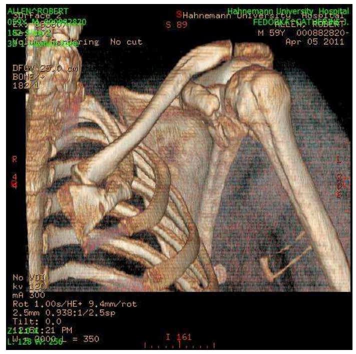

Figure 9.50: CT scan image.

Online patient support group.

Increasingly, patients are accessing online information resources to try understand their own medical conditions. Consumer health information. How citizens acquire medical information[22].

Information for Patients

Doctor-patient interaction (6.4.3). Patients will use colloquial language and may attend to unimportant details about their medical condition. Patient's descriptions of their symptoms and complaints. Telling the story of your medical history.

One way of structuring information about a patient is with "PICO" questions. These are: Patient Problem, Intervention, Comparison, Outcome.

So called, information prescriptions ask the patient to explore the implications of a condition or range of treatment options. Making health materials easy for patients to understand. Personalized health care benefits from extensive personal health records.

Tools to support doctor's communicating of information to patients. Information for hospital patients (Fig. 9.51).

Figure 9.51: Prototype display of patient notices[52]. (check permission)

Decisions about Treatments

Like other types of medical decision making there must be estimates of risks and risk management (7.10.3). Patient decisions about treatment options, about lifestyle choices.

Social networks and the diffusion of medical information (5.1.3). Social links seem to affect medically significant behavior.

Supporting Physican Activities

Coordination in hospital team work. Complications of a continually changing situation. Support for patient health care management. Management of chronic diseases.

9.9.3. Medical Records

Hospitals have a very complex organizational structure. There are many formalized roles. Encouraging transparency about health-care costs. We have already seen a wide range of information system interaction in institutional dialogs (6.4.3). These are socio-technical system. Related to other electronic records (7.4.1).

Personal and Patient Health Records

The potentially flexibility and accuracy of medical records. Improving health-care with information technology. Potentially, there would be a great deal of benefit from being able to access complete records about a patient. This is a special case of the management of electronic records (7.4.1). Keeping patient records have the potential to improve the quality of health-care delivery. However, the massive conversion costs are substantial. The requirements are difficult such as handling insurance claims. Universal electronic patient records. Many solutions have been proposed. Perhaps simple records are better than overly complex records. A more limited version is the records we find in an organization. Patient records in a hospital. Health insurance forms. Google healthVault. Personal recording of information. Paper chart for traditional medical records. Conversion of paper-based clinical medical records.

Electronic health records (EHR) and personal health records (PHR). Health Level 7 is an XML-based standard for exchange of health information. There are many different layers of records which could be incorporated such as lab reports, prescriptions, treatment records. Conversion of paper records to electronic records. Medical data codes involve classification of medical conditions (2.1.2)which can be useful for public health.

Beyond patients: Staff and stuff. Logistics (8.12.1). Equipment, business end, insurance/billing. Electronic Medical Records (EMR). Usability of health records. Adoption of health information systems by hospitals. EMR data centers and hospital information systems.

There are many difficulties in implementing them. It is important for people to have records of their medical condition. Doctors information needs are relatively well served by existing approaches. Medical privacy issues are often an extreme concern (8.3.1). However, there are many different types of information and strong requirements for privacy that developing a standard has proven extremely difficult. Broader ethical questions such as releasing information about people's genetic dispositions. There are also, many complications to allowing medical records to be disseminated. This includes establishing policies and workflows for managing the data. Medical information policy. Such as HIPAA privacy policy. Implementing HIPAA policies. These records have severe privacy issues. Difficulties of data mining the results given the privacy constraints. Legal issues for records, not just privacy. Liability and medical records. Security breaches. Ease of access.

Mining the data has the potential to greatly improve health. What's more, combing records of family members, or by census data has the potential to detect important health trends. Social determinants of health. Social networks and risky health activities.

Standardized indexing and organizing information are crucial to the effective records. Controlled vocabularies for specification of patient information. Use of UMLS and patient health records (PHR). While medical concepts can be relatively cleanly defined in the research literature, it is far more difficult to do that in the everyday diagnosis.

Letting people view and correct their own health records.

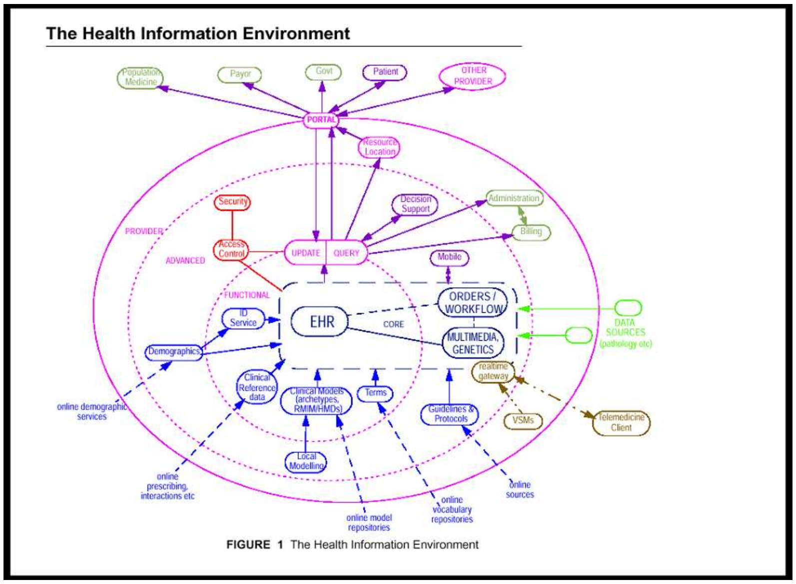

Figure 9.52: HL7 health information environment which is centered around the Electronic Health Record (EHR)[1]. (check permission) (simplify) (redraw)

9.9.4. Public Health Information and Public Awareness of Health Information

Analysis of population trends and precautions. How do people adjust to changing recommendations about treatments. Promoting health. Encouraging health literacy. Health care information access by the public. Developing a system that would be useful in detecting influenza outbreaks based on search characteristics.

Public health data sets.

Data collections from clinical sources. Disease informatics. Epidemiology such as for SARS and bird flu. Data analysis. Models of infectious disease spread.

Flu Trends. Predicting flu epidemics from search engine trend data. Privacy issues (8.3.1).

Deployment of Health-Care Information Systems

There are many promises of information systems in medicine but there are also many difficulties for that. Given the complexity of hospitals and other health-care situations it shouldn't be surprising that they have many of the problems we described earlier for other types of organizations.

Several distinct users. Physicians, Nurses, Patients, Administrators. Use cases and the difficulties of the distinct user groups. For instance, physicians generally do not like to enter information into structured forms.

Cost of health-care information systems.

Failures of health-care information systems. [63].

9.10. Spatio-Temporal Information Systems

Representations and data models for time and space. Spatial information systems describe the properties of objects in space such as geospatial relationships representing 3-D spaces, 3-D objects and environments (11.8.1). In these systems, one can interact with physical objects and their representation in space. The primary role of the representations is to refer to the location of objects in the physical world. One can observe the relative locations of parts of the body.

Spatial analysis. Optimization for spatial data. For instance, where are best places to position fire stations. Coverage models.

Locative media. Incorporating location information into other services.

9.10.1. Varieties of Spatial Information Systems

The most typical spatial information systems are geographic (or geo-spatial) information systems (GIS), which show spatial relationships of the earth. However, there are other types of spatial information and these are often available from information systems. It is possible to explore virtual environments for architecture. This allows architects and their clients to understand what a building will look like before it is built. Urban modeling such as knowing the layout of buildings.

There are many different applications beyond traditional geographic information, including astronomical star charts. And there are other systems in which geo-referenced data may be included; oceanographic and atmospheric systems are data libraries (9.6.3). Systems also differ in how they present space and in the level of interactivity they allow. Models may have metric versus non-metric spatial relationships and they may assume 2D GIS models or 3-D GIS models. Spatial environmental models (Fig. 9.53). Standardized metadata systems.

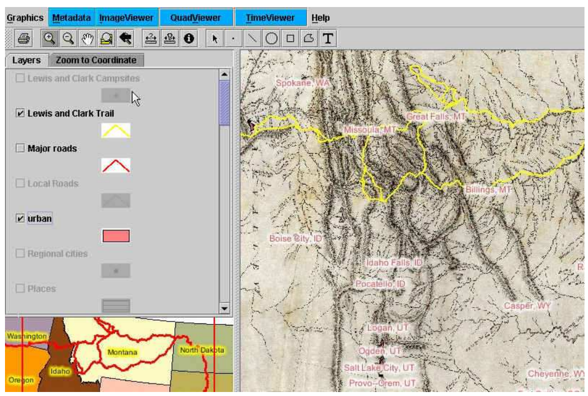

Figure 9.53: Maps as data sets[60]. Here, we see Lewis and Clark's route overlaid on a historical map. (check permission)

Geocoding. Map projections and consistent frameworks for matching points.

Overlaying GIS data sets with maps[60]. Data sets (9.6.0). Maps as representations, indeed visualizations, of schematics. Spatial humanities.

Inferring 3-D from photos. PhotoCity.

Panoramic views of streets.

GIS and epidemiology and criminal justice.

Location technologies and location analytics. Each map search tells a great deal about that person about the person Who does the search. Similarly, knowing the coordinates of a user's mobile device tells a lot. Landscape modeling. Stories and memories associated with land and the physical environment.

Coordinating GIS search with general knowledge about a user's interest.

3-D reconstructions from historical videos of places could be useful as a component of history education.

Stories (6.3.6)related to locations.

Location models. Roles of maps in games. Mirror worlds and the metaverse.

Figure 9.54: Policy map.

9.10.2. Geospatial Data

Data management issues (9.6.3). Historic real estate maps. The ambiguity of geo-spatial objects. Geographic data science.

Incorporating other models into the GIS. For instance, hydrological modeling of water flow combined with landuse.

Geography data sets can serve as a structure around which other data can be organized; GIS data can be used for visualization (11.2.5). There are many examples of such geo-referenced data sets. Other databases are intertwined with geographic information; for instance, the census is broken down by state.

Environmental information can also be geo-referenced, as can video[69]. Many aspects, legal issues. Closely connected to mapping. These maps can be used to biodiversity (Fig. ??)[61].

Describing Geographic Objects

Information model for GIS objects. This is another example of a Knowledge Organizing System (2.2.0).

"Metadata" descriptions of spatial objects (Fig. 9.55). [38]. FGDC. There are many difficulties in representing political debates if an administrative unit is challenged. OGIS.

Relationship	**Example**
Administrative part of	Mumbai :: India
Administrative seat of	Mexico City :: Mexico
Sub-feature of	Hudson Bay :: Arctic Ocean
Physical Containment	Lake Victoria :: Africa

Figure 9.55: Some relationships among geographic entities.

Describing geospatial objects and the problem of describing physical objects in general. Point objects and vector objects. Spatial synonymy. There is a difficulty identifying place — and place may have two separate names. For instance, a place may be identified by administrative boundaries and one identified by geospatial features. Proper names of geographic objects are also often very ambiguous; for one thing, the names of geographic areas may change over time. Gazetteers list place names and clarify exact locations[38]. Gazetteer details help distinguish Pittsburgh, Pennsylvania from Pittsburg, Kansas or Pittsburg, California (Fig. 9.56). As with most other categories, geographic categories, are social constructs and generally reflect the orientation of the speakers. From a European perspective, Europe is considered a separate continent although it is continuous with Asia. whereas North and South American are considered one continent although they are connected by only a narrow strip of land.

Location	**Description**
Pittsburg	1 city W. Calif. NE of Oakland on San Joaquin River, *pop. 19,062* 2 city SE Kans., *pop. 18,678*
Pittsburgh	city SW Pa., *pop. 604,332*

Figure 9.56: Geographic gazetteer entries for Pittsburg and Pittsburgh[17].

Geographic meta-models.

North Korea economy watch. Satellite images and determining social structure (Fig. 9.57). Surveillance (8.3.3).

Figure 9.57: Detail of a region in North Korea which has been identified by Web-based observers as a compound for the elite Party members (North Korean Economy Watch). (check permission)

GIS Queries and Interfaces

Spatial relationships imply different types of queries than we saw for text queries. Many spatial query relationships are relative to other objects: left, right, above, near, facing, and among/between are some of the terms used to describe them. Relationships like "between" are sometimes ambiguous because the positions of the objects are sometimes complex (Fig. 9.58). Range queries ask "Is a spatial object within a given area".

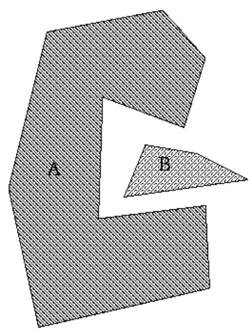

Figure 9.58: This illustration shows one of the difficulties of range queries. A query might ask whether city B in region A.

Queries to GISs can be complex and require considerable inference about geographic relationships. For instance, the query "what towns are in flood plains in the Pittsburgh area?" would require knowledge of both towns and flood plains. GIS queries and interfaces support tasks and decision-making. As with text queries, the "query semantics" should match the data model.

9.10.3. Searching Geospatial Information

Coordinating search with locations. For instance, finding pizza close to your current location. Alternative to yellow pages. GPS. Geospatial objects include natural objects such as mountains and rivers, human constructions such as highways, and abstract concepts such as boundaries and property lines. In ordinary use, the definitions of geospatial objects can be ambiguous; for instance, a "street" may be confused with a "road" or a "highway". However, it is possible to give a more exact definition.

Some spatial objects are "point" spatial objects such as a city center, others are "vector" spatial objects, such as a road. Still others are best described with a bounding box or perhaps more irregular polygonal footprints. Sometimes a system must deal with disjoint entities, such as the locations of all branches of a bank.

Spatial indexing organizes objects by locations. Data structures for spatial indexing such as bin-trees and R*-trees. The familiar longitude and latitude lines can be the basis of indexing locations in geographic space; other systems of coordinates such as the Universal Transverse Mercator (UTM), are also used. Geo-referencing is one example of coordinating data sets. The most common representation of space in cartography but other representations are possible.

9.10.4. Spatial Cognition, Orientation, and Navigation

Spatial Cognition

People learn about space by moving, crawling, and walking. How do people understand, remember, and use concepts of space? The representation and inferences people make about spatial relationships are known as “spatial cognition”. There are probably multiple, interlocking cognitive representations for space. As with other inferences (4.3.4), people may make incorrect inferences about spatial relationships Some people are confused about whether San Francisco or Los Angeles is closer to Hawaii. As you can see in Fig. 9.59, San Francisco is closer although it is farther north. Presumably, people reason that LA is south of SF and Hawaii is even further south. They don’t also realize that San Francisco is much further west than Los Angeles.

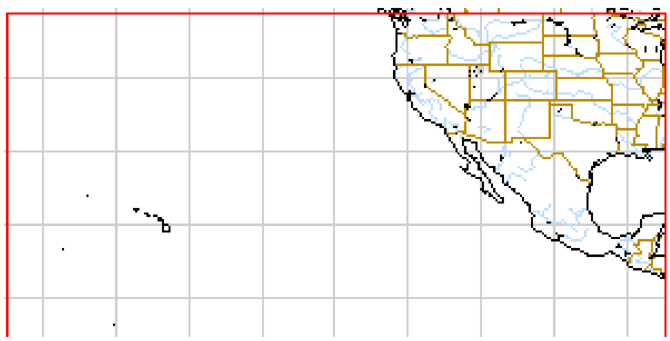

Figure 9.59: Without seeing a map, most people believe that Hawaii is closer to Los Angeles than to San Francisco. (check permission)

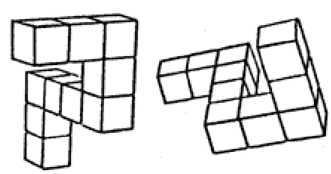

Figure 9.60: Mental rotation task. Are these two shapes congruent? (check permission)

9.10.5. Maps

Maps are schematics that support orientation and navigation; they are a graphical symbolic representation of space. Maps typically go beyond pictorial presentation of symbolic information. Maps can be used to find locations corresponding to physical reality, and to compare various properties of physical objects. Fig. 9.61 is a well-known drawing that blends pictorial and map-like information. Maps employ a specialized visual language (11.2.4) that represents space. When correlated with the world, they have a “referential semantics” (6.2.3). Place is emergent. Maps help people claim territory. Cartographic representation.

Spatial history. Cultural mapping.

Migration and cultural changes. Economic activity, trade, and commodities.

Place is emergent often related to cultural stories. Re-naming of place is often related to cultural transitions.

Figure 9.61: A drawing which suggests the typical mental map a New York City resident has of the western part of the United States. The focus is the area around 9^{th} Avenue. Beyond that, the view is not linear but distorted like a "fisheye" and only a few salient locations in the distance are included[72]. (redraw-K) (check permission)

A map is a document that identifies objects and shows their spatial relationships. As with any document, it reflects the author's sense of what will be most useful and most effectively understood by the viewer. Maps in the tradition of the Western culture often show things that can be enumerated, such as distance and population. Although we think of maps as primarily visual, geospatial information can also be conveyed in other ways. For instance, poems and songs may provide a cultural memory for spatial relationships. Places in digital environments. Spatial brain cells (-A.12.2).

Figure 9.62: Map.

Usability of maps. Orienting oneself with a map. First-person perspective. Similar concerns arise in virtual reality. Tethered perspective. Absolute perspective. This may also include focus+context visualization as we saw earlier (11.2.5).

Metadata and Cataloging Maps

As with other complex information resources, there are catalogs of map collections. Even seemingly straightforward attributes, such as the date, can be crucial, since geography is dynamic. Several metadata standards for maps are built on Dublin Core (2.4.4).

Spatial narrative. Spatial history. Spatial animations. Personal testimony.

Interactive Maps and Spatial Presentations

Interactivity allows users to explore details. We have already seen lenses to allow users to explore maps (11.2.5). Maps can be used to display responses to GIS queries, and as query interfaces for geo-referenced systems (9.10.2). Maps may also be used to orient people to other types of processes. or instance, SimCity uses spatial representation as the basis for games.

Maps may be elements in virtual or augmented reality. Indeed, they are an aspect of many games.

Spatial Modeling

3-D modeling.

9.10.6. GIS-Based Services and Neogeography

Many services have a GIS component. Location as a context. It can be useful in, for example, services to do with crisis management (8.6.4), law enforcement, the census, or the environment, GIS libraries. Map services.

KML files.

Mirror world. Metaverse (11.10.1).

Political disputes about boundaries reflected in the map. Layer of commentary and opinions over the spatial descriptions. This is sometimes termed “neogeography”. sNorth Map-based mashups with GIS.

Spatial Orientation and Navigation

People use their knowledge of space to determine their location and to move from one place to another. Orientation is locating oneself within an established framework – especially in space. To use a map, a person must understand how the map relates to the physical space. Maps may be egocentric or exocentric navigation – that is they may be based on an absolute position or they may be relative to an individual’s position. How do you figure out where you are in a virtual landscape? Context is vital to orientation, which is partly a recognition problem. Spatial navigation is called “wayfinding”.

Signage should be based on scenarios of use.

Figure 9.63: Signage is often essential for wayfinding. Each path a person may take through the physical environment and their spatial information needs should be considered. (check permission)

“Landmarks” are points that are easily recognized. Identification of the landmark allows orientation. Landmarks are important aids to knowing where you are and guiding navigation. They generally are familiar and highly visible, and have distinctive features. Longitude and latitude indexing can provide orientation as can be an alternative to using landmarks for navigation. Still other methods such as Western and Polynesian methods for navigation.

Figure 9.64: Polynesia navigation stickchart. (check permission)

Sensations such as smell, sounds, warmth, and wind often provide orienting cues. But, these are frequently not available in computer-generated virtual worlds (11.10.2). Pop-up navigation in 3D-spaces and virtual worlds (11.10.2).

Navigation is movement through a series of stages toward a goal (2.6.3). Polynesian navigation. While we may navigate an interface but navigation is regarded as moving through space. Landmarks and sign posts are among the clues that can be used to support navigation.

The explanation of directions illustrates some of the ways in which groups develop a shared understanding. The process of negotiating meaning during conversation (6.4.0) is particularly apparent when giving directions[74]. Sketching can add a visual component to the directions

Some people do navigation by a grid such as following a spatial grid such as city blocks.

9.10.7. Events and Time

Timelines and temporal histories. Temporal information retrieval. History (5.13.0).

Relevance changes over time. Episodic retrieval.

Processes.

Temporal landmarks.

Exercises

Short Definitions:

Academic freedom
Bibliometrics
Collaboratory
Occam's razor
Primary literature
Scholarship
Scientific methods

Review Questions:

1. Scholarship. (9.0.0)
2. How is science different from technology? (9.4.4)
3. Give an example of workflow in science. (9.3.3)
4. What Web site lists the format used for US Census data? (9.6.3)

Short-Essays and Hand-Worked Problems:

1. Calculate linkages in the citation lists of several related articles. (9.1.2)
2. What are the difficulties of using bibliometrics as quality indicators for scholarship? (9.1.3).
3. What is the impact of a scholarly journal that publishes 32 articles per year and each of them receive a total of 200 citations. How does that compare with a journal that publishes 110 articles per year that receives a total of 330 citations? (9.1.3)
4. Sometimes the number of citations to a scholarly paper is taken as an indication of quality. What are some of the problems with that? (9.1.3)
5. Contrast the goals of "text retrieval" from "knowledge discovery". (9.2.2, 10.9.0).
6. What type of metadata might be appropriate for a data set collected for a space probe sent to Mars? (9.6.3)
7. Genomics. (9.8.1)
8. We have defined information as that which reduces uncertainty. Do biological representations reduce uncertainty? ((sec:infodefinition), 9.8.1, -A.1.0)
9. GIS. (9.10.0)
10. Explain the differences between first-person and third-person perception from maps. (9.10.4)
11. It is said that people from older cities in the U.S. (e.g., Boston) navigate by landmarks while people from the newer cities (e.g., Phoenix) navigate by compass directions. Why might this be true? (9.10.4)
12. Describe the characteristics that make a map effective. (9.10.5)
13. Observe how people use maps. How could their use be better supported by interactive maps? (9.10.5)
14. Ask someone to give you directions. Note what they say. Record the questions the ask and describe the assumptions they are making. (9.10.6)

Practicum:

1. Data libraries,

Going Beyond:

1. Is scholarship a largely academic, ivory tower exercise or is it relevant to social issues and problems? (9.0.0)
2. Should a scholarly paper that has been found to plagiarize a previous work be deleted from a library? (5.12.3, 9.1.1)
3. Describe the pros and cons of peer reviewing and an evaluation for the value of ideas. (9.1.1)
4. Create a citation map of a field. (9.1.2)
5. Are citations good measures of quality for scholarly research? (9.1.2)
6. Are scientific laws created or discovered? (9.2.2)
7. What is the proper role of the government in science? (9.4.0)
8. How does the notion of a "collection" apply to a data library? Is a database a data library? (7.2.2, 9.6.3)
9. Specify data management procedures for a database of clinical trials. (9.6.3)
10. Describe a task for which the particle flurries would be a distinct advantage over other visualization techniques. (9.6.5)
11. Develop a MathML specification for $\frac{1}{\frac{1}{2}^2}$ (9.7.2)
12. If Biology is an information science rather than a physical science, what sort of generalizations can we make about it? (9.8.1)
13. Should personal genetic information affect insurance rates? (9.8.1)
14. Is there a net cost savings from implementing health-care information systems? (9.9.2)
15. Describe technologies what would be needed to match pictures with text documents. (9.10.5)
16. Describe how OCR techniques might be applied to automatic map analysis. (9.10.5, 10.1.5)

Teaching Notes

Objectives and Skills:

Instructor Strategies:

Related Books

- Baker, S. *The Numerati.* Houghton-Mifflin, New York, 2008.
- Boot, M. *War Made New: Technology, Warfare, and the Course of History, 1500 to Today.* Council for Foreign Relations, 2006.
- Borgman, C. *Scholarship in the Digital Age: Information, Infrastructure, and the Internet.* MIT Press, Cambridge MA, 2007.
- Bowker, G.C. *Memory Practices in the Sciences.* MIT Press, Cambridge MA, 2006.
- Brown, M.B. *Science in Democracy: Expertise, Institutions, and Representation* MIT Press, Cambridge MA, 2009.
- Bunker, W.E., Bal, R., and Hendirks, R. *The Paradox of Scientific Authority: The Role of Scientific Advice in Democracies.* MIT Press, Cambridge MA, 2009.
- Cole, S. *Making Science.* Harvard University Press, Cambridge MA, 1992.
- Deutsch, D. *The Fabric of Reality.* Penguin Press, New York, 1997.
- Giere, R.N., Bickle, J., and Mauldin, R.F. *Understanding Scientific Reasoning.* Thomson-Wadsworth, Belmont CA, 5^{th} ed., 2006.
- Green, M.A., and Bowie, M.J. *Essentials of Health Information Management.*
- Gilovich, T. *How Do we Know What Isn't So? The Fallibility of Human Reason in Everyday Life.* Free Press, New York, 1991.
- Heuer, R.J. *Psychology of Intelligence Analysis.* Novkinka Books, New York, 2006.
- Latour, B. and Woolgar, S. *Laboratory Life: The Construction of Scientific Facts.* Princeton University Press, Princeton NJ, 1986.
- Owens, W.A., Dam, K.W., and Lin, H. *Technology, Policy, Law, and Ethics Regarding U.S. Acquisition and Use of Cyberattack Capabilities.* NAP, Washington DC, 2009.
- MacEachren, A.M., *How Maps Work: Representation, Visualization, and Design.* Guilford, New York, 1995.
- Meadow, C.
- Merton, R.K. *The Sociology of Science.* University Chicago Press, Chicago, 1973.
- Nagl, J. *Learning to Eat Soup with a Knife: Counterinsurgency Lessons from Malaya and Vietnam.* Praeger, Westport CT, 2002.
- NAP *Ensuring the Integrity, Accessibility, and Stewardship of Data in the Digital Age.* National Academies Press, 2009.

- Pearl, J. *Causality: Models, Reasoning, and Inference.* Cambridge University Press, Cambridge UK, 2000.
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- Singer, P.W. *Wired for War: The Robotics Revolution and Conflict in the* 21^{st} *Century.* Penguin, New York, 2009.
- Stokes, D. *Pasteur's Quadrant: Basic Science and Technological Innovation.* Brookings Institution, Washington DC, 1997.
- Tenner, E. *Our Own Devices: How Technology Remakes Humanity.* Vintage, New York, 2003.
- Thagard, P. *Conceptual Revolutions.* Princeton University Press, Princeton NJ, 1992.
- Von Baeyer, H.C. *Information: The New Language of Science.* Harvard University Press, Cambridge MA, 2004.
- Yoon, C.K. *Naming Nature: The Clash Between Instinct and Science* Norton, New York, 2009.

Chapter 10.
Human Language Technologies

Figure 10.1: Illuminated manuscript (from Leige).

Here, we consider a variety of language processing applications. This includes text and speech processing and it looks at several specific applications such as text processing for search and question answering. Some ways of structuring multimedia may also be considered as language-like; these are examined in the next chapter.

10.1. Text

Text is an extremely flexible mechanism for transmitting knowledge. It is a fixed visual form that can appear in an almost infinite variety of locations, from books and magazines to road signs and T-shirts. Text, as a means of communication, is woven together much like a fabric is woven, with multiple individual threads joined tightly together to form a unified final whole; in fact, the word "text" is derived from the same root as the word "textile". Text is the visual form of a representational language. In addition to the shape of the text itself, the visual factors of how text is presented can indicate structure and convey meaning. Text is a common, fixed, relatively permanent and easily processed. While European-based languages use alphabets, other languages use syllable-based systems. Discrete versus statistical representations.

10.1.1. Alphabets and Character Sets

Historically, the letters in a alphabet represented the distinct sounds – the phonemes – of a language. Beyond the alphabet, other symbols associated with a language such as digits and punctuation are known as graphemes. Symbols.

The Latin Alphabet and the ACSII Code

There are many writing systems and many ways in which text symbols may represent concepts. English is written using the Latin alphabet, which is familiar to Westerners. Alphabets are sets of discrete symbols that are combined to form words, but individual letters (generally) have no meaning in themselves; it is only through their combination with other letters that meaning emerges. The 8-bit ASCII codes maps to the Latin alphabet allowing it to be recreated. While there are only 26 letters in the English alphabet, separate codes must be given to capital letters as well as the many punctuation marks and special characters used in writing.

Syllable Languages and Ideogram Languages

The written form of several East Asian languages, such as Chinese, Japanese Kanji, and Korean, uses pictorial ideograms to represent words (Fig. 10.2). Ideogram-based languages are not easily automated using current technology. Keyboard entry of ideograms is difficult because there is a such a large number of different characters. Compositionality of Chinese characters.

Figure 10.2: Part of the label on a package of Chinese herbal tea. Translated literally from top to bottom the Traditional characters say: (1) 10,000, (2) applications, (3) tasty, (4) harmony, (5) tea. (check permission)

Because of these difficulties and because of the need to assimilate foreign words, many Eastern countries have adopted phonetic alphabets. The Japanese use a mixture of traditional ideograms, a phonetic alphabet known as Katakana and some of the Latin alphabet.

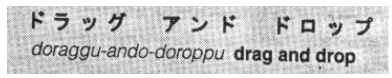


Figure 10.3: Example of a Katakana phrase [?]. (to be typeset)

There aren't enough bits in the eight-bit ASCII code to represent the symbols used in all languages. The limitations of ASCII are most serious for international character sets. Even some common symbols from European languages, such as German umlauts (e.g., ü) and French cedillas (e.g., ç), cannot be represented. Many proposals have been made for representing other non-Latin character sets. The Unicode standard was developed to extend the number of characters that can be represented and to facilitate interoperability across information systems. Unicode for sign language.

Ordering and Categorization of Characters

When we learn to recite the alphabet, in addition to learning the letters we also learn a standard order for them. This ordering is essential for looking up words in a structured list such as a dictionary, card catalog, or index (2.5.3). Traditional Chinese characters are categorized by "radicals". The characters for "flower" (Fig. 10.4) and "grass" share symbols to indicate that both are related to plants. This is the root form of the word and it is the basis of dictionary ordering. Once the radical has been identified, ordering is determined by the number of additional brush strokes required to draw the character. indexradical, Chinese characters

草 花

Figure 10.4: The Chinese characters for "grass" (left) and "flower" (right) both share the "radical" at the top indicating that they are related to plants. Indeed, the radical resembles a plant growing out of the ground.

Orthography

The rules and customs for written text are known as "orthography". Orthography enhances readability but may also add aesthetics. Calligraphy.

Graphic design includes both text and image. Motion graphics animates graphic design. The style, or look, of a set of characters is its font. Most of this book is prepared with two main font styles The main text is in Roman font, in which the characters have "serifs" (short lines extending from the letters), while the captions and headings are in Helvetica, a sans-serif (without serifs) font. Fonts provide a regularity that makes the text pleasing to the eye. The spacing of the characters may also be manipulated to improve readability. Adjacent characters may be fused or split by a technique called "kerning" (Fig. 10.6). Font design and humanisitc fonts (Fig. 10.7).

Just as the inflection of spoken words can highlight the intended meaning written text contains clues about the meaning. The convention of capitalizing proper names allows the reader to identify them

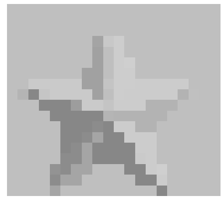


Figure 10.5: An example of Arabic calligraphy. Calligraphy was said to be one of the inspirations for Steve Jobs' emphasis on design.

RAVEN RAVEN

Figure 10.6: Spacing can greatly improve readability with typeset characters. Note the gap between the "A" and "V" on the left; no kerning has been applied. On the right, the letters "AV" have been kerned, in other words they have been moved closer together.

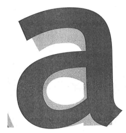


Figure 10.7: Fonts can improve readability. Clearfont font (dark "a") has recently been developed to improve the readability of highway signs compared to the older font (light "a").

more easily. Some other examples of orthography are the spacing between words, indentation between lines in an outline to show structure, and the ubiquitous smiley face :) emoticon.

10.1.2. Text Document Layout

From text to text documents. Equation layout (9.7.2).

10.1.3. Information Architecture

Web sites need to be managed. Consistency in design and navigation across the pages of a web site. Labels. Generalize principles of authority control across sites. Facilitate semantic publishing. Content management systems.

10.1.4. Digitization

Scanning. Digital photography. Color and image processing. Eliminating distortion from scanned image with post processing by de-warping. Large amounts of paper and text. Mass digitization (10.1.6).

Figure 10.8: This book scanner is designed so the page images can be captured without breaking the spine of the book. (check permission)

10.1.5. Recognition of Printed Text and Handwriting

There are many advantages in converting paper text to electronic text. Because this is essentially visual processing, we need an image to work from. In some cases, only bitmap images of documents are available, rather than the full text. The electronic version of a document has been lost, or may never have existed. Those lost versions may be recovered by scanning (-A.18.2).

Optical Character Recognition (OCR)

OCR can be a step in citation extraction and indexing of digitized text. [26]. Optical Character Recognition (OCR) processes the visual properties of text in a scanned image of a page. It can also be used in detecting text in images or video which is a type of image-recognition problem. The quality of the original production affects the quality of the characters; in poor-quality printing the characters are often irregular (Fig. 10.9).

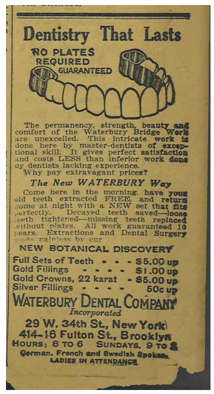


Figure 10.9: A scanned historical text. Note the uneven quality of some of the text. This adds to the difficulty of OCR.

The quality of the digitized image affects the OCR system's ability to recognize characters. As with other recognition processes, we may consider template-based and feature-based approaches. As a bottom-up model, OCR seems straightforward; individual printed characters are identified and combined into words. Individual letters may be identified by shape and attempt to determine words from them. Some of the errors that arise can be handled with spelling checkers (10.4.1). Unfortunately, this is far too simple a model. At the word level, some incorrectly identified characters may produce legal words while at the character level, the total number of characters may not even be correctly counted.

In complex recognition processes, some recognition occurs "bottom up". Bottom-up processing consists of gathering information from many sources and making an inference based on it (left side of Fig. 10.10). In speech recognition systems, an optical character-recognition (OCR) system might work bottom-up by identifying letters and constructing words and sentences from them. Other recognition systems work "top-down". Top-down processing starts with expectations about what is likely to be found; subsequent observations are used to confirm or reject those expectations (right side of Fig. 10.10). Characters might be more accurately identified by considering the possible words in which they may occur. The combination of bottom-up and top-down processing is known as "up-down" processing. In the previous example, the likely words would depend on the range of sentences appearing in the document in which they occur, effectively merging the two processing strategies. OCR performance can be improved by considering the lexicon and other linguistic constraints.

Processing OCR can be an example of parallel up-down processing (Fig. 10.11) (Fig. 10.12).

Much of the automated OCR for historical documents is poor because the print quality of the original documents is uneven. Crowdsourcing can be applied to OCR correction. Fig. 10.13 and Fig. 10.14. [6].

There are some additional difficulties in text recognition, such as segmentation of characters in Thai

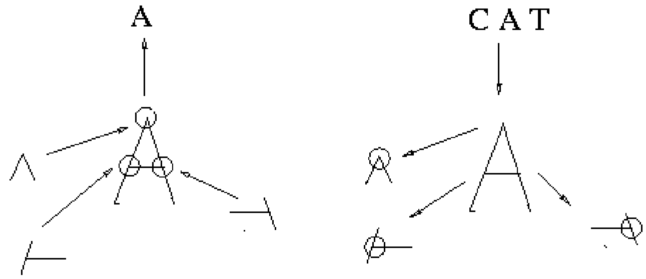


Figure 10.10: Two approaches for visual recognizing of the letter “A”. In the “bottom-up” approach (left), the model is confirmed if a sufficient number of features are matched. In a “top-down” approach (right) the context provides expectations that can be confirmed by looking for specific features. (redraw)

Word identification
↑
Character identification
↑
Segment characters

Figure 10.11: A bottom-up approach for OCR.

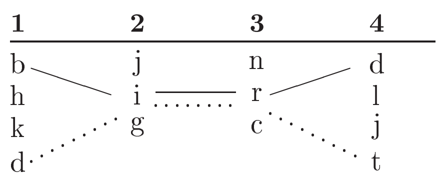


Figure 10.12: Characters may not be identified exactly. Thus, they may be ranked by probability and then the word from a word list with the highest net probability could be found. The word “bird” is preferred over “dirt”. (redraw) (under construction)

Figure 10.13: Text-correctors Hall of Fame from the Australian National Library[9]. (check permission)

(Fig. 10.15). Optical processing can go beyond recognition of text to the identification of other symbols, including non-traditional characters, musical notation, and mathematical formulas.

Visual Document Segmentation and Recognition

Uses of document the document are reflected in its structure (2.3.3).

A complex document, such as a magazine, has several different page styles; for example, there are title pages, tables-of-contents pages, and text pages (Fig. 10.16). Moreover, the text pages may have additional structure such as section headings and figures. A first step could be the identification of the document. This is a type of visual language. Determining visual structure can be useful for information

Figure 10.14: reCAPTCHA. (check permission)

Figure 10.15: Segmentation of a syllable for Thai.

extraction.


Computers for the Disabled

JOSEPH J. LAZZARO

Adapting desktop computers to meet the needs of disabled workers is easier than you might think

HyperMirror: Toward Pleasant-to-use Video Mediated Communication System

Developers need sophisticated understandings of prospective users' workplaces. Working with representative users whenever possible is standard advice for developing interactive systems.

Figure 10.16: Despite the apparent visual similarity; a document detection system should be able to determine that the first two of these pages are title pages, while the third is not. (check permission)

The recognition of the content from scanned documents is a special case of image segmentation and image processing, which we will examine in more detail later (-A.2.3). Visual document processing might begin by determining the layout, such as whether the text was printed in one column or two and the positions of the figures and their captions. Fig. 10.17 shows a newspaper which has been processed to identify text zones. Visual prototypes and deformable models can be used for page layout. Just as the shape of individual objects can be recognized, the layout of a whole page might be parsed as a type of visual language (11.2.4).

Handwriting Recognition

Handwriting has much more variability than does printing. To begin with, handwritten letters are sometimes block and sometimes connected, or cursive. Static Handwriting. Recognize content in manuscripts. Fig. shows a sample of handwriting. Some features such as the loops (l), ascenders (t), and descenders (y) stand out clearly. Thus, the first step would often be the segmentation of individual letters.

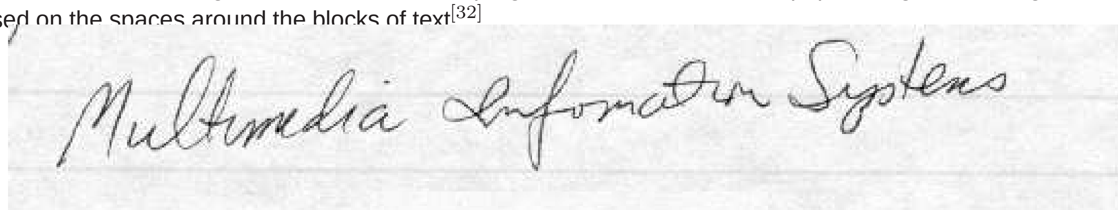
Dynamic Handwriting. The sequence of pen strokes in producing printing and handwriting can be used to improve recognition. These techniques could also be useful for signature verification. Fig. 10.18 shows an example of how this could help to distinguish between a “U” and a “V”. For ideograms character recognition, stroke order is particularly helpful. The recognition of the pattern of strokes is like other sequence-recognition problems such as the recognition of 2-D gestures (11.4.1) and HMMs. Pen-based interface.

Symbol recognition. Many more symbols than but more constrained patterns. This can employ dynamic


THE BROOKLYN DAILY EAGLE

BRITISH GUNS ON ITALIANS' FIRST LINE; TEUTONS TAKE ASIAGO, IN TRENTINO; U. S. TO IGNORE TALK OF ARMISTICE

Figure 10.17: Zone segmentation for an OCR program for a historical newspaper image. This segmentation is based on the spaces around the blocks of text[32]



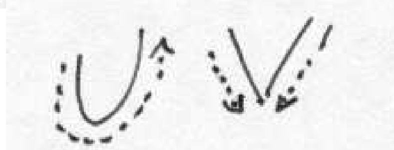


Figure 10.18: Although the printed letter U looks similar to the printed letter V, they can be easily distinguished by the strokes used to write them, as shown by the dotted lines. (to be rendered)

OCR (10.1.5). Operations on math (Fig. 10.19).

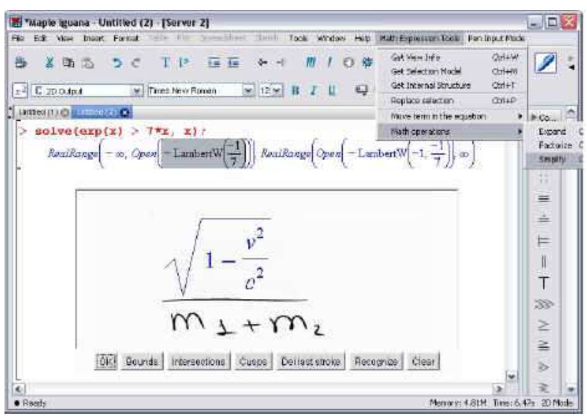


Figure 10.19: Pen-based input is effective for mathematics [?]. (generate own version) (check permission)

10.1.6. Digitized Collections of Books and Documents

Until recently information resources were committed to traditional media. Supporting collections this traditional material. This content can be digitized and can be organized into collections coordinating paper libraries. Digitization can facilitate preservation, distribution, and access of fragile material.

Because there is so much paper. Building the collection. NDNP. Millions of digitized pages of newspaper text will be available online soon. Million Book Project[54]. Multimedia. Google book scanning project. Digitization for access. Digitization workflow processing.

Consistent with the theme of interactivity Digitization for access rather than for preservation. Spatial relationships can contribute to meaningfulness. Visual languages (11.2.4) and image segmentation.

Much historically important material is found in manuscripts[17] and other personal papers — these writings often reveal the innermost thoughts of their authors. They are often kept in archives (7.5.1). Manuscripts and other original documents are "primary sources" and are often used teaching history. However, primary sources have limitations, In personal letters and memories people may puff up or simply lie about their contributions. Issue of authenticity of primary sources. Their interpretation can be difficult without the context.

In some cases, texts are digitized because they are deteriorating. Moreover, the resulting image can be processed. That is, electronic restored.

Printing has been used to produce books for hundreds of years, but historically, it was employed primarily to prepare only publications that were meant for a wide circulation. This means that over the centuries a vast archive of handwritten documents has accumulated. Until about 1900, typewriters were not often used for business correspondence and until about 1950, almost all personal correspondence was handwritten.

Collections of manuscripts are thus rich sources of historical material. Many of the original manuscripts of Mark Twain's books are kept in the Library of Congress, as are a number of original music scores. These early versions may include author or composer notes, which provide a fascinating insight into the work and/or creator, but which do not appear in the final publication.

Collections of "e-text" often combine traditional and digital approaches to collection management. The scanned images may be OCR'd and metadata may be extracted via the document processing and recognition techniques described above (10.1.6).

Semi-structured text. For instance, email has structured fields and free text.

The levels of abstraction are applicable beyond defining metadata. Instances of documents may appear in several different media and in different formats, such as the derivative works mentioned above, or even audio recordings of printed works such as books-on-tape[68]. A document viewer that allows several versions to be presented simultaneously (Fig. 10.20). An original text might be presented along with the output of optical character recognition (10.1.5). Document browsing. Multi-layer documents. Image based-electronic editions.

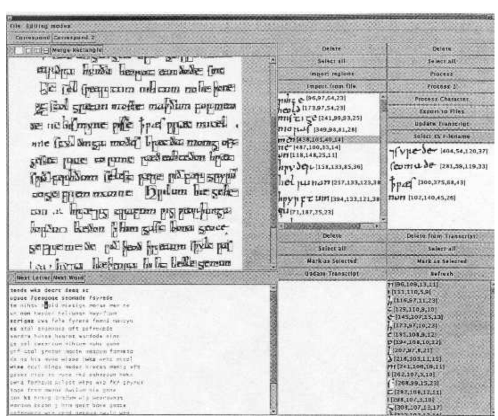


Figure 10.20: Multiple versions of documents can be compared through a single interface[33]. (check permission)

Increasingly, versions of a work proliferate. Levels of context to include. Metadata.

Superworks and families of works. Equivalent, derivative, and descriptive.

Ecolosystems of related documents. Annotations, Reviews.

Extracting Metadata from Text Documents

The next step would be to extract the content of the document. This can be done by processing the structure of documents. Fig. 10.21 shows an example of image extraction. The middle image shows parts of the page which have been confidently identified as not being text regions. Because so many of those regions are clustered together, it seems likely that the whole region is a picture. There is a similar challenge in extraction of values in a table can help one understand the structure and semantics of the table. Styles of tables.

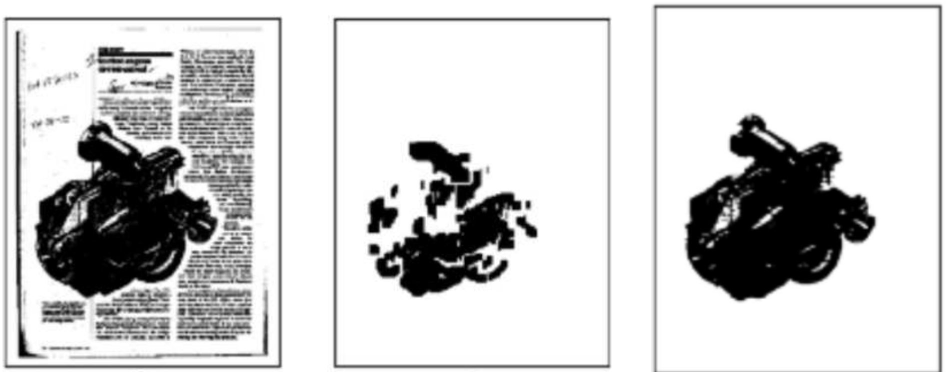


Figure 10.21: Stages in image extraction from a magazine page[20]. (new version) (check permission)

Once the title page has been identified, metadata from that page can be extracted to populate a catalog for an e-text database. That metadata can facilitate document classification, which could be useful for automatically creating a style-sheet for the document or metadata for a collection of documents.

Massive Digital Collections

Mass digitization.

Digital humanities (9.1.1). Libraries and archives (7.5.1). In the past, information systems have focused on business and natural science. Increasingly, information systems are begin used in the humanities. Mining digital humanities materials.

Literary criticism. Background of the author as reflected in the work.

History, literature, art, archaeology.

Google Book Project. Copyright issues (8.2.2).

Figure 10.22: The Hathi Trust (logo shown here) manages a very large collection of digitized books. (check permission)

Digitization of non-text. 3-D digitization ((sec:3Ddigitization)). Cultural informatics.

10.2. Reading

Ultimately, the purpose of a text is to convey information to the people who read it. At the simplest level reading is just the process of extracting meaning from writing. The technological developments of recent decades have had a significant impact on the acts of reading and writing. For the user, writing with a word processor is different from writing with paper and pencil. Writing and reading are complex human activities which have both cognitive (4.3.0) and social foundations. Education (5.11.0), and libraries (7.2.1). Written language is often more formal than spoken language (11.3.3). Discourse (6.3.2). Reading as constructing meaning. This is related to playing games (11.7.0).

The experience of reading produces a number of cognitive psychological effects on the reader [?, ?]. While the subtlety of an argument cannot be evaluated automatically, readability is affected by the complexity of the words and syntax in a text. Reading requires human language understanding. Because language is redundant, it is possible for somebody with a weak vocabulary to augment their understanding by deeper analysis of the structural relationships among the terms.

From reading to storytelling (6.3.6) and orality (11.3.3). Reading technologies (5.11.5).

10.2.1. Reading Documents, Books, and Hypertexts

While we think of reading a sitting quietly with a book, in fact reading is a highly varied activity. Books (8.13.6).

Figure 10.23: Types of reading: A) boy reading, B) nutrition label, C) poetry reading, D) Social reading. (check permissions)

Reading is a complex cognitive activity. Scholarly reading environments. Reading aids. Long form presentation of arguments in books.

Hypertext increases usability of online material and allows the user many choices, but this can potentially lead to discontinuity as the reader moves from one topic to another. Often media are only loosely coupled. and there is a lack of continuity – some hypertext contents are fragmented, others are structured. It is helpful if hints are included about where links will take you. On one hand, there is a distraction from clicking and jumping to different topics but there is also an advantage of being able to move quickly to topic of primary interest.

Jumping into the middle of a document without a coherent introduction can be disorienting. Part of reading is understanding the structure of books. Readability and document layout structure such as page numbers. News headlines, lead with the main news.

10.2.2. (Reading) Literacy

Reading has long been regarded as important for active participation in society — so reading skills impact not only the individual who acquires them, but also society itself. Reading allows individuals to learn about their society's conventions, laws, culture, etc. Reading as integral to scholarship and critical thinking.

Assessing literacy in children. Technology and learning to read (5.11.5). Increasingly, the various literacies are converging. Practice in reading directly affects literacy.

Social factors affect the ability to access written information. Reading is often associated with critical thinking. Because the new information technology has vastly increased the ease with which images and audio can be disseminated, literacy may become less common, with speech communication becoming as general as written communication. We may move from the symbolic reasoning that results from reading text to thinking more pictorially and orally.

10.2.3. Reading Comprehension

Reading is more than processing individual words and sentences; it involves making inferences about the material being read. Fig. 10.24 shows a sample reading comprehension test. This task can also be used to evaluate the performance of automatic question-answering systems (10.12.0).

Discourse comprehension. Discourse elements and text cohesion (6.3.2). In many cases, reading comprehension is related to sensemaking.

Up to 40% of heating and cooling needs in the home are due to air exchange. In the winter, heat losses occur when heated air leaks out of the house. Energy must then be spent warming the cool air that replaces it. In the summer, heat gains occur when warm air leaks into the house; thus, more money is then spent on cooling costs.

One area of the house that may allow up to 17% of this unwanted air infiltration is around windows and doors. Energy waste can be cut by the proper installation of windows and doors.

Which of the following can be inferred from the above description?
1. Air infiltration around windows and doors adds about $40 to each month's utility bill.
2. Homeowners can save on their utility bills by reducing infiltration around windows and doors.
3. Additional air infiltration occurs around chimneys, electrical outlets, and light switches.
4. Infiltration is a problem in both the summer and the winter.

Figure 10.24: Sample reading comprehension task (adapted from[3]).

As a person reads, there is an interplay between low-level perceptual processes and higher-level cognition. For instance, excessive eye fixation on a particular passage suggests that it is difficult to understand.

Reading comprehension and expectations based on semantics, syntax and genre, and norms. Bartlett (4.4.3). Thematic organization. Exposition (6.3.3).

Importance of reader's background on understanding narrative (6.3.6).

Certain discourse structures can ease comprehension[16].

Macro-rules for reading and summarization (2.5.5, 10.6.2)[34]. Conceptual synthesis and inferences made while reading.

10.2.4. Skills Needed for Reading

Reading is not a unified, simple activity. Rather, people interact with documents in many ways. However, reading is not a simple or easily defined behavior. Let us consider how people interact with text documents. Reading for participation in a text-oriented society. We regularly use reading to acquire information[10]; it is also a source of great pleasure. Reading is a foundation for accessing information. Understanding conventions such as chapters and page numbers.

Information technology is changing the use of text. We have already discussed hypertexts and annotations. It is even possible to imagine the decline of reading and the increased use of verbal language because of multimedia systems and speech-recognition technology. Reading and linking. Can we improve on paper books.

Reading is probably best thought of as a set of skills which must be mastered[49]. We learn, for example, the direction of the text. We also become able to associate printed words with their corresponding sounds; phonemes and phonics are two tools used to acquire this skill. Phonics. Difficulty of the English alphabet code[44].

Eye fixations are shown for a simple text passage in Fig. 10.25. In addition to the words themselves, many factors such as orthography (10.1.1) and layout structure affect reading.

```
     0 21        3         4       5     6     8     7
position.  Ultimately, they will pick one of the candidates.

     9     10         11          12   13       1415 16
The candidate chosen by the committee will have to be notified.
```

Figure 10.25: Sequence of eye fixations while reading. Note the fixations on the most important words in the text. Also note that the order is not perfectly sequential[1]. (check permission)

Cognitive Availability of Text

Orthography (10.1.1) can improve the readability on a display. Fonts. Layout to emphasize meaning. Pull-outs. Fonts. Computer displays are often poor devices for reading. The fact that they are back-lit is one problem; another is the difficulty of drawing truly straight lines on a typical computer display. Online reading also involves scrolling, which some may find tedious.

Electronic presentations may have fewer external clues to provide reference points as memory aids compared to paper.

Well-written text should match the reading ability of the students for whom it is meant, for example, in the complexity of its vocabulary and structure.

10.2.5. Close Reading and Active Reading

There are many forms of reading ranging from quick scanning to "close reading". Pre-reading. Close reading is trying to understand in detail what the author intended and how the author accomplished those goals. Transliteracy. Disputed texts.

Textuality versus reader-response theory and conversational analysis. A poem is "what the reader lives through under the guidance of the text" [57]. Intertextuality compares texts and considers how they relate to each other.

Reader Response Theory. Literary reception theory. How much of the meaning of a work is in the work itself.

Active reading is a way to interact with documents. Reading hypertext and "meta-reading" [50][??] Potentially, hypertext allows people to navigate to the parts of the text that t meet their information needs.

People often like to interact with the material they are reading [10], [51]. For instance, students may underline or highlight sentences and make notes in their texts. They are "active readers". Fig. 10.26 shows highlighting added to an e-text (10.1.6).

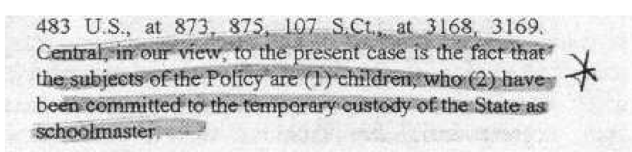

483 U.S., at 873, 875, 107 S.Ct., at 3168, 3169.
Central, in our view, to the present case is the fact that the subjects of the Policy are (1) children, who (2) have been committed to the temporary custody of the State as schoolmaster

Figure 10.26: Highlighting is one way to personalize an information resource[27]. (re-create) (check permission)

Reading requires continual integration of new information with a user's existing knowledge; this integration can be facilitated by reading aids that encourage assimilation of and reflection about the material. Titles, marginal notes, and structure markers may serve as "cognitive organizers" for readers [?]. Ultimately, this is a type of sensemaking. Cognitive organizers can also be graphical.

10.3. Writing and Text Communication

10.3.1. Writing and Authoring Text

Writing involves many types of cognitive activities, from motor responses to language generation. Indeed, writing may facilitate the assimilation of knowledge, as note-taking forces deeper processing of the material (4.3.3). The full process of composition involves language generation such as planning and revision. Writing is often done without fully knowing the audience. Writing as an ongoing content development process. Language generation (10.4.3). Information extraction (10.5.0).

Rhetoric in persuasive writing. Authoring multimedia (e.g., film). Argumentation (6.3.5). Constructing texts with complex argumentation[63] Argumentation zoning.

Mechanics of Writing and Editing

Writing combines complex motor responses with complex cognitive processes in composition. We discussed handwriting recognition (10.1.5). Handwriting and keystroke production are complex examples of motor behavior (4.2.4). Errors in typing may be due to motor or cognitive difficulties. Many of the errors are cross-hand transpositions such as typing "whihc" instead of "which". Word processing has changed the way writing is done.

Text entry on mobile phones.

Many alternative keyboards have been proposed as well as other text input modes such as pen-based entry and editing.

Authoring Text

Composing text is one type of language generation. Just as graphic design emphasizes using visual media to convey a message effectively, design can be applied to natural language to convey meaning and emotions, and to enhance clarity. This design allows for statements to be structured effectively, and for the construction of topics sentences. Language generation (10.4.3). Discourse types (6.3.2).

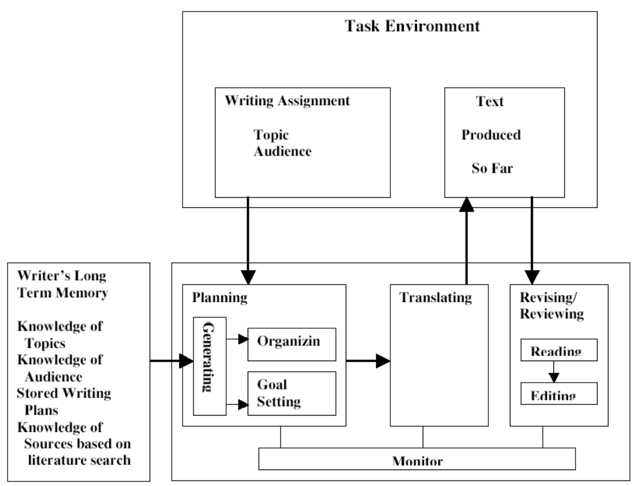


Figure 10.27: Schematic of writing and editing process (from[28]). The process shown here may be repeated through many iterations. (redraw)(check permission)

Writing and new media. More versions and the management and collection of those versions. Digital lives of authors. Cultural preservation.

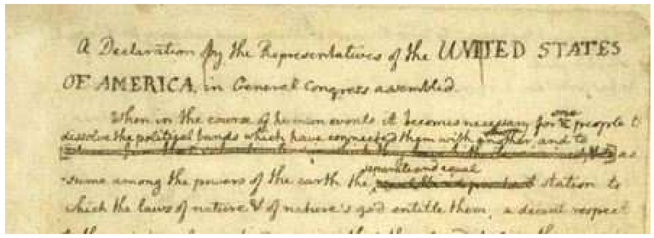


Figure 10.28: Here are edits to a draft of the Declaration of Independence. Saving the digital versions of an author or artist. (different example) (check permission)

Assessing Readability and the Quality of Student Essays

Student essays teaching reading. Perhaps surprisingly, statistics can help in assessing good writing. Good writing should be easily readable, and there are two easily measured factors that contribute to the readability of a text: the number of words/sentence and the number of syllables/word[61]. These are combined as shown in Eq. 10.1 to determine a Reading Ease score. Text coherence.

$$Reading\ Ease = 1000 - (5 \times \frac{words}{sentence}) - (400 \times \frac{syllables}{word}) \quad (10.1)$$

Reading Ease is one component of essay-grading scores (-A.6.4). The reduction of readability to such a simple formula as this is frequently criticized. Style, layout, and font also have an effect on readability. Student writing is highly variable, and it is often difficult for teachers to assess it fairly. In some cases such as writing samples on a large standardized test, tens of thousands of essays may need to be scored with as high a degree of reliability as possible. Some standardized tests are graded by one human reader and one automated reader. One strategy for automatic grading employs information extraction would look for high counts of words such as "because" that suggest the author is giving evidence for his or her arguments; this is seen as a sign of good writing. Fig. 10.29 shows two paragraphs rated by a technique discussed in (10.3.1). (-A.6.4)[22].

> The human heart is divided into two parts: left and right. In infants this division of the heart is not so clear as it is in adults; although by the age of one the division becomes clearer. The heart receives blood, and pumps it to the other organs in the body, so they can perform their functions. Most important the heart pumps blood to the brain so it can dictate to the other parts their daily functions...

> The heart is the main pump in the body that supplies the rest of the body with oxygenated blood by way of the arteries. There is a reaction that takes place at the ends of the arteries where the oxygen is taken out of the blood and replaced with CO_2. This reaction takes place in the capillaries. The arteries branch to become smaller and more numerous, these are then called arterioles...

Figure 10.29: Excerpts from two essays about the circulatory system which were graded by Latent Semantic Analysis. The first excerpt was given a low score (1 out of 5) while the second excerpt was given a high score (4 out of 5)[37]. (check permission)

10.3.2. Text Communication and Collaboration by Text

Text messages are widely used for communication between people. Because of bandwidth limitations and computer capabilities, interaction via text is still very common and effective. Because transmission of text is cheap, it is widely used, and supports a wide variety of collaborative services such as online chat, emails, newsgroups, online chat is an interactive, live, text discussion.

Communication modalities (5.6.5).

Social interaction mediated via text. Creating online communities (5.8.2). Collaborative tasks and facilitating coordination. Conversation (6.4.0).

Telephony and connectivity (5.1.5).

Email

y Unlike chat or live telephone calls, email is asynchronous. That is, once an email message is sent, it can be stored until the recipient is ready to access it. Email readers also receive metadata such as the email address of the sender and the date it was sent. Email introduces new features such as replying to messages while appending previous messages; thus, a thread is created that provides a context for the message. Because of its flexibility, email is more effective at facilitating social interaction than many tools which have been developed specifically for that purpose.

Email is an asynchronous medium. Unlike synchronous interaction, the synchronous interaction in email includes reflection about the dynamics of the interaction.

Texting. Mobile service.

IR for non-standard content (10.11.1). For instance, email files can become archives and can be searched. Fig. 10.31 shows a fragment of the email protocol. This involves aspects such as linking of email files, finding conversation threads, and determining social networks (5.1.0). Using roles and honorifics in determining group structure from email archives.

> Correcting HTML seems a pretty hard problem. Tidy makes a
> valiant effort and gives us a good start on the job in many
> instances. Doing everything might be more than can be hoped for.
> Try making a long outline in MSWord, save it as HTML, and then
> try to clean that up.
I succeeded in being able to infer a noframes element and in
moving the trailing body inside the noframes, and in placing
the new noframes within the outer frameset. The fix is part of
the April 15th release.

Figure 10.30: Sample email exchange (from TREC). (check permission)

Emails and social norms.

Email spoofing. Email mining. Privacy records.

Gmail and advertising. Increasingly, spam leads to security attacks.

Filtering Out Spam Filtering can also be used to block the presentation of unwanted material such as spam. It is difficult because the topic of the spam is not known. However, the accuracy of these filters is often low; for instance, filters may be tuned only for English. One of the most successful techniques is filtering based on linking (10.10.2); for instance, sites containing pornographic content are often linked together. This may be used to filter spam. Among the specific methods which have been proposed are communications procedures, Bayesian filtering (-A.8.2), and collaborative filtering. It's harder to determine what the user will consider junk.

Two methods. User authentication. Sender bond which is something like a stamp. Essentially, this is the reputation of the sender (5.2.2).

1ow cost 1nsuranCe
personal Medic@ti0n

Figure 10.31: Examples of mis-spellings which are indications of spam.

About 90% of email traffic is spam[7]. Because it is a free good, it is abused. A spam filter could be based on text processing principles. Filtering out (10.3.2). Another alternative would be to change the nature of the email service. A service could require a "stamp". Another alternative would require a valid return address for a message to be valid. Blacklist.

Newsgroups and Threaded Discussions

Extended and ongoing discussions may help to form a community (5.8.2), as a discussion might evolve from threads to concepts to topic-oriented threads. Discussion groups often branch off into very different topics and it would be helpful to have tools for keeping the "threads" of these discussions straight. This may be seen as an evolving hypertext, although threading gives it topical continuity. Structured conversation.

Roles for a group discussion; a moderator may manage, focus, and re-conceptualize topics to facilitate discussion. A "lurker" will observe a discussion without contributing to it. Newsgroups are a favorite haunt of lurkers. A "newbie" is somebody who is new to a group. Social networks (5.1.0).

Netnews as a content archive, DejaNews.

Indexing threaded discussions.

Supporting Collaborative Interaction with Information

We have seen many forms of collaboration, Collaborative organization (5.7.0) and communities (5.8.2). This is one type of collaborative task and groupware environment (5.6.2). An activity associated with organizational sense making (5.7.3).

Tools to support collaborative search. Shared retrieval versus collaborative understanding. Information commons.

Collaborative creation of knowledge. Collect information from a range of people[66]. This is an aspect of Web 2.0.

We have considered question answering in many places in this text. Get people to answer questions like reference service (3.3.2). Yahoo answers. Difficult of spam in responses and picking best one. Characteristics of users.

Encyclopedia. Wikis have proven effective as a platform for communities to organize and discuss issues. Wikipedia as a organizing system. Very good for some topics. Probably less accurate where somebody has a vested interest in certain perceptions. Possibility of a concerted attack on Wikipedia. Contrast this to traditional scholarly communication (9.1.1). Particular emphasis on popular culture.

Wikipedia is the community-edited encyclopedia. Wikipedia facilitates a neutral viewpoint by allowing open commentary. It is disputed how well that works in practice. It has evolved a number of governance mechanisms for ensuring quality[23]. Among the principles are that contributions are verifiable and that no original research is published. On the other hand, issues of the reliability of information ((sec:informationqulaity)). Criteria for articles: notability. Verifiability. Responsibility of a individual for the credibility of the information. Social transparency.

Wikipedia and as an online volunteer community (5.8.2).

10.4. Natural Language Processing

Language processing has many applications. Given the ubiquity of natural language we may consider how to process it automatically. Text retrieval and many other tasks may be considered as natural language processing. In text and natural language processing, shallow methods may be distinguished from deep methods. Shallow methods may include rules of thumb; deeper methods include full parsing. Speech processing and linguistics (11.3.3).

To what extent can the text be processed in a way that preserves meaning. The traditional model of language suggests it can be decomposed into several levels: words, phrases, sentences. There are many levels of language processing. Here, we consider processing for basic components such as words and then consider tasks that involve processing entire documents. We focus on methods appropriate to this breakdown; later, we consider statistical approaches to text-processing.

Figure 10.32: A portion of the log of editorial discussion on the Wikipedia article on the Boxer Rebellion (accessed on Sept 1, 2007). Note the editorial comments inserted into the head of the article. (check permission)

Lexical resource. Corpus linguistics.

10.4.1. Word-Level Processing

Spell Checking and Correction

A simple spell checker looks through all the words in a document and matches them against words in a dictionary. If a mismatch is found, the program may generate a word that may be what was intended. Several algorithms have been developed for determining the similarity of two words. Suppose a misspelled word were found in a document; candidates in the dictionary for the correct word are proposed to replace the misspelled one. The misspelling might come from a missing letter, an extra letter, or transposed letters. Suggestions for the correct word could be obtained from a calculation similar to the edit-distance calculation below. Suppose a person had typed "INFORVATION" into a word processor. The spell check program might compare that word to its dictionary. The easiest way to make this comparison is with "approximate string matching". If the dictionary contained the terms "INFORMATION" and "INNOVATION," the steps for finding edit distance are shown in Fig. 10.33. Several constraints can be added to these simple word-distance measures. For instance, we might weight possible spelling errors by the likelihood of their occurrence.

Steps	Change	Cost	Current Guess
0	original		INFORVATION
1	V->M	2	INFORMATION

0	original		INFORVATION
1	F->N	2	INNORVATION
2	drop R	1	INNOVATION

Figure 10.33: Finding edit distances between an incorrectly spelled word and two candidates from the dictionary. The term "information" would be selected as the match because fewer steps are required to match it with the incorrectly spelled word.

The second phase is spelling correction such as for queries submitted to a search engine. Specialized situations. Learning spelling from previous example. Spell correction by learning from web queries. Examples of the mistakes some people make and how they are corrected. Based on expectations. Spell correction based on examples.

Word-Sense Disambiguation

Word-sense disambiguation determines which sense of a word is meant in a given context. People can often distinguish between word senses with a very brief context of surrounding words. One word sense in any given discourse. Many attempts have been made to automate sense disambiguation.

Word Segmentation

Earlier we discussed segmentation in OCR (10.1.5). For some languages, words run together when they are printed and this requires segmentation. An example from German would be *weltanschaung* or world-view — this is the perspective a person brings to their interpretation of events — where "welt" means "world" and "anschang" means "view" Dynamic programming can also be used for effective segmentation.

Part-of-Speech (POS) Taggers

As we noted earlier, parts of speech define highly structured language. Part-of-speech tagging is often used for language checkers such as those found in word processors; they are also useful for determining phrases (6.2.2). A simple, but inefficient, approach checks all words in a dictionary for all possible parts of speech that they can assume. Ad hoc rules could then be applied to improve on the original guesses [15].

10.4.2. Syntax and Parsing Natural Language

We have described the importance of syntax in (6.2.2) and we have already discussed parsing of formal grammars (6.5.1). If we focus on the syntax of a statement to understand it. In the sentence: "The cotton sails on the wind". it is essential to know that "sails" is a verb rather than a noun. This can be determined because there is no other word in the sentence that is likely to be a verb. Generative models.

Grammars can be also implemented with augmented transition networks (ATNs) (6.5.1) though the notation is not as compact.

Rule-Based Models

Earlier, we examined parsing formal grammars (6.5.2). Determining grammatical structure is one of the most obvious strategies for language. Grammars are often assumed to be the representation for natural language. Parsing attempts to identify the components that underlay a sentence. Fig. -A.40 shows an example of re-write rules and a lexicon for a highly simplified sub-sample of English. A number of parsing algorithms have been developed some of them are summarized in (-A.5.4). There is a particular problem of parsing ambiguous example sentence the "man on the hill".

State machines (3.10.1). Garden path sentences. ?The man who hunts ducks out on weekends?. Uncertainty and NLP state models. Toward HMMs.

Statistical Models

State machines make transitions from one state to another. by the fulfillment of certain conditions. These machines can also be probabilistic; "weighted automata" have probabilistic transitions between states. Similarity rather than categorization.

10.4.3. Text Generation

How can a computer make appropriate statements about the world? Many tasks are closely related to language generation such as the generation of explanations, translations and summaries. Human language generation may be modeled on several of the same strategies used for planning (3.7.2) such as generating and testing means-ends analysis.

The problem of language generation may be broken into two parts. The first is generating a natural language description from a symbolic representation. For instance, we might generate the description of a computer program. Fig. 10.34 shows several stages for such a description[46]. The basic concepts with an ontology (2.2.2). the description is organized (discourse planner, Section 6.3.2), words are chosen (lexicalizer), and finally a surface generation is produced. Text generation to accomplish pragmatics, not just semantics.

Stage	Description
Plan Generator	Determine goal
Ontologizer	Decide what concepts need to be included.
Discourse Planner	Decide how the concepts should be assembled.
Lexicalizer	Select words.
Surface Generator	Develop coherent surface text from the selected words.

Figure 10.34: Stages in language generation when starting with a formal specification (adapted from[46]).

Often, relatively simple rules can support generation. One such rule would be to give a full description of a named-entity the first time it is introduced. In other cases, sentences can be combined; for instance, in Fig. 10.35, the two sentences in the first line can be combined as shown in the second line to eliminate redundancy. This is an example of the rule that creates a modifier at the beginning of a noun phrase [46]; in other words it creates "ellipsis".

Camilla Jones visited 31 patients. She is a doctor.
Doctor Camilla Jones visited 31 patients.

Figure 10.35: The surface generator might combine two sentences (top) into one (bottom).

One of the maxims of communication is that material be adapted to a situation and recipient or user. User models (4.10.2) can be applied; from some of these, base-rate expectations are established about how to respond to a user (e.g., an automatic system for selling train tickets) with appropriate level, word choice, and sentence complexity. Sometimes high-level organization is required. One needs to know not only about the recipient's knowledge but also about the environment in which that person is working; for example, whether tools are available and what they are.

Complex text generation shares some similarities to conversation because it takes into account the goals of the reader. Thus, it needs to consider both user models and task models. However, the audience is often less well-defined; traditionally text is more formal.

Unrestricted conversation development is still difficult. Successful language generation applications often build from well defined specifications. Ultimately, language generation should include speech generation (11.3.3) and even extend to the coordination of expressive modalities such as gestures, glances, or hesitations in speech.

10.5. Information Extraction from Text

A lot of information is stored in text documents; these can be documents that were originally created as text documents, or scanned images of older hard-copy files. While this information may technically be available for the gathering, it can be difficult to extract it in a systematic way. Information extraction methods attempt to find from within a complex document its most essential information, such as dates, numbers, names, etc. These few facts could be sufficient for simple question answering (10.12.0).

Extraction from semi-structured data sets. For instance, find a name or a date on a web page.

Simple text-processing methods[29]. This is useful for question answering (10.12.0), automatic metadata and semantic annotation assignment, summarization (10.6.2), and mining blogs.

Because many concepts are complex, with multiple elements contributing to an overall idea, it is difficult (currently impossible) to create a system that understands complete concepts. It is easier, however, to find concepts associated with specific terms. Knowledge-based extraction, though an improvement on techniques based on key words or numbers, is a still shallow method for extracting some information from text. It looks for specific patterns, either of individual words, or more complex, but regular, arrangements. These regular arrangements could be numbered instruction lists, for example, or directions — both of these things tend to take the same format, and could be searched for using knowledge extraction techniques.

Language has a lot of structure beyond syntax. For one thing, structured information allows a program (and those creating it) to form fixed expectations about what information and attributes a document will contain, where it will be contained, and how it will be presented. Many of these methods are "lightweight"; that is they do not attempt to analyze the meaning but use only surface clues (10.4.0).

Using templates.

Discovering new facts from a collection.

10.5.1. Named-Entity Extraction and Entity Resolution

Names provide generally distinct identifiers (2.2.1). They are helpful in understanding text such as a news story. Names in text have a variety of distinctive clues [47] that identify them. They are usually capitalized, and, grammatically speaking, are treated as nouns. A variety of techniques can be employed by a system when attempting to distinguish people's names from place names or other possible confusions, such as the use of "Mr." or "Mrs." or the proximity and semantics of certain word combinations. Multi-tiered and cross-referenced screening processes can provide strong evidence of the use and type of proper name (10.4.0). There are, however, difficulties in named-entity extraction techniques; Fig. 10.36 illustrates the fact that even names can be ambiguous.

1.	Washington gave his Farewell Address.
2.	I drove to Washington.
3.	The boat was near Washington.

Figure 10.36: Is Washington a place or a person in these examples?

Finding all references to a given individual can be very difficult. Washington might also be referred to as: The "father of his country", the first President of the United States. Many names are in common: "James" and "Jane". Same-person with different names, different people with the same name. Named-entities and name authority (2.2.1). Social networks. Named-entity disambiguation.

Further, the specific type of named-entity can sometimes be identified from the surrounding context.

Semantic annotation is adding semantic descriptions to objects. These descriptions are often drawn from ontologies.

Because it is relatively robust, POS tagging (10.4.1), is a good place to start for named-entity extraction.

Named entity extraction as feature extraction.

Using a name authority for named entity extraction.

Lists of known names are useful for disambiguation.

Entity co-reference problem. Co-reference resolution.

Types of named entities. This is useful in question answering.

Creating an index of named entities. Using the Web to extract named entities because the Web is so large that there is a lot of redundancy.

10.5.2. Extracting Conceptual Relationships using Verbal Templates

Frames are structures for information. Some information can be extracted into a frame [8]. Frames and templates lead to document segmentation (10.1.5). This segmentation can be helpful for metadata extraction, but it can also cause concepts and information to be presented too simplistically, or even incorrectly Fig. 10.37 shows some examples of templates.

Structure may provide useful clues. A classified advertisement often has a predictable structure. Similarly, modeling the structure of a table is essential for extraction of content from those tables.

IF you go to the store **THEN** please buy some bread.
WWW **STANDS FOR** World Wide Web.
a car **IS A KIND OF** vehicle.
ON ONE HAND Jane was happy **ON THE OTHER HAND** Jill was sad

Figure 10.37: Linguistic templates can be mined to extract useful information. Here are some template markers highlighted with bold font.

For complex information, establishing what category is associated with each word and dealing with co-references between information categories is hard to do with complete accuracy. Much of a template's functionality is determined by its construction; there must be both flexibility and specificity to make information extraction possible or effective.

One way of accomplishing this information categorization is to apply statistical analysis to information to establish the parameters, or rules, by which the observable content is defined. While there are different methods, Hidden Markov Models (HMM) are particularly apt in that they work backward, deriving the underlying parameters from an aggregate of data that display visible patterns. These findings can then be fine-tuned for further accuracy.

10.5.3. Applications of Information Extraction from Text

Factoid extraction for question answering (10.12.0). Consider the statement "Marie Antoinette was the last Queen of France". This may seem obvious enough but consider the wide range of knowledge it implies and the additional facts that are needed to make sense of it and put it into context.

Information extraction for semi-structured texts. Fact Book for question answering.

Wiki extraction. [2]

Using clustering and concurrence clustering.

More complex is extracting evidence from many Web pages. Combining evidence from many sources.

Association rules. Market-basket analysis attempts to find interesting relationships among concepts.

Attribute Extraction and Ontology Extraction

It is difficult to build an ontology (2.2.2). Perhaps that could be automated. This would be useful for question answering.

More ambitions is use the templates into a collection of facts so we could call the entire process "fact extraction". This can be useful, for instance, in automated question answering (10.12.0).

Attribute extraction. But, of course, attributes are not always clearly defined for categories (2.1.3).

Ontologies are very costly and time-consuming to develop. It would be helpful to extract them automatically. Find local context such as related words in a sentence.

Argument Extraction and Discourse Processing

Use templates to identify discourse structures (6.3.2). OPV. Discourse markers are often subtle and difficult to extract automatically.

Examples

Figure 10.38: Difficulty of extracting opinions. Irony

Detecting Opinions and Differentiating Conflicting Viewpoints

Based on discourse analysis (6.3.2). Attitudes (4.5.2) and affect (4.6.2).

Detecting buzz (8.4.3). Sentiment analysis. Movie reviews. Restaurant reviews.

The basic level is fairly easy: Mining opinion words and valence words. Using templates and heuristics. This can be used for processing phrases such as "The food is good".

Extracting opinions versus extracting facts. Opinion summarization. Feature-by-feature comparison. Determining the spectrum of opinions.

Considerably more challenging is the extraction of satire, sarcasm, and irony.

Review 1. We stayed here for a weekend trip. We checked in around 1pm but they didn't have any rooms ready so we had to wait about 20 mins. When we did get our room, it was worth the wait. Very spacious and modern design. Clean and comfortable. The fridge and microwave were very handy for us.
Review 2. This is the second time I have stayed at this hotel. I was in room 204. I thought it was average the first time. I was less than impressed this time around. The room looked dirty. Then I start tearing the beds apart to look for bed bugs (thankfully I found none) but I saw a long strand of hair.

Figure 10.39: Reviews example.

10.5.4. Content Analysis

Qualitative and quantitative content analysis. Often a numeric analysis of properties. Sentiment analysis (10.11.2). Discourse analysis (6.3.2).

Word Bursts in Text Streams

[35] Query streams. Communication models.

Resolving Disputed Authorship

Authors impart very distinctive characteristics to their writings. The *Federalist Papers* are essays published in the 1780's encouraging the adoption of the U. S. Constitution. They were written by Alexander Hamilton, John Jay, and James Madison. Most of them were published under their author's name. However, the authorship of some of the papers is a matter of debate; some historians attribute a given work to Hamilton and others to Madison. By analyzing the word frequency, we might identify the author's characteristic pattern. An analysis of word frequency applied Bayes Rule (-A.8.2) to characterize the words selected by the two authors[48]. This Bayesian model was then applied to the essays whose authorship was uncertain and the author was identified with a high level of confidence. [38] This is a type of behavioral signature.

> A fifth desideratum illustrating the utility of a Senate is the want of a due sense of national character. Without a select and stable member of the government, the esteem of foreign powers will not only be forfeited by an unenlightened and variable policy, proceeding from the causes already mentioned, but the national councils will not possess that sensibility to the opinion of the world, which is perhaps not less necessary in order to merit than it is to obtain, its respect and confidence.

Figure 10.40: The beginning of Federalist Paper #63 whose authorship was originally disputed. The Bayesian statistical analysis assigned this essay to James Madison.

10.5.5. Literary Analysis

Stylometry.

How do authors affect each other's writing.

10.6. Text Categorization and Summarization

We described indexing earlier (2.5.3). Automated indexing can be considered a language technology.

10.6.1. Text Categorization and Classification

There are many aspects of language which need to be categorized: POS, topics. speech acts (6.3.1). The detection of spam (10.3.2) is a text categorization problem — text filtering techniques are not wholly successful at identifying the subject or type categories of email (3.2.3).

There are two ways in which text categorization can be accomplished: through a priori categories and through ad hoc categories. A priori categories are predetermined categories; using them, a document is placed into the category that best fits its subject matter. This is a general classification system (2.5.1) or subject hierarchy, such as the Dewey Decimal Classification system. Relevancy signatures[56] may be included to illustrate how strong is the thematic link between a document and the category that contains it![??]

Adaptive categories are created in response to the subject matter of different documents. This method may give a more descriptive account of documents content, but it is also difficult to locate such adaptive categorizations into a larger system.

Statistical models for classification. (-A.11.2). Feature extraction. When a set of examples is available, they may be used for training (-A.11.0), to categorize texts without human input. Word distribution, frequency statistics, and overlapping word strings can be combined with information filtering (3.2.3) to facilitate the creation of document hierarchies. Other methods include Bayesian learning algorithms (-A.8.2) and linear regression models[69].

10.6.2. Text Summarization

Summarization has many uses: meeting archives could be summarized for fast comprehension, instructional and how-to books could be summarized to identify particularly apt sections, stories can be summarized to identify interest, etc. It is often helpful to get a quick impression to understand a long text in a short time. Supporting a variety of inter-related information needs. Relationship to abstracts (2.5.5) and tutoring (5.11.3).

Summarization, though seemingly simple, is a very complex process that speaks to the core of language understanding difficulties. Summarizations generally need to be based on semantic relationships and logical order. It is helpful to start by identifying the structure of a text, and likely its summarization. Multimedia summaries. Problems of including different information.

Extractive Summarization

Extractive summarization plus smoothing. Abstractive summarization and text generation. Problem of pronouns.

The simplest approach to creating summaries simply extracts passages. One statistical method for this uses $tf{\cdot}idf$'s, which are term-weighting measures used for text retrieval (10.9.2), and stand for term frequency and inverse document frequency, respectively. Sentences within a text that have the highest $tf{\cdot}idf$ are considered pertinent, and can be used to create a summary.

Query-term methods.

To a limited extent, this can be achieved using concept maps and discourse. Other methods, such as statistical and rule-based systems can also be used. Statistical analysis, using semantic understanding and word charts, can be performed on a text and can, to a limited degree, determine the most useful sections to keep in a summary[59].

A particularly effective technique is to take intermediate frequency words[42] and find sentences with those words (10.9.2). Templates can be helpful in summarization.

Extraction followed by fusion. Among the problems is minimizing redundancy.

Abstractive summarization. Use a semantic grammar (6.2.3).

Task-Specific Summarization

A summary might be constructed as a response to a user's query. These can range from current awareness abstracts (2.5.5) to responding to specific user's query[4] and explanations (6.3.4). This latter is similar to question answering; though, the content is based on a single document. This entails not only the difficulties of automated summarization, but also those of question answering. In a sense, this would function as both a simple search engine, pulling up documents that fit a user's query, but it would advance a step further and summarize the most important information that those documents contained.

A summary could then be made interactive. That is, a user could highlight information within a summary that was either very useful or not useful, and the system would re-generate the summary based on that feedback. As a particular individual or category of individuals (based on job type, for example) use a system more, that system could generate a model of their information needs and retrieve and generate information according to those parameters. This effectively becomes a tutoring system which tends to put answers in a context that a user can understand. Indeed, this type of summarization can be seen as similar to query-oriented question answering (10.12.0).

Summarizing Multiple Text Documents

Beyond coordination of documents to coordination between collections. Certain elements of query-based summarization require that an information system be able to glean information from multiple sources and synthesize it. This could also be termed "document compilation". Multiple document summarization[45] provides a summarization of the information contained in a collection of documents. This is not only helpful for query-based summarization, in which information pertaining to the query may not be contained in a single document, but it also proves helpful to give an indication of the differences among related documents[43].

News summarization often gives extra weight to the ordering of information since in news stories the most important information is often presented early. Topic themes in multi-document summarization. Discourse processing.

Comparing articles.

10.7. Search Engine Interfaces and Interaction

Search and information needs (3.2.1). Search engines typically support simple queries. Document structure (2.3.1). Taxonomic organization (2.2.2). In the past few years, search engines have gone from being a relatively obscure academic specialty to the transformation of society. Cognition and usability (4.8.0). HCIR. Combining social search with search engines.

Search results presented via an app.

Conceptual models for interaction with search engines [**?**].

10.7.1. Using Search to Interact with Collections of Text Documents

Searching is one way for a user to interact with a collection of documents. Indeed, the Web would barely be useful without search engines. In these sections, we are primarily concerned with how this can be enhanced. Indeed, this interaction might be seen as a conversation; a user asks a question of a collection in the form of a query, and the collection respond based both on its content and the manner in which the question was phrased. A searching interface should be designed to support all aspects of this conversation. Because information needs are often complex search interaction can be very complex. Beyond the desktop metaphor.

Anchoring a query with one term and then making revisions to it.

Understanding how a person searches by following eye movements (Fig. 10.41).

The full range of interaction involves a combination of the user, the task, the corpus, the interface,

Figure 10.41: Eye movements during examination of a search engine results page. (from Cornell). Note that the user is focused almost exclusively on the first two returned results. (check permission)

and the retrieval algorithms; having access to this complete range of aspects allows the user to address larger tasks and to build information environments, and not simply to search (3.5.4). The ease of a user's interaction with any of these aspects is largely determined by interface design.

Privacy and browsing history.

Search Engine Query Logs

Can be used for targeted advertising or for improving services.

10.7.2. Using, Forming, and Modifying Search Engine Queries

Earlier, we considered strategies a trained reference librarian might use to improve queries. Based on information needs (3.2.1). Here, we can consider query management in terms of ranked retrieval. A large number of queries consist of only one word[14]. This can be difficult if my query were "Russia" or "Beatles" what would you infer as my information need? What would be the results to return. A particularly wide range on issues for Web queries (10.10.2).

Earlier, we considered systematic search strategies (3.3.1).

Query characteristics. One or two words.

Interface tools can help a user develop effective queries. The difficulty users have when constructing Boolean queries can often be alleviated by utilizing graphical interfaces. These could be designed in a way to first support the creation of a query and then aid in its reformulation for more pertinent results.

Query Categorization and Analysis

Query signals: "Swiss Baker Alpena" For instance, names are most often entered in natural order. Query term order.

Like question categorization (2.1.1), it is also helpful to categorize queries. Automatic processing of the query. Does this query include a proper name? This is analogous to the discussion of question types (3.2.3).

Query Expansion

If we have a query with the term "car" it is probably reasonable to expand that query with the term "automobile" so that both terms can be presented to the search engine. There are often difficulties with exact-term techniques because alternate semantic forms of the words are not included in the search. Or, there are other plausible search terms. One approach is to use thesauri (2.2.2) to expand the query. The query term "boat" might be expanded with "yacht," "barge," "freighter," and "ship". This would increase the number of documents returned, while at the same time preserving their pertinence. Unfortunately, it is also possible that the wrong word sense of the query term will be selected, and the query expansion will generate irrelevant words. This often occurs with homographs, such as wind (to wrap around) and wind (breeze).

Example of query expansion. Fig. 10.42

Query expansion.

Figure 10.42: Examples of query expansion.

Relevance Feedback

Relevance feedback employs terms from documents which the user has indicted as the most relevant one retrieval. Frequent terms from those documents could be added to the original query. after one set of responses has been received from the search engine, the user can select what items have the most relevance, and the system will use these rankings to help the user construct a more accurate query. A user asks the system to return "more documents like this" (Fig. 10.43).

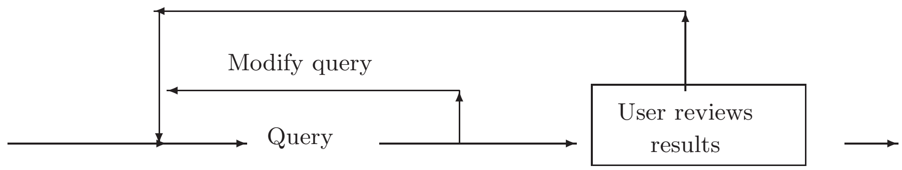


Figure 10.43: Relevance feedback example.

In addition to positive relevance, negative relevance feedback must also be included when using relevance feedback to modify a query; the characteristics of documents selected as "not relevant" can be used to restrict the type of documents returned on subsequent retrievals.

Query Development and Re-formulation

Many routine queries are reformulated. Query assistance.

As we noted when first discussing search, users will frequently revise their queries. Fig. 10.44 illustrates how a manual document query reformulation might occur. Other difficulties with queries can be more easily solved; spelling errors in queries can be fixed by the inclusion of a dictionary program into the text search field.

Query development and controlled vocabularies.

Interfaces, Stages of reformulating a query.

Figure 10.44: Examples of reformulating a query.

Supporting Complex Queries

Complex queries (3.2.3). Using search histories.

10.7.3. Examining Search Results

Following a search, the user browses. Search followed by browsing. Combine aspects of the two processes with a graphical interface. These are tools which could be attached to an information workspace or a document management system.

Terms in context. Identifying results and telling us more about them.

This gets us into the more complex task of retrieval of highly complex searches (3.2.2).

Document Surrogates

When the documents are returned, they need to be described by surrogates so the searcher can judge whether the documents with which they are associated are relevant to the information need (3.3.3). Typically surrogates include metadata and brief metadata descriptions or summaries (2.5.5).

Visualization Search Retrieval Interfaces

Although ranked retrieval is simpler, some sophisticated users prefer Boolean retrieval procedures, because it is easier to understand how to modify the search, as this is part of the users' models for how the search engine works. We will see general visualization interfaces (11.2.5).

Duplicate detection for web page search engine output.

These interfaces do more than simply showing surrogates, they can provide interactivity for rapid exploration of the result sets. In particular for comparing different attributes.

The Vibe[52] interface for browsing the return document sets (Fig. **??**). There are reference or anchor points among which retrieved documents are positioned. In this example, a set of eleven documents is positioned across a space generated by three terms.

May perform set operations on query returns.

Viewing the distribution of terms within a document.

Categorizing Search Results

Categorizing search results is essentially developing a table of contents for the results. Automatic classification. Part of categorization involves clustering document return sets[12] (Fig. **??**).

Similarity within categories.

It helps to have an established metadata set.

Sometimes there is a focus on individual aspects of searching, sometimes on entire tasks. Coordination across windows. As noted earlier, managing the search may be contrasted with managing the task completion (3.0.0). The focus of interface design can move from supporting word search to full task support. Desktops can be maintained with queries in progress.

10.7.4. User Issues and Interfaces for Web Searching

Search engines have proven to be very powerful but they do not support complex search very effectively [30]. Because the Web is so varied, perceived effectiveness is often important for commercial search engines, which depend on their customers believing they have done a good job. Search behavior (3.2.3). Re-visitation.

Applications of searching in a heterogeneous knowledge sources such as the Web. Web site design Earlier we described the Web as a common-use hypertext, (2.6.3).

Web Page Filtering. Some Web pages, may be dropped from search engine results. This is similar to spam filtering (10.3.2).

Interfaces for Web Searching

Unlike collections of separate documents, Web documents are richly linked together and it should be useful to maintain that linking in access. Just as we considered interfaces for browsing the results set of a text retrieval interface, we can consider interfaces for browsing Web searches. These are not simply hierarchical connections.

Providing context for search hits.

Visualization tools for showing search results.

Related Web pages which are retrieved may be grouped together even beyond ranked retrieval[18]. It presents a hierarchical view of pages that reflect the internal structure of Web sites that have pages that match query terms.

10.7.5. Web-Based Collections

Using a search engine to find child-friendly materials.

10.7.6. Personalizing Search

People often repeat searches. Problem with personal relevance.

Desktop Searching

Desktop searching. Such as Gmail. Personal information management (4.11.0).

10.8. Web Search Engine Business Models and Policies

Because searches often reflect a searcher's needs, a search engine is a good place to advertise. This can be done by auctioning search terms. The search engine company needs to guarantee neutral rankings (8.12.5).

Search result ordering as free speech.

Sponsored search. Advertising campaign. (8.12.5). SEO (8.12.5). Because many users are led to Web pages by search engines, some Web site designers who want their sites ranked by those search engines add spurious text to Web pages that will be picked up in Web indexing processes. This is known as "keyword spamming". A variety of techniques have been developed. These include link farms.

Search results as free speech or as a utility. Neutrality in search engine results. Avoiding bias. Transparent search ranking policies.

Search engines presenting service directly rather than search results.

10.9. Search Algorithms

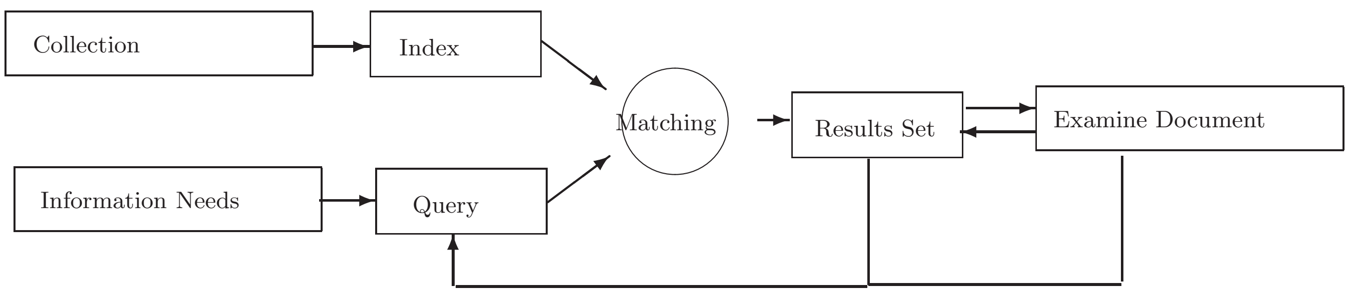


Figure 10.45: Recall that during search the user's needs have to be coordinated with the indexing system.

Represent a document in the context of a collection.

Term and vector indexing. Social media. Linked data.

Standard search methods tend to employ exact matching, which returns sets of documents based on exact keyword matches. Statistical methods, on the other hand, use various formulas to match documents to a query based on statistical similarity. Perhaps surprisingly, the techniques of natural language understanding and processing generally (10.4.2) are not as effective as purely statistical techniques. The decision to implement a text retrieval system is not based only on effectiveness. Many factors, such as effort and cost (3.3.3) can guide system selection.

Normalization and indexing.

10.9.1. Content-Based Models: Text Retrieval via Term-Matching

The simplest techniques approaches treat text retrieval as a data retrieval problem. Significant words from a text are stored in a database, and documents containing those words are returned in response to a query. To return all the news stories about "California," exact term-matching would find all news stories that contained the word "California".

The inclusion of metadata searching can increase a searcher's effectiveness. A search that is limited to the words that appear in the text often have difficulties returning pertinent results. One difficulty is the return of spurious matches. Using the example above, spurious returns might include stories that referenced California Avenue in Washington D.C., or California University, which, curiously, is in Pennsylvania. Alternatively, when multiple terms are in the query as keywords, we say the query is "over-specified". While there may be a chance that all of the selected terms will be present in a single document, it is much more likely that nothing will match the terms exactly, and no documents will be retrieved. This approach is similar to database retrieval although it may be made more efficient with data structures such as an inverted indices.

The basic term-match model can be extended in several ways, such as utilizing Boolean (3.9.2) combinations of terms. Other ways of applying the term-match model include adjacency and proximity operators: "immediately adjacent to," "within the same sentence as," "within three words of," etc. An illustration of the usefulness of these types of searches is that a search for the Federal Bureau of Investigation is quite different from, and will return very different results, than a search for a "bureau of federal investigation" or the "investigation of a federal bureau". This can be a phrase search.

Simple term-matching can be extended in several ways. These may search various fields of a database or a collection's metadata and allow users to specify search criteria for each one. The more search criteria that are selected, however, the greater are the chances of over specifying the search and retrieving no documents; these are known as fielded searches.

Proximity search.

10.9.2. Ranked Retrieval and Term Weighting with the Vector Space Model

Both simple Term Matching and Boolean techniques return an unordered set of documents — any document that contains a term that corresponds to the search criteria will be retrieved, and a document that contains one instance of the term will be given the same weight as a document that contains five instances of the term. Ranked retrieval methods attempt to rank documents according to how well the system believes they would answer the user's question. Generally, these ratings are based on a statistical measure of similarity.

Representing the Corpus with a Term-by-Document Matrix

As we have seen elsewhere, the representation is the key for information systems. For the task of searching documents, the representation must capture the richness of a complex document in a way that allows matching relatively unpredictable queries. Essentially, these are distributed representations for the contents of a document or book. Problem with orthogonality assumption.

Zone indexing.

The Vector Space Model is the t-known procedure for ranked retrieval[60]. With it, both the query and documents are represented as vectors. This is also known as a "bag of words," since the order of the words is discarded. This algorithm does not preserve our intuitions about natural language very well, but it is the most robust technique.

Taken together, the set of vectors from the documents in a collection form a "term-by-document matrix" Fig. 10.46 shows a hypothetical term-by-document matrix for a document collection — such matrices for actual collections may include thousands of documents and terms. This is a representation of the collection (1.1.2).

Matching Queries to Documents

The details of the calculations for the Vector Space Model are given in (-A.6.3). Suppose that we wanted to find documents that matched a query "automobile tires". When there are several terms in the query

	Document						**Query**
Term	D_1	D_2	D_3	D_4	D_5	D_6	Q_1
boat	1	2	0	0	1	0	0
boats	3	0	7	0	0	0	0
sailing	4	1	1	0	1	0	0
water	2	5	3	0	0	0	0
car	0	1	0	0	6	2	0
automobile	0	0	0	4	0	5	0
truck	1	0	0	1	3	0	1
tires	0	0	0	4	0	2	1

Figure 10.46: The term-by-document matrix is one way of representing the documents in a collection. Each document is a vector and the query “automobile tires" is also represented as a vector. The query vector is compared to each of the documents for the match. The match would be D_4.

and different frequencies for each of those terms in the document, it is necessary to determine how to weight the terms in the document to best match the terms in the query. Two particularly effective weight-determining equations are the term-frequency (tf) and the inverse document frequency (df). Eq. 10.2 shows tf and is illustrated in Fig. 10.47. Fig. 10.48 shows df. Eq. 10.3. These actually are calculated as $\frac{tf}{df}$ the inverse of document frequency, $\frac{1}{df} = idf$ is usually written as $tf{\cdot}idf$. A complete calculation of $tf{\cdot}idf$ is given in -A.6.3.

$$tf_{simple} = \frac{number\ of\ times\ the\ term\ appears\ in\ the\ document}{total\ number\ of\ terms\ in\ the\ document} = \frac{t_d}{T_d} \tag{10.2}$$

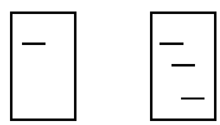


Figure 10.47: A document should be more likely to be returned in response to query terms if contains several occurrences of a query term (right) than if it contains only one (left).

$$df_{simple} = \frac{number\ of\ documents\ with\ the\ term}{number\ of\ documents\ in\ the\ collection} = \frac{D_t}{D} \tag{10.3}$$

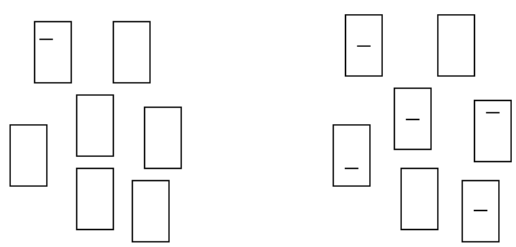


Figure 10.48: A document should be more likely to be retrieved in response to a query term if that query term (indicated by a short dash) occurs in only a small number of documents (left) than if it appears in many documents (right).

There are many extensions and variations of the Vector Space Model ((sec:additionaltextretrieval)). In addition, techniques related to the Vector Space Model are useful for retrieval of other types of content such as color matching in images. matching notes in music ((sec:audiovectors)), and for collection selection. Precision and recall (3.3.3) can also be used as metrics for the effectiveness of an indexing algorithm – such as the vector space model – to match a user's queries

These measures can also evaluate the performance of a similarity-based ranked retrieval engine. They are usually inversely related: as more documents are retrieved, fewer of them are likely to be relevant (Fig. 10.49). People are not very good judges of the number of relevant documents in a collection and the performance of a related system in retrieving them[13].

Total documents in collection	100	100	100
Number relevant in collection	20	20	20
Number retrieved	10	30	60
Number relevant and retrieved	5	10	15
Precision	0.50	0.33	0.25
Recall	0.25	0.50	0.75

Figure 10.49: Example calculations for precision and recall when retrieving 10, 30, and 60 documents. Usually as more documents are retrieved, the precision decreases and the recall increases.

10.9.3. Statistical Representations Beyond the Vector Space Model

Retrieval Based on Probability rather than Similarity

Probability rather than similarity. The most effective models for search engines are statistical. Because models such as the Vector Space Model are based on the statistics of words in documents, it is worth considering the properties of language. As might be expected, the word "the" is the most common word in the English language. Conducting a search for that word matches too many documents.

The *idf* value is another way to describe the frequencies of terms in a set of documents. While we've shown that the most common words in a language can be useful for text retrieval, the *idf* value uses the least common words for the same purpose. People generally express themselves using only relatively small set of words, and these words tend to be similar from person to person. Therefore, these words are used in the context of a wide range of different types of documents, and are thus not very specific. The *idf* value uses the *least* common words to identify relevant documents under the idea that the less common they are, the more specific they will be.

Zipf's Law (-A.10.2). For instance, this can optimize index compression. Derived from least effort [**?**].

Ideally, retrieval systems would be based upon a model of the properties of natural language. Most of these models, however, would depend on the structure of the training corpus. Different disciplines use different writing and communication styles and, to an extent, a different vocabulary. Accurate document retrieval is thus based on language models of the type being used in retrieval that accurately established the frequencies of word occurrences and co-occurrences. This requires a large and specific training corpus for the results. The text-processing principles used for most systems are derived from statistical measures of the language of these corpora.

Distributional semantics.

Various analyses have shown that words in the middle frequencies are the most predictive and useful for text retrieval. Furthermore, within these useful words, two different kinds of words may be identified: "function words" and "content words" (Fig. **??**). These roughly track to the different functions that verbs and nouns play in a sentence. Poisson-distribution.

Another method for utilizing statistical information for text retrieval generates statistical concept spaces. These define the semantic relationships between concepts for a given corpus. Then, these relationships are used in conjunction with standard statistical analyses to produce more accurate retrieval results.

Language Models

Topic Models

LDA.

10.9.4. Search Based on Machine Learning

Many queries are regularly repeated. Search engines from massive data sets and machine learning rather than from the traditional analysis of text. So many searches are repeated and it's possible to collect large numbers of searches. How many people are asking the same question.

Algorithms for learning. Machine learning (-A.11.0). Spell corrections (10.4.1).

Rank position.

SVM and learning similarity.

Humans in the loop for high-frequency searches.

10.9.5. Indexing and Searching the Web

The Web is a particularly chaotic environment compared with organized document collections. The most common application of text retrieval is Web search engines. The Web seems to encourage keeping multiple versions of a document on different servers. Here we focus on text search engines, but many of the principles also apply to multimedia Web search engines. Manage several components: index, retrieval. The Web is a common-use hypertext environment (2.6.3).

Semantic information added explicitly to web pages. Schema.org and microdata elements for indexing the web.

10.10. Characterizing and Indexing the Web

10.10.1. Dynamic Content on the Web

Some Web pages are frequently updated. Some pages change a lot but others do not. Simil Staying on a page. Words on a page that are unique to a page. Curated Web pages and analogous issues addressed in the archival literature (**??**). Changes within pages. Indeed, some types of pages are expected to change. Fig. 10.50. Expected changes versus unexpected changes. For instance, breaking news (8.13.7). Preservation of changing web sites.

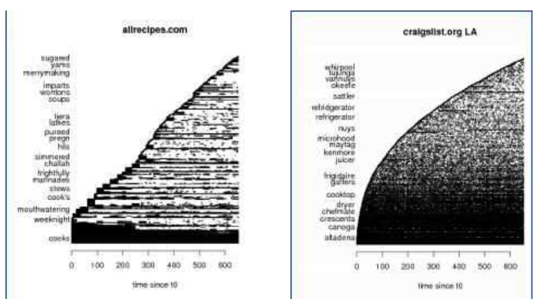


Figure 10.50: Two examples of term-longevity graphs (from[21]). (check permission)

10.10.2. Crawling and Indexing the Web

Because the Web has no systematic overall organization, search engines often are the most practical way to find pages. The machine index of Web pages used by a search engine is usually created by a Web "robot" or "crawler," which follows engine links to visit as many pages as possible. Pick a page and explore all links from there. Dynamic web (10.10.1).

Web characterization (2.6.3).

The Web is frequently updated. "Link rot" occurs when a Web page changes its location so it no longer links to it are no longer accurate.

A second problem is that some content is frequently repeated on many Web sites. Redundancy.

Targeted Web search. Focus on those pages which are most promising.

The software that generates these pages is known as a "robot" and the process is sometimes called "spidering" ar ?crawling?. Many pages are not indexed — the robots cannot get by passwords or image maps. Furthermore, Web pages can also be marked "robot exclusion" meta tags to request that the pages not be indexed.

<META NAME="ROBOTS" CONTENT="NOINDEX, NOFOLLOW">

Crawling policy. There are many databases whose contents cannot be searched by Web robots. This may be because of security or simply because the Web pages are generated dynamically. This content is called the "deep Web". In some cases, appropriate responses to the database query can be inferred from the page.

Duplicate detection.

Measuring Web Traffic

Most visited sites. This is an issue for search advertising.

Characteristics of Web Queries

Because the Web is so broad, and it has so many different resources, Web queries are very broad. (3.2.3). e to explain why a specialized database would

Search tools when there are ambiguous query terms.

One strategy for processing queries would be to categorize them. For instance, whether a user is searching for a document or an Internet service. Web queries are often quite broad. 1) apple, peach, kiwi 2) Moscow. How might you categorize each of these queries? What would be the optimal response by an information system? A user may be trying to find not just a document, but a service as well.

Perhaps not surprisingly, the most frequent searches deal with entertainment and sex.

Types of Web searches[24][58] with different information needs.

Using Web Page Links as an Indication of Similarity

Web communities are powerful predictors of association (2.6.3). The Web has aspects of both collections and hypertext. With most search algorithms, only the text of the document itself contributes to the likelihood of a document being retrieved. We identify many types of links between Web pages can indicate the similarity among them. Effectively, this is a principle of social retrieval. This is comparable to citation analysis (9.1.2). If the central node has links from other important nodes, it should acquire a high value (Fig. 10.51). The PageRank algorithm [**?**] provides a mathematical solution for this problem (-A.6.5). This type of analysis is also useful for building "family-friendly" indexes since adult-only sites often link to each other and these can be filtered out.

Relationship of journal impact (9.1.3) to PageRank.

In the context of a document structure. Path queries.

Using social networks to find associations (5.1.0).

Indexing Large Collections

Because the Web has so many documents and because there are so many hits on search engines, search procedures must be very efficient. Indeed, several shortcuts may be taken. The retrieval algorithms are not necessarily used. Web archives (7.5.5). Distributed data centers ((sec:datacenters)).

Web pages change frequently which if different from typical documents.

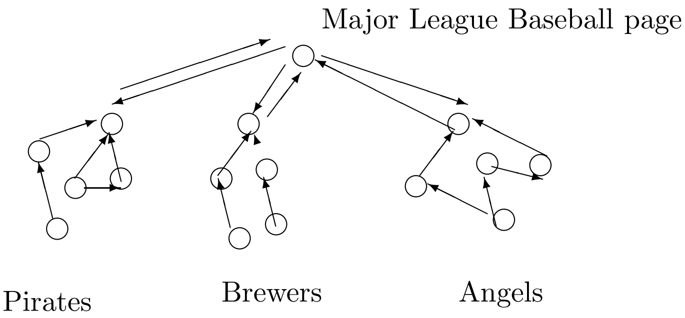


Figure 10.51: The PageRank algorithm includes the link structure in determining search hits. The Major-League Baseball site might be a good match for a query on "baseball" because it is centrally located among many other sites such as the names of individual teams (Pirates, Brewers, Angels). (redraw)

Furthermore, the results should be matched with the needs of real users. Many queries on Web servers are repetitive. The same user may simply repeat a query, or several users may be interested in the same thing. For common queries, the results may be saved in a cache so they can be retrieved later; these responses can even be hand-tuned (-A.14.2).

Duplicate detection.

Efficiency of building an index for very large collections. Often across several machines.

Real-Time Indexing

Indexing Tweets.

Tweet examples.

Figure 10.52: Tweets

Updating search engine results. Global data centers (7.7.3).

10.11. Beyond Basic Search Algorithms

Text retrieval has proven so useful that we can extend it in a broad range of content types. Social networks (5.1.0). Recommendation systems (5.5.5). Knowing more about searcher's context. Semantic search.

User Context and Search

Using location and context to determine searcher intent.

10.11.1. Social Search

Merging searches, and social media.

Use of context based on friend's interests. (5.1.4).

For what items do you value your friend's opinions. This shares some aspects of a recommendation system ((sec:recommendation)).

Finding People and Extracting Information

Representations of people. Social perception (5.5.2). Finding people with similar interests. Blogs, Twitter, Facebook. Dating. This is a slightly difference sense of social search than we encounter before (3.3.2).

Finding People with Expertise

Sometimes when we cannot find the answer to a question, we can find a person who might be able to answer that question. People are very helpful at providing information. People finders help to locate people with specific attributes (5.1.3). Knowledge management and organization charts. One simple approach could be to enumerate all the attributes and attempt to describe these simple database listings with a controlled vocabulary. True expertise versus claims of expertise.

Representing expertise. Expertise for different topics (3.7.1). Multiple dimensions of expertise. You may need to find somebody who speaks Urdu or somebody who knows how to build a house. Expertise network as a social network (-A.3.5) or community of practice (5.8.2).

You could search for your human expert in much the same way you would search for a document[36]. As with other information search tasks, representation is an issue here. The expert needs to be identifiable in the same way a document might be; that is, the expert's credentials would be represented in text and retrieved by a search.

Privacy issues in people search.

Information "logistics". Getting critical information to an analyst.

Organization Roles and Structure

As we have observed earlier. Consider all the information artifacts that an organization generates. Could we sift this to for a view of the organization. This is an aspect of enterprise content management (7.3.6) and text mining.

Intranet searching.

Personal information services (4.11.2). Social filtering (5.5.5). Email tasks (10.3.2). Email can be very messy.

Beyond simple documents to heterogeneous sets of materials.

Finding people's home pages.

Privacy concerns.

Summarizing email.

Fig. 10.53 shows empirically derived social network with a pathfinder network.

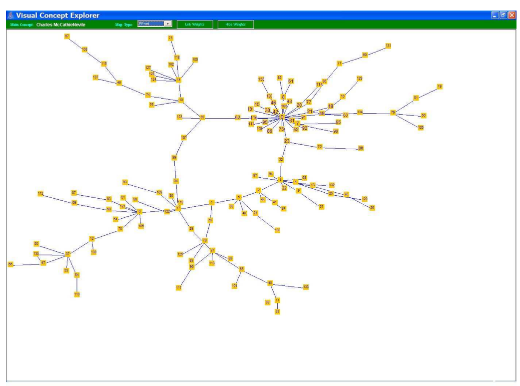


Figure 10.53: Social network derived from a set of email messages[71].

Argumentation pro and con.

Getting away from the traditional view of documents.

Interaction in virtual and loosely structured organizations (5.7.3).

Using evidence about what kind of searches other people are doing and what sort of selections they making from those searches.

10.11.2. Processing News and Other Content Streams

A lot of content evolves across time. Text streams. real time.

News, enterprise search, affective materials.

How should time be weighted as a factor in interactive information systems?

Lipstick on a pig (5.1.3).

Social curation and media aggregators which select content from media streams such as blogs.

Processing News

News (8.13.7). Provides a challenge for text processing. Newsblaster and summarization (10.6.2). Temporal summaries.

Change detection.

Citation analysis which we discussed earlier (9.1.2) can also be thought of as looking at streaming content.

News is an almost continuous stream of information. Imagine trying to track a news story from day to day in a newspaper. There are often new wrinkles and even stories that split off to form other news stories. Some question whether a "topic" is a distinct entity. We would like to group events to identify the story. It is basically a cluster analysis to show whether a document falls into an old cluster or a new one.

Content streams are particularly challenging because the content changes frequently. This makes it difficult to calculate the $tf*idf$ formula. News may develop on unpredictable topics from many sources, so topic detection is important for broadcast news services (10.11.2).

Judging relevance of news stories adds the dimension of recency to the user's interest.

News versus newspapers. Newspapers have more than formal news. In fact, a newspaper has a complex collection of content such as classified advertising, sports scores, and weather reports.

Video news.

Ranking these might include weighting the articles by recency. Articles for newspaper will be clustered.

Sentiment and Buzz Analysis

Public opinion (8.4.3). Because the Web is now so interactive, news items and trends are widely discussed online. Check social media sites.

Information sharing in virtual environments.

Blogs.

Blog Quote

Text analysis of blogs. Determining what makes a positive review of negative review finding affective tone – instance in music reviews. Epidemics and the spread of information. This is a type of information diffusion.

Many domains: from product reviews.

Counting polarity. Polarity classification. Difficulty of using single words. "I think that is a spectacular idea..."

Many blogs are full of grandstanding and gamesmanship and this has to be unwound before any valid analysis can be conducted. True identify is often unknown (5.5.1). As a community norm, blog contributors can be anonymous except when then have a vested interest in the claims made in the blog. The latter are known as sock-puppets. Blogs anonymous authors. Blogs and information overload.

Cultural and population effects. (Fig. 10.54)[70]. Google Trends. Correlated with news.

Using search terms to make predictions. Even to the point of basing stock market trades on sentiment [41].

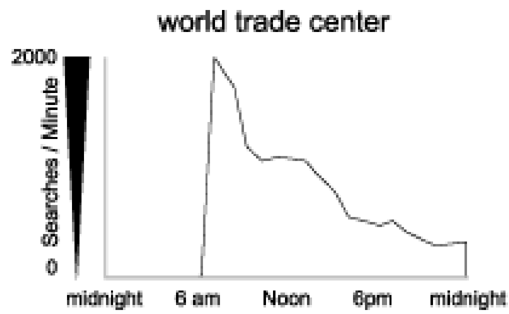


Figure 10.54: Searches on google.com from the "World Trade Center" during September 11, 2001[70]. Note that the attack there was just after 9AM ET (6AM PT). (check permission)

Buzz analytics. Opinion words (10.5.3). Sentiment flow. Sentiment combined with discussion of aspects.

Figure 10.55: Web ratings.

Monitoring the effects of advertising with search engines.

Detecting agreement in conversational. (6.4.0).

Detecting Misinformation and Deception in Language
Deception (5.3.3). Deception in voice.

10.11.3. RDF Search

Searching XML triples and RDF. Mixing RDF and semantic web, Incorporating structure into search.

10.11.4. Personalized and Social Search

Personalized search is a special case of social search. Representation of personal interests. Personalized selection of news articles. Many under-specified search terms.

Combine recommender systems and social search with page rank to make predictions for every individual on the web about their search topics.

10.11.5. Specialized Search

Search for specific categories of items such as search for personal names. We expect the order to be important.

Search semi-structured documents. Patent search. Family search.

Figure 10.56: Family search.

Search engines which return responses fitting a certain religious or cultural sensibility.

10.12. Automated Question Answering

Questions are the natural way we use language in social interaction to get information. Questions are different from queries, in that a query is processed by selecting the words in it, and a question is answered based on the totality of the question's meaning. Document management. Information needs are often formulated as questions (3.2.1). Question answering is a step toward more complex interaction, such as verbal dialog systems (11.10.4) and tutoring systems (5.11.3). Answering complex questions often leads to explanations (6.3.4).

Question answering by reference services (3.3.2). Determining what the user really wants (3.2.1). What makes a good answer[39].

Question Categorization. As we discussed for reference interviews, categorizing questions is a useful first step in answering them. Earlier, we had described a category system used for reference interviews (3.3.0).

For factual questions, the most obvious category scheme is the familiar journalistic questions. Simple "who," "what," "where," "when," and "how" questions are fairly stylized and can, sometimes, be processed automatically.

This generally occurs by generating a query from a question. The question "Who is the Queen of Sweden?" might generate the key words "who," "queen," and "Sweden". From that, the system would have a formalized, yet accurate, accounting of what the question sought. Another simple approach, only functional in particular information areas, is to pre-store answers to common questions.

Using Information Extraction for Generating Answers. Creating an index with information extraction. Extract responses from fact networks (2.2.2, 10.5.0). A quality information resource is needed.

Closed domain versus open domain. Domain-specific question answering questions. Easier for specific questions.

Fact-based questions are the only practical type which can be answered.

Source of the data with which to answer the questions. Mining information from the Web.

A question answering system can use parsing to determine question components which could then be processed with by decomposing the structure of the query (3.3.1). Such a system's first step would be to analyze the question and identify the type of query with simple natural language processing, which involves grammar parsing and ontologies (2.2.2). The system would then need to search for the appropriate information in existing documents or other sources and pull that information from the sources using information extraction and data mining; Matching questions to questions that have already been answered by human beings.

These techniques are discussed in the following section. Then the information would need to be presented back to the questioner in an understandable manner. Information presentation is a complicated task; a system must be able to determine what information is pertinent to the questions, how to

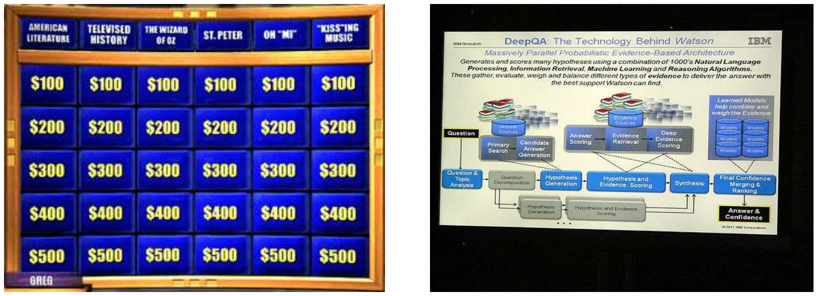


Figure 10.57: Watson is a system from IBM [?] which plays the game of Jeopardy. It is good at handling the ambiguities of natural language but is still does not approach human beings for unconstrained natural language interaction. (recapture)(check permission)

“Married President Washington”.

Figure 10.58: Finding answers with approximate queries followed by information extraction.

paraphrase complicated information, and how to normalize concepts so that they are not repeated throughout the presentation. Each of these requirements presents unique challenges.

Automated answering systems should eventually move beyond simply retrieving documents to synthesizing actual answers to questions. This is difficult, as it requires more natural language processing. As we noted earlier, a question answering system may involve the presentation of background information; indeed, it can begin to approximate a tutoring system (5.11.3) and it can organize that information in a way that is comprehensible for the end-user.

Query splitting[5]. Transforming questions to declarative form and then submit to a search engine.

Result aggregation.

Information fusion from several documents. The job of the QA system is to generate

a focused natural language response and not a document.

10.13. Translation and Cross-Language Processing

Language barriers are some of the greatest difficulties in human communication. Translation combines aspects of language recognition and generation. There are lots of differences between languages. Processing different alphabets possess some challenges but that is only the beginning. Transliteration is expressing one language using the alphabet of another.

Voice translation followed by synthesis in your voice in a second language.

Foreign language reading and writing aid.

Language segmentation such as Chinese. Culture differences (5.9.1) are not always readily explainable so it is more difficult to handle and cross-cultural processing.

10.13.1. Translation

As with other text processing tasks, there is a gradation from light-weight methods to rich-text processing (4.3.4). This simplest strategy would be to translate one word at a time. However, this word-by-word translation would be very poor quality. The difficulty of word-by-word translation. More difficult than the translation of terms of linguistic structure is the translation of cultural sensibilities (5.8.2). For example “Step up to the plate”. Cultural interpretation. Crowdsourcing translation.

Translating idiomatic phrases can cause a great deal of confusion. The English phrase “art theft” translates into French as the idiomatic phrase “xx”; when re-translated into English, it becomes “flight

Figure 10.59: The Rosetta Stone provided the key for decoding the meaning of Egyptian hieroglyphics because it used three different scripts (hieroglyphic, demotic, and Greek) to display the same text in two different languages (Egyptian and Greek), thus providing a reference point between the tongues. (check permission)

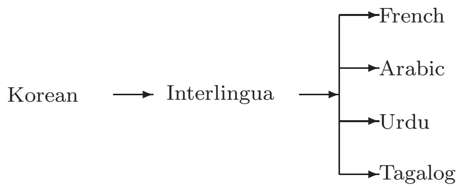


Figure 10.60: An interlingua is a common semantic representation that is independent of languages. It could be useful for translation between languages.

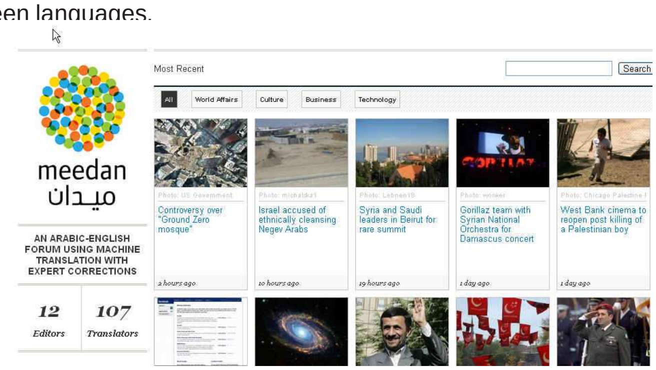


Figure 10.61: Meedan Arabic-English (human) translation blog. (check permission)

of art".

Translation from one language to another stretches the capabilities of language processing. Domain-specific translation is easier than general purpose translation. Domain customization. Tailoring to many languages.

Translation of poetry. Difficulty of finding rhyming. Even aside from poetry, a lot of language is metaphor and metaphor is particularly difficult to translate.

Multilingual chat service.

Interlingua

As with other types of language processing simple methods are often adequate for translation. The simplest approach is surface translation. A lexicon can be helpful in connecting concepts. We do not want to just translate a word, we want to get at the correct sense of that word. A word many translate into a phrase or vice versa; one should aim at an alignment between texts in different languages. An "interlingua" is a common underlying semantic representation which can then be used to generate text in other languages (6.2.3).

There are different qualities of translations. A translation may simply provide the gist of a passage or the details of a weather forecast, while the translation of a poem may itself attempt to be poetic. Several dimensions for measuring the quality of a translation are shown in Fig. 10.62. This can be used as a criterion for improving the performance of an automatic translation system.

Factor	**Description/Example**
Adequacy	Are the semantics conveyed?
Grammar	Is it grammatical?
Idioms	Are idioms used correctly?
Fluency	Is it easy to read (speak)?
Style	Is it elegant?

Figure 10.62: Criteria for effective translation[53].

Text-to-text. Speech-to-text. Speech-to-speech.

Multilingual blogging. Multilingual chat.

Machine Learning for Translation

Parallel corpora. Machine learning (-A.11.0).

Wh-questions (i.e., what, where, when, why, how). Fact extraction (10.5.3). Word alignment. Probabilities of word senses.

Get some reference translations and use them to calculate simple statistics. We could use precision/recall (3.3.3) as overlap measure. Long, continuous word strings are good.

Use probabilities of different word-sense translations.

Alignment of parallel corpora.

10.13.2. Cross-Language Text Document Retrieval

Sometimes, we may want to search a set of documents in a language with which we are not familiar. This is another variation of information retrieval. Sometimes the term is not available. Some tasks are multi-lingual; searchers may want to know of the existence of relevant documents in foreign languages. Thus, searches may cross languages (Fig. 10.63).

Figure 10.63: Two models for cross-language document retrieval. Translating the query or the document. It may be better to do both and combine the results from the two approaches.

Suppose an Arabic-speaking searcher wanted to pose a query to an archive of English-language documents. There are two general strategies: the query can be translated from Arabic to English, or the corpus can be translated from English to French. Clearly, it is easier to translate the query than to translate the entire corpus, but because the queries are generally short, a poor translation could have a serious negative effect on retrieval. A unified representation of the corpus (e.g., LSI) is needed, as is normalization of language. It may be most direct to translate between languages and then do retrieval.

As we have noted earlier such categorization in integral to a culture's identity. Traditional monolingual retrieval provides a benchmark against which cross-language retrieval can be measured. It is worth noting, that in some cases, the concepts themselves are different in different languages (5.8.2). A cross-language thesaurus link attempts to link concepts across languages (Fig. 10.64). As with other thesauri (2.2.2), this can be useful for term expansion. Apply query expansion (10.7.2) for both queries and documents. In addition to simple cross-language issues, cross-cultural factors must be taken into account. Thesauri can be useful for comparing similarity or conceptual structures across languages. Apply cross language frame semantics. Cross-language FrameNet (6.2.3).

English	**German**
simian	Affe
monkey	-
ape	Menschenaffe
timepiece	Uhr
clock	-
wall clock	Wanduhr
standing clock	Standuhr
tower clock	Turmuhr
watch	-
pocket watch	Taschenuhr
wrist watch	Armbanduhr

Figure 10.64: Some examples from a German-English cross-language thesaurus. For some English terms such as "monkey" there is no analogous term in German. In other cases (e.g., "clock" and "watch") there are no single-word translations from English to German; rather, adjective phrases are needed to translate them (adapted from[64]). (check permission)

Exercises

Short Definitions:

Adjacency operator
Alerting service
Click-through
Cognitive organizer
Copy-detection
Deep Web
Dialog
Document surrogate
Emoticon
Fielded search
Grapheme
Hubs and authorities
Ideogram
Image extraction
Intranet
Information extraction
Lexicon
MathML
Meta-search
Orthography
Parsing
Path queries
People finders
Plagiarism
Primary source
Proximity operator (search)
Question answering
Ranked retrieval
Relevance feedback
Streaming content
Term-by-document matrix
Vector space model
Word sense disambiguation

Review Questions:

1. Describe the writing system for (a) Arabic, (b) Farsi, and (c) Vietnamese. (10.1.1)
2. Is this sentence written in a serif or a sans-serif font? (10.1.1)
3. Give the ASCII and Unicode values for the word "media". (10.1.1)
4. List some skills required to be a proficient reader. (10.2.0)
5. Give some examples of "shallow" and "deep" methods for natural language processing. (10.4.0)
6. Calculate the edit distance between DIMENSION and DINEMSION. (10.4.1)
7. Describe the usefulness of ranked text document retrieval methods. (10.9.0)
8. Explain the steps by which a Web is created and then used. (10.7.4)
9. How would you mine an email archive to identify and find people with interests similar to your own. (10.11.1)

Short-Essays and Hand-Worked Problems:

1. a) Research and describe in a paragraph how Arabic writing is presented in Unicode.
   b) Create page of Arabic characters from Unicode on your laser printer. (10.1.1)
2. Some people have bemoaned the fact that reading will be less important as interactive multimedia systems become more common. Handwriting letters is much less common now that people can communicate by telephone and email Do you think there is a connection between literacy and intelligence? Justify your answer. (10.2.2)
3. Why is linear presentation of text often easier to understand than a hypertext like presentation? (2.6.0, 10.2.4)
4. Get the cooperation of a friend and watch his/her eyes as they read a page of text. About how many times do their eyes stop? Describe a cognitive model of readability based on these observations. How is this related to the number of lines on the page? (10.2.4)
5. One simple measure of readability might be based the average length of words. Describe some other simple measures. How could you validate these measures? (10.3.1)
6. Calculate reading ease score for the sentence "The quick brown fox jumped over the lazy dog". (10.3.1)
7. Estimate how many words are written by the world's population in a day. Justify your estimate. (10.3.1)
8. Give an example of how people adapt their communication to the capabilities of the communication channels. (10.3.2)
9. Calculate the edit distance between "apple" and "able". (10.4.1)
10. Sketch parse trees for the following sentences (10.4.2, -A.5.4)
    a. The quick brown fox jumped over the lazy dog.
    b. Surely sweet Susan sells sea shells by the sea shore.
    c. Buffalo buffalo buffalo Buffalo buffalo. (Hint: Buffalo is a city, a verb, and an animal.)
11. Develop rules for text categorization of news stories dealing with the wheat crop harvest. (10.6.1)
12. Choose two Web search engines and compare their search results for several terms. How do you explain the differences? (10.7.4)
13. Are databases search engines? (3.9.0, 10.7.4)
14. How is Web searching similar to or different from a conversation with another person? (6.4.0, 10.7.4)
15. Describe some ways that document structure could support retrieval? ((sec:structure), 10.9.0)
16. When is a controlled vocabulary (such as a thesaurus) better than full text descriptions for retrieving information resources? (2.2.2, 10.9.0)
17. Distinguish between text retrieval and text data mining. (10.5.0, 10.9.0)
18. Explain the advantages and limitations of "proximity search". (10.9.1)
19. What is the ordering for a set of relevant documents? (10.9.2):

Total in collection	100	100	100
Relevant in collection	20	20	20
Number Retrieved	10	30	60
Relevant and Retrieved	4	7	9
Precision			
Recall			

20. Identify and describe the differences between two representations for text retrieval systems. (10.9.2)
21. Evaluate a Web search engine on several dimensions such as the interface and the accuracy. (10.9.5)
22. Explain the relationship between hubs, authorities, and the PageRank algorithm. (10.10.2)
23. When searching an index for a set of query terms that appear in a document set, why is it helpful to make the least frequent term in the set, the fist one to be searched? (10.10.2)
24. Classify the following questions according to the taxonomy in Fig. 3.8 (10.12.0)
    a.
    b.
25. In what way might the widespread use of English on the Web represent a network effect? (8.7.2, 10.13.0)
26. Give some examples of shallow methods for text processing (10.13.1)
27. Explain the distinction between shallow and deep linguistic processing methods for machine translation.(10.4.0,10.13.1)
28. Describe examples of algorithmic processing and statistical methods for text processing. Contrast the advantages and disadvantages these two approaches. (10.13.1)

Practicum:

1. Text processing.

Going Beyond:

1. Use a scanner to create a bmp file from a text document. Write programs to (a) distinguish lines of text from images and (b) Identify the title page. (10.1.5)
2. Develop a program to do table extraction from a bmp file. (10.1.6)
3. For people, what is the connection between ability in reading and ability in conversation. (6.4.0, 10.2.0)
4. Develop models for (a) reading and (b) writing that are consistent with limitations of cognitive processes we have discussed. ((sec:cognitiveprocessing), 10.2.0)
5. Build a filter for blocking articles having to do with automobiles from being displayed on a Web browser. (10.3.2)
6. Should we rely on Wikipedia for accurate information? (10.3.2)
7. Develop parse trees for the following sentences (10.4.2, -A.5.4)
   a.
   b.
   c.
8. Write a program to categorize news articles. (10.6.1)
9. Evaluate the usability of a legal search service. (7.10.2, 10.9.0)
10. Obtain a freeware search engine from the Web. Install it. Test it. (10.9.5)
11. If you were developing a Web robot to create an index on a specific topic, what would do to focus the search? (10.9.5)
12. If we ever develop effective question-answering systems; would people still use search engines? (10.9.5, 10.12.0)
13. Are there some types questions that a question-answering system should leave to a human being? Give some examples. Could this automatically determined? (10.12.0)
14. How are text similarity matching algorithms similar to copy detection algorithms? (8.2.5, 10.13.1)
15. Develop a system that determines the language in which a Web page is written. (10.13.1)
16. Given the variation of concepts across languages, is it ever possible to get an exact translation from one language to another? (10.13.1)

Teaching Notes

Objectives and Skills: The student will understand the basic components of a search engine as well as basic techniques for processing natural language.

Instructor Strategies: Some sections such as 10.6.1 are fairly specialized and may be dropped for some students.

Related Books

- Basbanes, N.A. *A Splendor of Letters: The Permanence of Books in an Impermanent World*. Harper-Collins, New York, 2004.
- Coulmus, F. *Writing Systems of the World*. Blackwell Press, Oxford UK, 1991.
- National Center for Reading *Report of the National Reading Panel: Teaching Children to Read*. National Institutes of Health, Bethesda MD, 2001
- Manning, C.D., Raghavan, P., and Schutze. H. *Introduction to Information Retrieval*. U. Cambridge Press, New York, 2008.
- Sunstein, C. *Infotopia: How many Minds Produce Knowledge.* Oxford University Press, New York, 2006
- Tancer, W. *Click: What Millions of People Are Doing Online and Why it Matters.* Hyperion, New York, 2008.

Chapter 11. Multimedia, Hypermedia, and Entertainment Technology

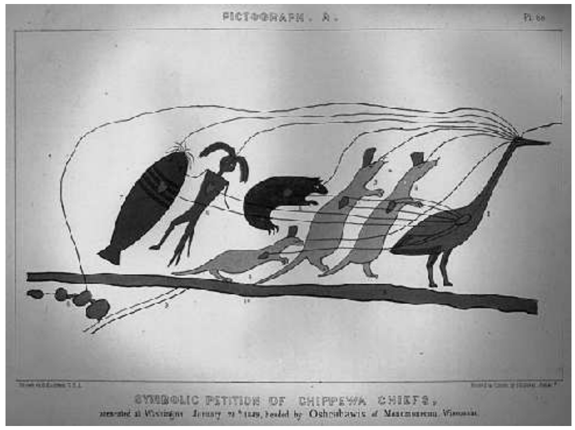


Figure 11.1: What is the meaning of an image? Pictograph (from www.library.wisc.edu/etext/) that represents a peace party of Native Americans represented by their totem animals. Their unity of purpose is shown with lines connecting their heads and hearts. Understanding such an image requires considerable cultural knowledge. (check permission)

11.1. Overview

Multimedia is content beyond text. It often emphasizes affect (4.6.0)[2]. Its scope has spread far beyond a few images and sound files by the rise of consumer electronics. Digital convergence. We can distinguish between multimedia and hypermedia.

On one hand, these technologies are rather different. On the other hand, they share many issues.

Processing, metadata, libraries.

We go beyond traditional multimedia to consider related issues such as 3-D copying. Mashups.

Multimedia surrounds us much more than it did in the past. Television programs have gotten much more complex. Television viewing habits. Social viewing. Video in applications ranging from meeting archives (5.6.4) to media spaces (5.6.6).

Representation for multimedia at several levels. Storyboard. Semantic annotation with identification and recognition.

The focus of the experience of multimedia is often different than for text resources. In particular, it is less often applicable for scholarship. Types of information needs for multimedia. Including for entertainment.

The Media Experience. Multimedia is a way of telling stories. Media only partially captures reality. Entertainment technology.

Comparative media studies.

11.1.1. Art

Art evokes an affective response (4.6.2). Art is often representational. Visual Art and Representation.

Social dimensions of art. Art museums (7.6.1).

Many levels of description and indexing for art. Images and culture. DOIs for art objects.

Paintings that emphasize linear perspective do not necessarily our subjective impressions of the visual world. Impressionist painting attempts to capture that (Fig. 11.2). Literal perspective. From representational art to abstract art.

Figure 11.2: Impressionist (left) and abstract art (right). (check permissions)

Such representations capture aspects of the world, or perhaps just patterns. There may be a cultural meaning associated with images[31]. How should that affect indexing.

Multimedia and Culture

We have already seen print culture (8.13.6). Fan groups.

Participatory culture.

11.1.2. Multimedia Libraries

LSCOM (Large-scale Concept Ontology for Multimedia)

YouTube channels.

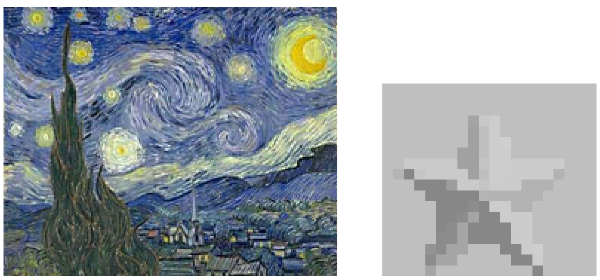


Figure 11.3: Museum of TV and Radio collection.

11.1.3. Processing Multimedia

Types of indexing for multimedia.

Segmentation of multimedia objects.

Fixity of multimedia objects changes their nature.

Common issues for processing across multimedia types, segmentation, frequency.

Interactivity and hypermedia.

Annotations for the internal structure of complex media.

11.1.4. Representations for Multimedia

Hypermedia Models

Synchronization.

11.1.5. Interactive Hypermedia

Interaction design (4.8.1). Need to manage the user's attention.

Interactive collages.

Representing Multimedia and Hypermedia

We have emphasized representations throughout this text. What expressiveness is required for a complete multimedia model? Coordination among the media in a hypermedia presentation.

The unique aspect of hypermedia is interactivity. There are also issues of sequence and coordination in hypermedia structure. We would like to have device-independent multimedia.

State and Language-Based Hypermedia Models State machines (3.10.1). Discrete state hypermedia. be described in sequences of states. Features that might be needed include looping, concurrency, synchronization points, and alternate or optional paths. The real trick is to determine how the model is structured. ATNs (6.5.1) are a better representation for multimedia.

Ultimately, we might use the models we have described earlier. From semantic graphs to multimedia presentations[23].

Temporal Scripting Languages manage events in time. Sometimes scripting languages are created for the interaction of media. These are different from languages for the interaction of objects in the media. For instance, they may support looping. Animation languages.

Multimedia and Hypermedia Authoring

The definition of the word "authoring" has changed over time. While it once meant simply to write, it is now used much more freely to describe the act of creating a multi- or hyper-media information object. Authored objects of this sort typically included many forms of media, such as text, video, audio, hypertext, and animation. As was noted earlier, authoring is a design activity (3.5.4); there is purpose and rationale behind the structure of the information object, or the way in which the various media modes interact and work together. The ultimate purpose of most multimedia authoring projects is to create structured content, be it for logical, aesthetic, or educational ends.

Multimedia authoring is a complex activity. It can be conceived of as combining the difficulties of writing, drawing, sound engineering, and video editing. Perhaps the greatest difficulty is specifying the synchronization of these various mediums. One tool for aiding in this synchronization is storyboarding.

Storyboarding has been used for a long time in movie making and advertising, to name only two examples, to visually organize the interaction and transitions between different conceptual elements or narratives. In the same way, storyboarding is used to synchronize or organize the different media applications in a multimedia object. While it is similar to a navigation map, a multimedia storyboard may not contain all the eventual detail, such as hyperlinks, of the authored object, but it will contain sketches of the layout of the different pages. In many ways, a storyboard for a multimedia object is far more complex than one for a movie or other linear formats because of the interactivity between the different mediums.

Movement through a multimedia object does not progress only in one direction, but skips and jumps from place to place; this makes its organization, visual or otherwise, difficult. Just as multimedia comes in many versions, so too are there many types of storyboards. The main characteristic of generalized multimedia storyboards, however, is the ability to specify interaction between media; for instance, how links should be specified and organized (2.6.3). Many storyboarding tools utilize intuitive, user-friendly interfaces, such as drag-and-drop authoring[11](Fig. 11.4) for organizing material, rather than formal or technical descriptions for media placement. Multimedia content may be evaluated by a person interacting with the environment via "walkthroughs" [20].

Path through a multimedia application matches information access. Layout and use-cases.

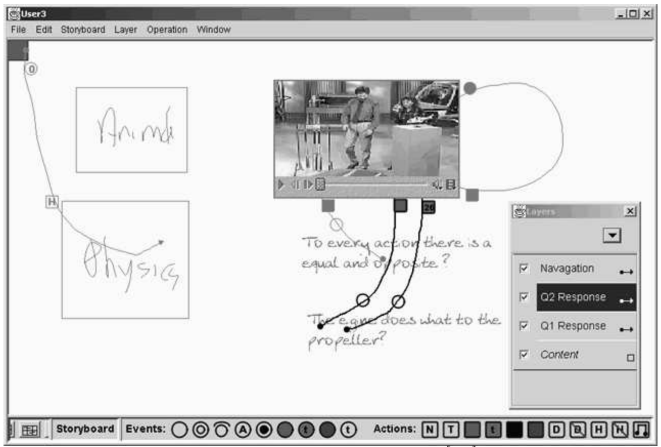


Figure 11.4: Drag-and-drop authoring for multimedia[11]. (check permission)

Multimedia Desktops

Web-based portals and even personal computer desktops (3.5.4) can be seen as multimedia environments in which users can interact with various information services. A workspace can collect work in progress (4.11.2) and many computer applications, such as text editors or even the entire desktop interface, are types of discrete-state multimedia objects.

These objects exist within a larger environment, and are controlled by defined multimedia events: "tool was opened," "data was entered," "tool was closed". Although each of these tools or objects may operate independently, they nay be required to interact and to function together, and in a larger sense they all need to obey the laws that govern the operating environment. Multimedia environments and the tools that populate them can be quite extensive, and when developing environments such as this it often becomes necessary to design exactly how the interface will work.

11.2. Visual Information, Visual Languages, and Visualization

2-dimensional visual materials can convey meaning in several ways. Images approximate our visual perception and capture spatial relationships and colors inherent to objects in the world. Images are merely representations of those objects and relationships, and may not contain all the intellectual or emotional context that comes from visualizing first-hand. The context that a representation conveys is therefore dependent in part on the viewer and in part on its creator; the creator to present the image in the fashion that they believe conveys the message they want, and the viewer to contextualize the image according to their own experience. This dichotomy allows images to communicate an enormous range of information in a purely visual format, from images that simply duplicate an image of the world, to those visualizations that seek to use a representation of the physical world to convey more abstract concepts.

Human beings primarily use vision to understand the world — this makes the visualization of images and data structures a particularly effective means of communicating information. Imaging and visualization systems can be combined with descriptive abilities to further enhance this effectiveness — note how textbooks always use images and figures to reinforce education. We are only now beginning to tap into the power of visualization to analyze large amounts of data and data libraries. Other means of using imaging and visualization to enhance information science and systems include schematics that show visual representations of abstract relationships and spatial information systems that deal with the position of objects in space.

Cognition and images. Brain processing and images (-A.12.2).

11.2.1. Representations and Images

Pictures record information. Before the widespread use of the printing press most recorded communications were pictorial. This form of communication proved to be very effective in large part due to the ability of images to convey complicated messages. A photographer or painter has many ways to draw the viewer's attention and convey meaning, often very subtly — images may be posed or edited to present a particular viewpoint or perspective, and they can be used sequentially to narrate a story. Indeed, many images or sets of images are very language-like. In pictorial presentations, one can perceive meaningful units (4.2.1) that function as a whole. Composition, or the way these units or objects are arranged (or the manner in which they are viewed or perceived) can amplify the significance that may be inherent to the objects in the first place. In Fig. 11.5, the repetition of objects and the viewpoint from which they are seen creates a rhythm. Other visual information objects, such as schematics and maps, can be even more language-like than a single image (11.2.4). How do we understand and represent space in images[32].

Figure 11.5: Note how the convergence of the parallel lines draws the eye.

Use of images in engineering, science, and medicine.

Attribution of painter[22].

11.2.2. Image Processing

More image processing (-A.2.3).

Edge detection.

Affine transformation.

Object recognition.

Photo sequencing.

11.2.3. Image Collections and Retrieval

Image metadata. It has proven difficult to develop useful descriptive systems for images. This may be because there are too many difficult tasks to be satisfied by any small set of descriptive systems.

Photo matching. Compare cellphone pictures to image database.

ARTSTOR. Medical images (9.9.2).

Value of metadata for image retrieval. Too many image retrieval tasks to be satisfied by any one metadata system.

Query by image content.

Computational photography.

Searching Images

Difficult to extract semantically meaningful features automatically. Described with metatadata. GWAP (2.5.4).

Figure 11.6: Image search.

11.2.4. Visual Languages

Visual objects can be highly structured. A language was defined earlier as the output of a lexicon and a grammar (6.5.2). Visual presentations can have some properties of a language. We may say there is a visual language, which includes a lexicon, a syntax, and semantics. This may occur within a single image but more often is found in composite images or sketches. We have already discussed the visual layout of documents (2.3.3). We will see similar structural implications for cinema (11.6.3) and even the structure of Chinese Opera. Visual language and visual literacy.

Visual Lexicon and Structure

As with any language, a visual language is composed of a lexicon and a structure. Icons are one part of the lexicon of the visual language (Fig. 11.7). The icons indicate functions they represent in different ways. Some use metaphor; a file system may be represented by an icon showing a filing cabinet. Some things are difficult to represent with icons and some icons are obscure. The selection of effective icons with arbitrary meanings can be a challenge for interface design. Some icon-based systems show text describing an icon's purpose when the cursor is placed over it.

Figure 11.7: Examples of icons associated with computing. (redraw) (check permissions)

Visual Grammar and Syntax

Graphical design.

As with natural language, managing the focus of attention is necessary for visual language processing.

Cartoons is designed to highlight the significant points in a narrative.

Diagrams employ visual language. Design of visual language presentations. Gestalt principles (4.2.1). Layout.

Visually clustered concepts are viewed as more related. Concepts linked with a line, are believed to be particularly closely associated.

Visual parsing (Fig. 11.8). There is often a syntax-like structure in visual materials. An arrow on a display may indicate the movement; in other words, it functions as a verb. Lines show connections between concepts or to separate one set of concepts from others. These lines form a type of visual punctuation.

Visual similarity.

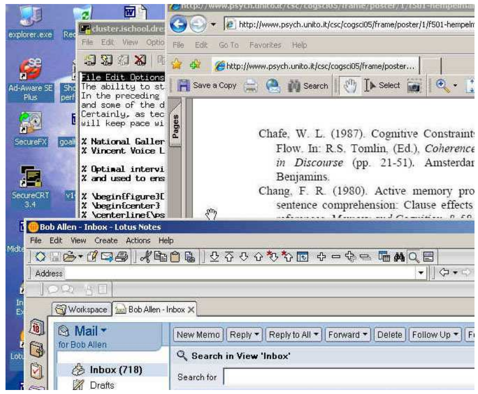


Figure 11.8: A complex scene such as this screen dump of a computer desktop can be segmented by visually parsing its components.

Visual Discourse

Visual discourse. Creating meaning and impressions by associations. [?]

11.2.5. Information Visualization and Interactive Visualization Environments

Visualization presents representations of the attributes of entities and the relationships among those attributes. These are based on information structure but they also add interactivity for exploring data. There are two types of visualization: information visualization and data (or scientific) visualization. Data visualization focus on the display of quantitative values. Scientific visualization and visual analytics (9.6.5).

Information visualization concentrates on qualitative values. They can be thought of interfaces for database attributes. Schematics and diagrams typically show qualitative visual descriptions but information visualization adds interactivity. However, primarily a schematic is a model.

Browsing Hierarchies

Focus + Context. Visualization of hierarchies. People often lose the context of the information they are accessing. This is one of the reasons that books, such as this textbook, include chapter headings at the top of each page. Zooming text and zooming images.

Interactive visualization tools often allow users to view content at a high level and the focus is on details while keeping a context of the high-level content. For browsing hierarchical structures.

Zooming

Zooming allows the user to control the level of detail when examining objects. With logical zooming, the display simply highlights different aspects of a display in continuous or discrete steps. This makes most sense when there is a spatial relationship among the objects. Spatial hypertext (2.6.2)[??] Many conceptual systems are best understood at different levels of granularity. Consider, for instance, a user viewing a galaxy and zooming in to look at stars within that galaxy. While it is possible to zoom smoothly into an image of a physical system such as a view of outer space, information spaces have discrete steps. Powers of 10[5].

Logical or Semantic Zooming: Graphical zooming may be accompanied by richer description descriptions. "Semantic zooming". One might "zoom" into the structure of the information. The relationships among objects can be highlighted with color and linking. Getting more meaningful detail in regions of a display.

Hierarchies are easy to understand and are widely used. When the relationships between entities are purely conceptual, only the category labels need to be displayed, as in tables of contents (TOCs) (2.5.5).

Menus display hierarchical actions or concepts without context. Menus can be seen as structured hypertexts (2.6.2). It is possible to generalize the logic of fisheye views to 2-D fisheyes and multi-foveal fisheyes. 3-D depth perception provides approximations of layered depth. Fig. **??** illustrates navigation in multi-scale space; this is one way of displaying visual context.

Lenses and Filtering

A traditional magnifying glass enlarges all parts of an image. By analogy, a visualization lens could give the user enlarged and/or re-focused views of graphics or images. Indeed, different types of physical lenses could be modeled (Fig. 11.9). Visualization lenses are not limited to enlarging the objects that are being viewed; different attributes of the objects in the display can be presented when the lens is positioned over them. Once users have found an area of interest in an information display, they may want to examine other attributes of that area of interest. such as focusing on Madrid in an interactive map, The same system could show other properties such as its population (9.10.5). As we will see later, a lens can also be used to extend the physical analog. 3-D lenses could show internal structures much as an X-ray does (11.10.1).

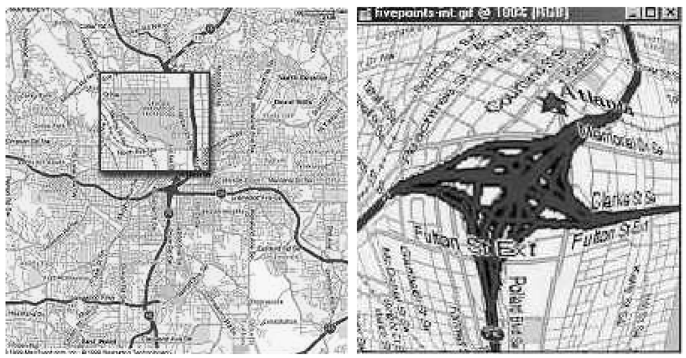


Figure 11.9: Bi-focal lens (left) and fisheye lens (right) for viewing details on a map of Atlanta[39]. (ACM check permission)

11.3. Audio

11.3.1. Sounds

Speech, music, heart beats, sighs, bird song, water dripping, glass breaking — we live in a world of sound. It is good then, that human beings are well suited to it. Not only can we hear a vast range of sounds (from 20 to 20,000 Hz), but our brains also learn to determine what sounds are appropriate for a particular environment. We use sound to communicate with speech, but also use sounds to represent general ideas, such as the sound of a sweeping broom to indicate that a file has been thrown in the "recycle bin". Audio is a very flexible medium; rarely do we use sound in isolation. Based on the biology of human beings, there may in fact be attentional and cognitive implications to modern multimedia applications. In this chapter, we will explore the many aspects of audio information: its capture, its storage, its forms, and its processing.

Acoustics.

Audio spectrogram.

Simulated audio environments.

11.3.2. Music and Sonic Arts

There are many types of musical experiences. I may whistle a popular song, listen to a live rock band, or go to the opera. Moreover, each piece of music may be performed in many ways. Music is sound with a rich structure. However, unlike speech the sound is generally not symbolic. Instrumental music does not usually convey information in the sense of helping a person to predict events. Music is

Figure 11.10: Ella Fitzgerald. (check permission)

highly structured at many levels, and that structure provides much of the aesthetic pleasure we have in listening to it. However, overly structured music can be tedious and some unpredictability is needed. Music comes in many genres from jazz to classical. Music is social. Music genre and mood detection. Musical production is often a social effort. Though, increasingly "music is a thing", a fixed recording [15]. The technology dramatically affect the content and the usage. The development of recording made music much more accessible to the masses and led to mass-market culture. Moreover, increasingly, music is integrated with information systems. Music and speech analysis use similar methods.

The Structure of Music

Music can be considered structured sound; some music is highly stylized, such as Western classical music, while other music is more free-formed, such as some jazz music. The structure of music can be compared to a building: the beat and rhythm provides the foundation with other sounds layered on top. Music can create listener involvement through theme and variation. A theme or structure is established within a piece and that theme is then varied to create a tension between a listener's expectations and their sense of novelty (4.6.2).

There are many other ways in which music is structured. Often, the structure of the music determines its style; it is its structure that defines it. In some cases, the structure of music may become so rigid that it may be modeled with a grammar (6.5.1)[12]. Fig. 11.11 shows a repetitive pattern that can be diagrammed like a sentence. Musical structure based on mathematical principles. While maintaining structure is important, it certainly does not have to be slavishly followed; deletion and variation from structure are essential aspects of art (4.6.2).

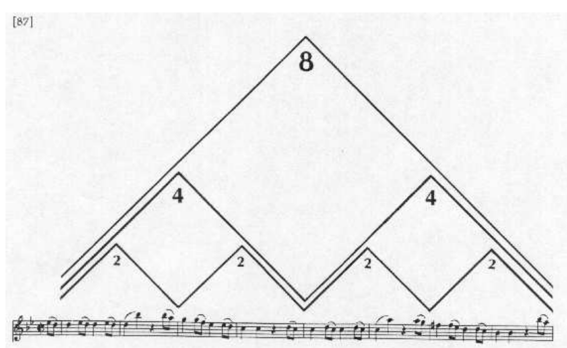


Figure 11.11: Music can highly structured. In some cases, that structure can be represented by regular expressions and grammars. Structure in music is particularly apparent in classical music. Observe the repeating pattern in the notes across several levels[12]. (check permission)

Representation and Markup for Music

Music can be as simple as a verse of “Happy Birthday” or as complex as Handel’s Messiah with a 100-voice choir at Christmas. Thus, any representation of music must be scalable to different complexities. While a representation may include each of the 100 voices separately, this variety would require 100 different pieces for one single work. A representation such as that may be useful for a performer, but not so useful for a conductor. Similarly, it may not be necessary to represent all 100 voices to store the work and retrieve it later. Musical performance is dynamic, and not every detail of a piece of music needs to be defined. Instead, it is often preferable to represent the theme, or baseline of the music, and allow individual interpreters to scale it as they may.

Music markup and metadata.

CSound. Composition. Algorithmic and probabilistic approaches to music generation.

Musical Instrument Interfaces

Novel interfaces. KBow.

Figure 11.12: Musical interface controllers.

Music Communities

Social music.

Music Indexing and Retrieval

Music libraries.

Music metadata.

Query-by-humming.

11.3.3. Speech and Speech Processing

Speech is interwoven with language; speech communicates natural language using sound. There are many differences between natural language as expressed through text and speech. When a speaker can be seen, many factors, such as the speaker’s eye contact and gestures, convey meaning and may be analyzed in conjunction with speech (11.4.1). Even purely verbal nuances, such as cadence, emphasis, and volume contribute to the meaning of speech.

We will look at elements of human speech, from the physical aspects, to linguistic theory, and on to certain speech information services. People don’t always use speech in auditory communication; rather, we may communicate with a grunt or even a Bronx cheer.

Phonology and Phonemes

Phonology is the study of the generation and perception of speech sounds. Similar to language itself, speech is a system of small, discrete sound units that are combined to form larger, more complex structures. Phonology studies these basic units in an attempt to better understand not only how we use language, but how and from what it developed.

While many languages use sounds in a way that speakers from other languages are not used to, some languages use sounds that are completely strange to foreign speakers. The trilled r in Spanish as in the Spanish word “rojo” has no analog in English. An even more extreme case is the !kung language from southern Africa (a member of the Khoisan family of languages), which includes a series of unique

Type	Code	Example
Voiced	AA	Bob
	AE	bat
	AH	bought
	AO	boat
	AW	down
	AX	about
	AXR	butter
	AY	buy
	EH	bet
	EL	battle
	EM	bottom
	EN	button
	ER	bird
	EY	bait
	IH	bit
	IX	roses
	IY	beat
	L	let
	M	met
	N	net
	NX	sing
	OW	book
	OY	boy
	UH	book
	UW	boot
	W	wit
	Y	you
	Z	zoo
	R	rent

Type	Code	Example
Voiced-fricatives	DH	that
	JH	judge
	V	vat
	WH	which
	ZH	azure
Unvoiced-fricatives	F	fat
	S	sat
	HH	hat
	TH	thing
	SH	shut
	CH	church
Voiced Stops	B	bet
	D	debt
	H	get
	DX	batter
Unvoiced Stops	K	kit
	P	pet
	T	ten
Glottal Stop	(stop)	

Figure 11.13: Phonemes are the distinct sounds which carry the meaning of words in a language. Here are the phonemes for English as defined by[1].

tongue-click sounds (which are all represented by the ! symbol); this sound is absent from the regular speech patterns of all other known language families on earth.

There are several basic categories of phonemes, such as vowels, liquids, fricatives, plosives, and stops. Each of these phonemes is associated with a particular means by which the sound is produced. Vowels are generally the most distinctive; they are produced by air passing largely unimpeded through the vocal chords and the mouth, tongue and jaw forming tubular, or hollow shapes.

One of the biggest distinctions is between voiced and unvoiced phonemes. Voiced phonemes pass air through both the nasal cavity and mouth. Unvoiced phonemes, on the other hand, pass air only through the mouth. You can test this by holding your hand in front of your mouth and comparing the air movement produced by voiced versus unvoiced phonemes. This difference is why speech sounds strange when a speaker's nose is plugged.

When a person is speaking, the phonemes are not constant and regular. The variants of a phoneme are called “allophones”. In part, this is due to the blending that happens when a speaker transitions from one sound to another; this is termed “coarticulation”. Many of these differences are produced by the tongue, which has its own trajectories and mechanics that produce different sounds. Regional differences in pronunciation.

Just as morphological analysis determines the meaning units of written words (6.2.1), “morphemes” are the meaning units of spoken words. Such phonological analysis has its limits. Words such as “here” and “hear” are homophones; they sound the same, but are spelled differently and have different meanings. Even if their phonemes are correctly recognized, the particular meaning of a word can be identified only by considering the surrounding context. Lexical semantics was covered in (6.2.3).

Linguistic Markers in Speech

Linguistic markers affect the meaning through sound alone. this could take the form of pronunciation, accents, stress, cadence, intonation, tone, or duration. Fluent speech conveys meaning in what is said, and there how it is said. How something is said is important to its clarity. Emphasis also helps in conversation management. Vocal cues such as uptalk can indicate solidarity or even power relationships.

Prosody is the intonation, rhythm, and stress of speech. It is analogous to orthography (10.1.1)in written text. Prosody can change the nature of a statement. One common example is that questions tend to end in an upward or higher inflection.

Figure 11.14: Prosody places the emphasis in spoken phrases. On the left, the speaker emphasizes that it is the listener they like, whereas on the right, the emphasis places the focus on the speaker.

Some spoken languages base the meaning of words on inflections which are known as “tones”. These are known as “tonal” languages. Although English has some tonal elements (an example is “too” vs. “to”) it is primarily a-tonal. In these languages, prosody becomes very important.

Inflection and discourse. Deception detection in speech [**?**]. Specifically, there is often a high-pitch from the stress.

Inflection and affect.

There are a variety of individual differences in speech. Indeed, a “voice model” can be developed that represents the characteristic speech sounds of an individual. There are many variables that make up an individual’s speech patterns. As a starting point, women generally have shorter vocal chords than men; their voices are generally of a higher pitch. Another factor may be accent; even within the same language, speakers often develop different “accents” which are characteristic patterns of speech. This effect is heightened when a person is speaking a second language. Because of the widespread use of television and radio, extreme forms of accents are heard much less frequently than they used to be. Socioeconomic and individual differences may also contribute to differences in speech patterns; these effects may be manifested in particular word choices and cadences. One example is “up-talk,” in which all statements sound like questions with a rising pitch.

Diction.

Disfluencies are hesitations and mistakes in speech. Many different types. They can be forced with tongue twisters.

Spoken Language

Speech processing has a wide range of possible applications, from live audio streaming, to speaker identification, to administrative and business uses. These technologies are only recently beginning to become widespread. As computer processing power and our understanding of human speech grows, there is no doubt speech processing will play a larger part in our day-to-day lives.

The top panel of Fig. 11.15 shows the raw speech waves for the phrase “Every salt breeze comes from the sea”. In the lower portion, the amplitudes are converted to frequencies to show a spectral analysis. The very dark bands of high-energy at the bottom of the display are the “formants” of that phrase. The formants are the most distinctive components of phonemes so that identifying them will improve speech recognition.

In particular, formants indicate phonemes. Phonemes are the building blocks of the sounds from which words are constructed. The sounds of the vowels in the words “bad” and “bed” clearly indicate a

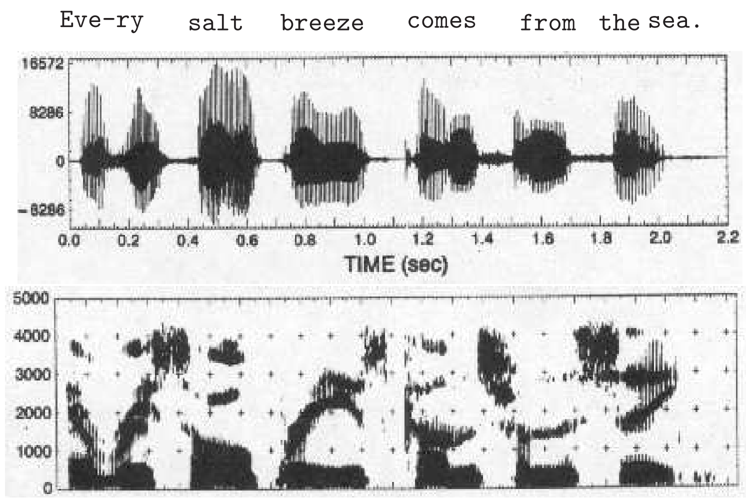


Figure 11.15: Raw speech amplitudes (top), converted to frequency spectrogram with spurious frequencies removed, the formants are clearly visible (bottom)[33]. (add text) (check permission)

difference in meaning. The basic speech sounds that make up a spoken language are categorized into phonemes. The commonly accepted English phonemes are listed in Fig. 11.13. The word "multimedia" is composed of the phonemes M-UH-L-T-AY-M-IY-D-IY-AE. Each language has its own sets of phonemes that define the way that language is spoken, even though the majority of phonemes are consistent across languages. Important distinctions among sounds from one language may be ignored in other languages; thus, there is no absolute set of phonemes.

Phonemes in spoken form sequence of states. These can be described with Hidden Markov models.

Orality

Orality is the use and understanding of spoken language. Spoken language is quite different than written language (e.g.,[30]). Some of the differences may be due to human cognition that process written text visually and spoken text through sound. Other differences are likely due to the environments in which each medium is used. Oral material generally uses shorter sentences and is less well constructed. Communication by text-based electronic media has an oral texture perhaps because it is informal and transitory. greater shared context between speakers in spoken language and conversation, both because their participants may have more of a history (even a very brief one) than in anonymous written communication, and because body language and gesture play such a large role in our understanding of one another.

Modes of Oral Interaction Story telling. Preservation of stories and traditions.

Oratory. Poetry.

Oral histories enhanced with annotated touch screens showing information resources. Narrative (6.3.6). History (5.13.0). People are not very good at understanding and describing their own behavior. Self-attribution and delf-reports can be unreliable (5.5.1).

Autobiography (5.13.3). Story corps. Great speeches. The advantages of oral information not being recorded. Oral arguments need to compensate for that. Oral documents.

Oral cultures. Epic poetry as an oral medium. Indeed, it provides cultural memory. Polynesian navigation. Inuit maps of the coastline.

Cognitive Effects of Language Use

We have already discussed human language learning as well as computer models for text generation

Figure 11.16: Homer, who is credited with writing *The Odyssey* and *The Iliad*, was an oral poet. Campfire (center). Polynesian navigation song. (check permission).

(10.4.3). In addition, we have cognitive processes in reading (10.2.0)and writing (10.3.1). Cognitive effects of bilinugualism.

Voice Applications

Searching podcasts. Indexing radio programs.

Personalized speech synthesis.

Speech Recognition

Automatic Speech Recognition (ASR) attempts to identify speech elements — phonemes — and match them to words. This is increasingly effective but this can be difficult; for instance, compare the sounds of the spoken phrases in Fig. 11.17; the sounds are very similar, but the meanings are quite different.

I scream	Ice cream
Wreck a nice speech	recognize speech

Figure 11.17: Some passages that are particularly difficult for speech processing systems to distinguish.

In addition, people differ greatly in their speech patterns and pronunciation. An important element of speech recognition systems is the training that the people using them may require. An individual with a need for continued and prolonged use of a speech recognition program, such as a person without the ability to type, may use what is known as a "speaker-dependent system". These systems are trained to individuals. With time and training, these systems generally develop a high degree of accuracy. More general ASR systems are known as "Speaker-independent systems," and apply to all users. These require no training, but are generally not as accurate.

Recognition of conversational speech is also much more difficult than recognition of prepared speech (e.g., news broadcasts). Whereas prepared speeches are usually composed of complete sentences, whole words, and — if delivered properly — lack stutters and miscues, conversations are usually completely the opposite. It is difficult for a speech recognition program to understand many of the half-words and colloquialisms typically used in conversation.

Another dimension of speech recognition systems is the differences between isolated-word recognition schemes and continuous-word recognition schemes. Isolated-word recognition seeks to simply identify the word being spoken, usually by first identifying its phonemes. Continuous-word recognition, on the other hand, seeks to understand and identify words using not only their phonemes, but also the context in which they are used, partly basing the definition of a given word on what has come before it.

Phoneme Recognition

As the basic elements of speech, phonemes also constitute the most fundamental units that can be processed by speech recognition software (11.3.3). A high degree of phoneme recognition is necessary to both isolated- and continuous-word recognition programs. Obviously, this process begins by identifying a word's constituent phonemes, or by segmenting and categorizing them. As with speech recognition

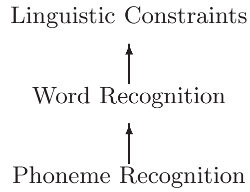


Figure 11.18: Stages in a simple a bottom-up spoken language processing system.

as a whole, phoneme recognition and segmentation processes can proceed by feature matching alone or by a combination of features-matching and templates (1.4.4), or models. The differences between these two methods are similar the differences between "bottom-up" and "top-down" processing, as used in other recognition processes (1.4.4).

When the combined feature matching and templates are used, Hidden Markov Models can prove particularly useful as they recursively calculate the identification probability as each new phoneme is recorded by the recognition program (-A.5.5). These prediction models can determine the probability that a particular phoneme matches a particular template, and revise that probability as new information (more input) is added. While there may not usually be an exact fit to the template, Hidden Markov Models help to select the match. Other methods for clarifying and increasing the accuracy of word recognition are through the integrated use of multimedia. In addition to speech many visual cues can supplement speech understanding.

Fig. 11.19 shows lip positions for different words. The lip positions are the result of producing phonemes (11.3.3). Image processing can be used to identify lip positions and these can augment the processing of the sounds. Other methods that increase the accuracy of word-recognition programs include gesture annotation (11.4.1) and social context, which analyzes gaze and pose (5.6.5).

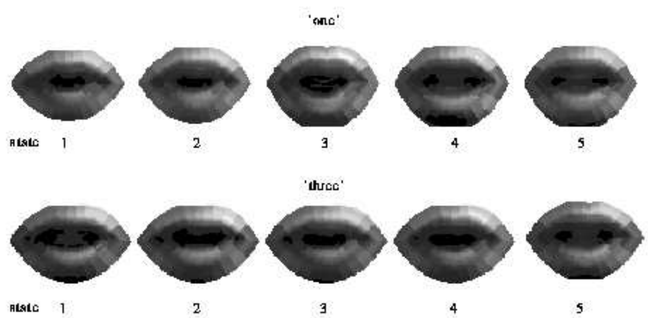


Figure 11.19: Vision can enhance speech processing. Lip positions for the word "one" in the upper row and the word "three" in the lower row[19]. (check permission)

Word Recognition

Acoustic models. A spoken word can be characterized as a sequence of phonemes. How is a program to move from recognizing a phoneme, or series of phonemes, to recognizing an entire word? From a purely numeric approach, if every phoneme were recognizable then every word could be tabulated according to its included phonemes. Certain elements of spoken language, such as alliteration, could confuse such a system.

It can be difficult, even for human listeners, to differentiate between two similar sounding words; the same is true of word and speech recognition programs. One method of differentiation is to use inflection as a type of punctuation (11.3.3) to contrast similar sounding syllables.

Developing Word Models with HMMs A spoken word may be modeled as a sequence of phonemes. Word models. Language models and word sequences. Models of words and matching them.

Markov Chains and Stochastic Finite State Machines are also weighted automata. These may be adapted as Markov models. This is helpful if we observe a process that we feel is not random, but we are not sure what the pattern is. The pattern, or model, is "hidden" and must be inferred. To do this, we chart the observations (the process) with a Markov Model and then apply that model to whatever end we need, such as speech recognition. Hidden Markov Models (HMMs) are very important for many applications such as speech and gesture recognition (-A.5.5).

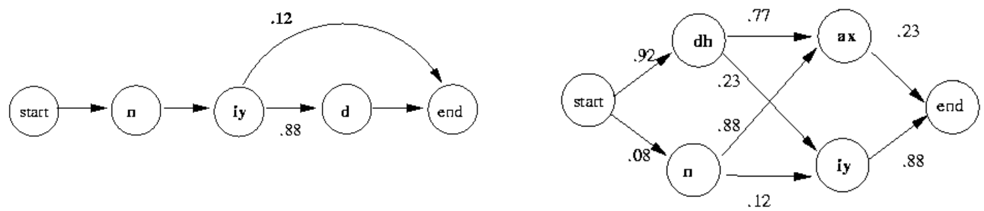


Figure 11.20: Words may be described as strings of phonemes. Word-level Hidden Markov Models for pronunciation of "need" (left) and "the" (right)[28]. Notice that phonemes may be skipped as with the "d" in need and that several related phonemes may be substituted.

11.3.4. Audio Search

11.4. Action and Behavior

11.4.1. Gestures

Motion is essentially changing position in space through time. The thing that extends video beyond the media we examined in earlier chapters is motion. Descriptions of behavior are useful for animations and multimodal inputs. Motion recognition is also integral to many types of interactivity. Motion ranges from simple and regular motions to complex motions that are semantically meaningful and that communicate intentional patterns of action. From actions to intentions. Beyond hand gestures. Facial expressions. Behavior monitoring and observation. Motion pattern analysis. Action as part of tasks. Gesture input (4.2.4).

Modeling typical human behavior and activities from large numbers of photographs on the web.

Gestures are behaviors which convey meaning directly or are used in conjunction with other types of communication. They are especially associated with speech, Fig. 11.21 illustrates the use of a metaphoric gesture. Fig. 11.22 shows one system of categories for gestures[29]. Gestures for framing a space. Gestures as rhetorical device. Expressing emotion with gestures[3].

Gestures as related to visual languages [?] indeed, they may be predecessor to spoken language. Gesture has meaning units analogous to phonemes.

Sign language (6.1.2).

Gestural interfaces. WII. Kinect. For instance, gestures can be used for musical performance [?].

Kinematic gesture corpus[4].

Generating gestures and facial expressions for conversational agents.

Gesture recognition.

Gestural play. Wii (4.2.4).

11.4.2. Formal Models for Action

11.4.3. Visual Tracking

We may want to follow an object or person as it moves through a scene [?]. Visual tracking combines aspects of motion analysis and object recognition. For this we can use tools such as spatial position,

Figure 11.21: One example of a gesture is a "conduit metaphor". The hands indicate space along which a sequence of objects is located.)[29]. (redraw-K) (check permission)

Type	Description or Example
Iconic	"OK" sign with fingers resembles the letters "OK"
Metaphoric	Abstract metaphor such as using hands to show containment
Beats	Rhythmic actions, often synchronized with speech
Deictics	Pointing
Cohesives	Indicating that ideas are tied together
Emblems	Specific actions that have acquired a meaning of their own

Figure 11.22: Categorization of gestures that are coordinated with speech (based on[29]).

sound localization and multimodal tracking. Projecting trajectories, understanding physical processes. Plan recognition (3.7.2).

11.5. Performance

A performance is an ensemble of actions. Theater. Opera. First person games. as a type of performance. Enactment.

11.5.1. Dance

Dance, like music, is highly structured. Dance shows physical aspects of emotions, social interaction, even communicative gestures. It has regularities at several levels: in the movement of an individual, in the group of individuals on stage, and across a composition. Dance can be expressive. Fig. 11.23 shows an example of Labanotation, which describe ballet movements; however, this is not a full language. Dance emotion as expressiveness and conveying meaning. Labanotation is like a musical score. Dancing may be described with high-dimensional grammars[41].

Creating a dance composition is choreography. Creating a story with dance.

Non-western dance.

11.5.2. Theater

Stage directions. Scene descriptions.

11.5.3. Cyber-Drama

Dynamic story telling. Increasingly, stroes are interactive and immersive. The concept is illustrated by the holodeck from StarTrek (Fig. 11.25). Beyond interactive theater and cinema. Procedural rhetoric. Branching story graph.

Player model.

Game generation.

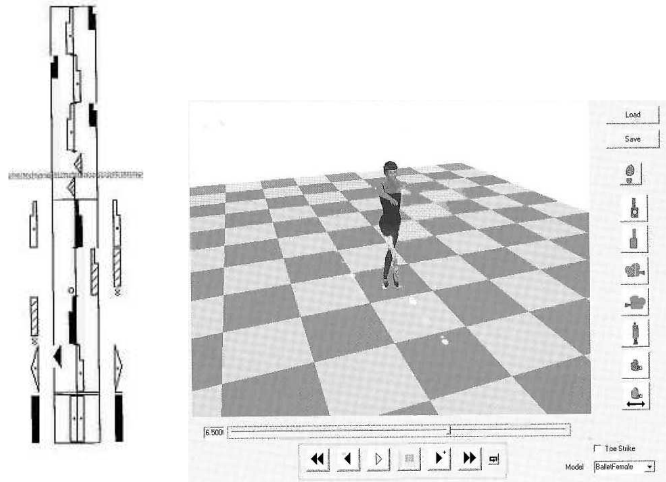


Figure 11.23: Labanotation is a representation for describing ballet movements (left) and is used to generate the animated figure on the right[7]. (check permission)

Figure 11.24: Managing theater.

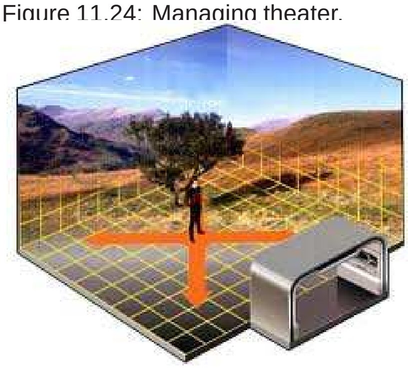


Figure 11.25: The holodeck is a fictional virtual reality environment for creating a personalized story. (check permission)

11.5.4. Drama and Narrative Theory

Aristotle again. Poetics. Poetics versus rhetoric (6.3.5). Experiencing drama as a kind of rehearsal for real life. Tragedy as catharsis.

Narrative is recounted while drama is enacted. (6.3.6). Narratology as a theory of narrative. Artistole's Poetics and drama. Hypertextual fiction. Does interactive fiction fit the Poetics? The interactive story, Facade [?] allows players to interact with and attempt reconcile the relationship between two characters in a story space.

Drama management (11.7.2). Cyber-drama (11.5.3). Experience management. Virtual theater (??).

Story is a lot of causal relationships.o

Figure 11.26: Facade interactive game. (check permission)

11.6. Active Visual Media

11.6.1. From Video to Active Visual Media

Active Visual Media is distinguished from static visual media, very simply, by its use of moving pictures or images. For a long time — since Louis Lumiere invented the first widely accessible and practical motion picture camera and projector in 1895 — television and film were the only common examples of active visual media. Over the years, however, a wide range of formats have been introduced, ranging from digital video recording to computer simulation.

Structured and unstructured video.

Active visual media play an increasingly large role in our lives. The continuing development of better, faster, smaller, and more reliable information transmission systems, infrastructure, and devices has had a significant impact on the shape and consciousness of our society. The ever-increasing number of video cameras in the hands of individual citizens led to a bystander being able to record police beating a suspect, thus sparking the Rodney King case (Fig. 11.27); satellite transmission of video allows news footage, and even live war coverage, to be beamed into the homes of viewers half a world away — instances and technologies such as these will continue to influence the development of our society. Now, cameras on every cellphone.

Figure 11.27: The arrest of Rodney King, a Los Angeles motorist, was captured on video by a bystander. It became the basis of a controversial court case. (YouTube example) (check permission)

Increasingly, these active visual media are being augmented by information processing to create hypermedia formats: Media environments composed of different modes, formats, and technologies. Similar to hypertexts, in which embedded links can take a user to content outside the original document, hypermedia applications allow users to do the same thing with active visual media. Interactivity disrupts the continuity of narrative in video and film production. Electronic games and such story-telling media will remain distinct.

11.6.2. Video Retrieval, Processing, Formats, and Libraries

TV Anytime, PBCore.

Figure 11.28: Home movies. (check permission)

Video summaries.

MPEG-7 is a standard for describing multimedia objects. Just as text documents are marked up following the DTDs of the Text Encoding Initiative (2.3.3), video can be marked up. For instance, news programs and football games are highly structured and could be marked up. Many standards are being developed for describing the contents of videos. MPEG-7 is XML-based. Descriptors and Description Schemas can be part of the mark-up; one can have a record for each scene and shot (Fig. 11.29). Video documents.

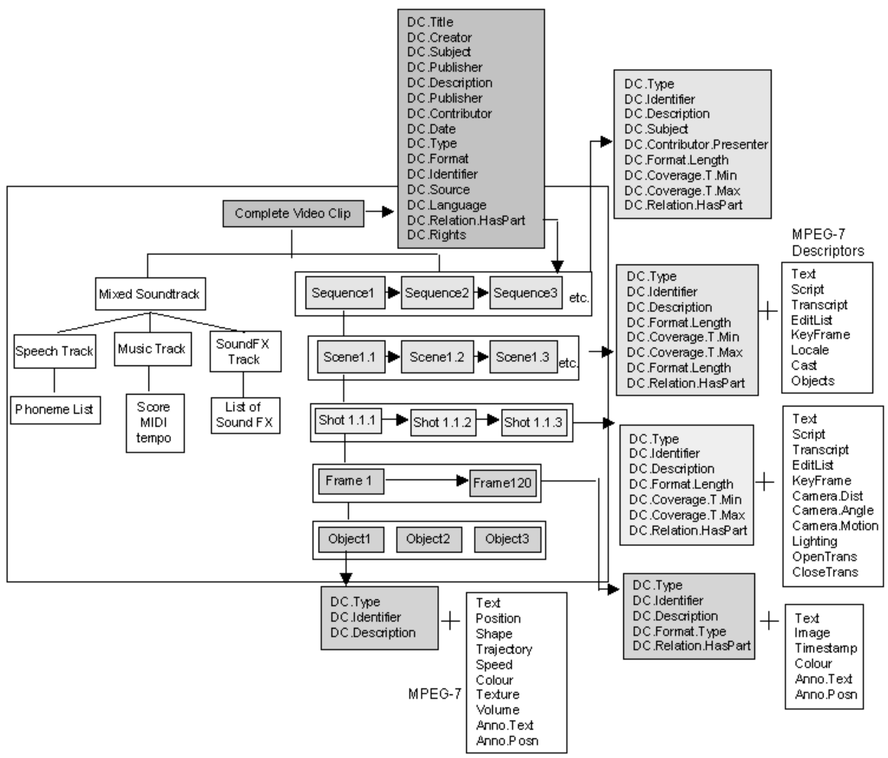


Figure 11.29: MPEG-7 Description Schema[21]. Note the separate metadata that is kept for frames, shots, scenes, and sequences. (check permission)

Video summarization.

Semantic Annotation of Video

Semantic annotation (7.8.4). For complex multimedia such as video, we may have a human observer describe the content.

Inference for enriched indexing of the video.

Video Processing
Combining motion data from several cameras.

11.6.3. Movie Animation
Animation languages. Virtual camera (POV).

Motion capture. What creates an impression of human-ness. Fig. 11.30 Uncanny valley. Quasi-human. Evolutionary hypothesis. Evolutionary caution. (**??**).

Figure 11.30: Motion capture of Tom Hanks from the movie *Polar Express*. This unsettled some viewers because it fell into the uncanny valley. (check permission)

Types of human motion: voluntary, involuntary, social. Human emulation. Avatars (11.10.3). Clothing. Hair (e.g., Fig. 11.31). Hair is difficult because each strand has a complex interaction with all the other strands.

Figure 11.31: *The Incredibles* was particularly noted for its advances in the simulation of human hair. (check permission)

Digital Cinema

Film Editing
Montage: Narrative and High-Level Structure. A movie, obviously, is more than a series of shots and scenes: it tells a story. Each part of a film is intended to work together to create a unified, final whole. Equally obvious, is that some films do this better than others. The movies that successfully create this final, unified whole have usually managed to make a multimedia presentation; it is not simply a single actor or a good story that makes them good, but the way that they integrate these and other elements to create a mood, or cohesive overall effect. Many of these things often go unnoticed by viewers at the time of viewing, like the way varying theme music may be associated with specific characters, or the way that distinct individual narrative components relate to the work as a whole (6.3.6). Through things such as "establishing shots" that provide context, pacing that matches the film's overall feeling, the director's portrayal of space, architecture and geography, and the depiction of time passing, a successful, cohesive film will monopolize a viewer's attention and create an immersion effect.

11.7. Play and Games
11.7.1. Play
Specific time and place. For fun.

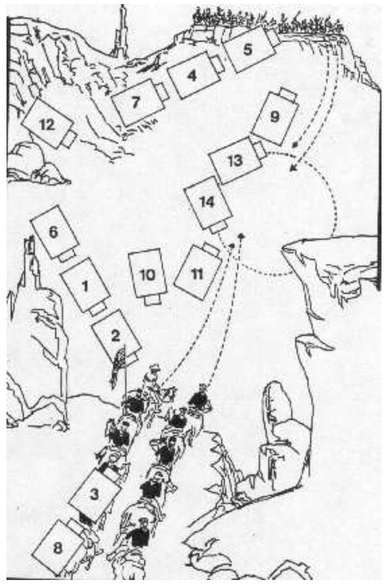


Figure 11.32: The sequence of movie shots for two groups approaching each other is designed to shift attention from one group and the other and to highlight the tension between them (from[9]). (re-draw-K) (check permissions)

11.7.2. Variety of Games

Games and constraints. Taxonomy of games. Games are interactions with structured environment which often resemble natural environments but which have consequences less extreme than the natural world. As we have observed, there are many types of games (2.1.3). Social aspects of games. Role-playing games. Comparing games to sports to play.

Because games mimic aspects of the world, they often reinforce culture.

Scoring.

Business models for games include purchasing good for participation in the game rather than subscription to the game.

Retention. Social

Virtual environments like Second Life. Adding user generated content to virtual environments and games.

Many aspects of game design beyond technical issues. Participatory design for games.

Player model for developing adaptive game engines.

Games typically have few direct real-world implications. Indeed, they may be practice for real-world tasks. One exception is the effort to develop serious games, Those which can be seen as models of complex interactions and are educational.

Games as facilitating experience and enjoyment.

Effects of games on the players. Emotionteering. Narratives (6.3.6).

Games also raise many issues we have seem about other types of information systems such as business models, security, and censorship.

As we discussed back in Section 2.1.3, there does not seem to be any simple set of attributes which define a game. Genres (6.3.7).

Indeed, the definition for games seems to be based on the lack of clear motivation. That is, a game is an activity which does not seem to accomplish a task. Presumably, games, like passive entertainment, meet other human needs such as sociability, exercise, and arousal.

Rules are known. The games are winnable.

One of the most rapidly evolving and expanding hypermedia applications is game design. There is a huge variety in the types of games.

Another type of market.

Principles of effective game design. Make it clear to what the choices are. Scaffolding keeps them involved in a game.

Massively multiplayer games. Organizational skills for developing Guilds.

Many games, however, are educational and teach necessary, or at least useful, life skills; in this sense, games are more than mere entertainment. Whatever their larger definition or significance may be, games are human activities that are structured in such a way that any actions taken within the context of the game produce only very limited real-world consequences. Fig. **??** shows some dimensions of games. At what point is a game different from an interactive simulation.

While computer, or technology-based games are the focus of this chapter, all games — from sport to simulation — have a lot in common. All games simulate reality to some degree, though often metaphorically. All games, have rules (9.5.0), though games are typically much more highly structured. Games are typically characterized by interactivity and by a lack of task.

Why are games absorbing? Physical stimulation. mental challenge. Cyberdrama is a combination of story and game. Rhetoric and procedurality. Immersion, agency, Transformation [**?**].

Games offer insights into both overall human behavior and local or regional culture. Real-world behaviors and customs are often expressed or represented in the rules or structure of games; his similarity has often been noted[35]. In addition to the explicit rules of games, there are often constructive rules or implicit rules. The various implicit and explicit rules of a game have many purposes, themselves both explicit and implicit. These may include the enhancement of the entertainment value of a game; abstract or theoretical intellectual enhancement (5.11.0) as in game theory and strategy (3.4.1); the emotional development that comes from competition, surprise, challenge, teamwork, and even violence (5.9.4); and cultural education that results from the history of a particular game or its narrative (6.3.6).

Puzzles and Riddles

Tetris (Fig. 11.33).

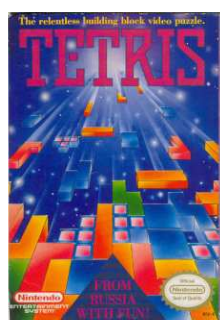


Figure 11.33: Tetris. (check permission)

Interactive Stories

Cyber-drama (11.5.3). Drama management shares many aspects with intelligent tutoring systems (ITS) (5.11.3) and adaptive hypertext. Experience management.

Point of view. First-person and third-person.

Team communication in games.

Stories and character development for games[36].

Augmented reality games. Overlay games on to the natural world.

Serious and Persuasive Games

Motivating aspects of games. Games can improve training. How effective are they for education? Management games. Related to education (5.11.5).

Game space and game trees (-A.3.2).

Figure 11.34: Guitar Hero. (check permission)

11.7.3. Games as Information Resources

Board games often have a set of rules and physical playing environment. Electronic games have implicit rules and control the playing environment. Either way, games can be seen as information resources. Thus, they can be indexed and organized. For instance, they can be assigned metadata.

Game genres. Designing experiences.

Video recording of a person playing the game.

What does it mean to preserve MMORGS where the interaction with other players is the key.

State graph for game states (-A.3.2).

Player modeling is related to student models (5.11.3)and other user models (4.10.2),

Graphical rendering.

Games as Cultural Works

Games as an art form. Preservation of games as cultural memory (5.9.3). Game culture evolves really fast.

Descriptions of how games play. Event capture for games.

Each game instance may be considered a distinctive work since it evolves as it is played.

Fan blogs. “Who owns the game?” The players or the game company? Socialization. Preservation of games[27]. Killing characters in MMPG In some cases, games include game mods. That is, players can develop extensions to them.

Game Users

Video game violence (5.9.4).

11.8. 3-D Images and Solid Models

11.8.1. 3-D Images

The development of representation techniques for 3-D objects is an important advancement in information systems. This allows digital objects to be represented in a way that more closely approximates how we already see the world, and how our minds understand it. This can lead to a more natural interface for humans and computers. There are many elements just on the human end of developing accurate 3-D representations, including the physical principles of vision (4.2.3) and 3-D visual perception. Depth perception in particular is critical to developing a 3-D experience. There are many applications for even simple 3-D representations, ranging from art to engineering, and many that have yet to be imagined; that the computing power to develop these objects is only recently becoming readily available is something that has surely limited the scope of the possibilities.

Extending CAD models by adding behavior and by incorporating simulations (9.5.0).

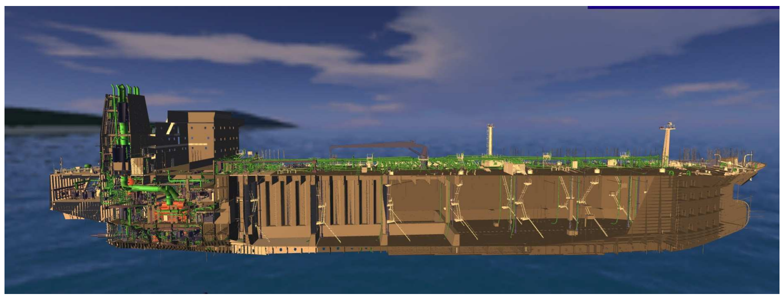


Figure 11.35: Supertanker graphic applies a multi-layer model so the viewer can interact with the model at several levels of granularity[6]. (check permission)

Design specification (3.8.4). CAD for design, for Manufacturing, for Use, for Assembly.

3-D printer technology (8.12.1).

11.8.2. Solid Models

3-D Modeling.

A voxel is the name given to a 3-D pixel.

Perhaps the most widespread and established technique for developing a 3-D representation of an object is Computer Aided Design, or CAD (3.8.0). CAD-designed objects are solid models ((sec:solidmodels)), in the sense that they have shape, size, and dimension, and can be viewed from all angles, the same as any solid object. Engineers, draftsman, designers, and architects have been using CAD for more than twenty years to model 3-dimensional structures or objects. Over that time, the power and capabilities of CAD programs have increased dramatically. Fig. 11.35 shows a CAD wire-frame model. We have already considered 3-D perception and representation for people (11.8.2).

3-D representation's are fundamental for people interacting with the world. Thus, we focus on them here (Fig. 4.9). One theory suggests that 3D perceptual representations are based on simple volume-filling shapes which are processed at the pre-attentive stage[13]. Fig. 11.36 shows how such geons can describe the shape of an airplane.

11.9. Wearables, Tangibles, and Smart Environments

11.9.1. Wearables

Embodiment.

Tracking personal health.

Personalization of fashion selections.

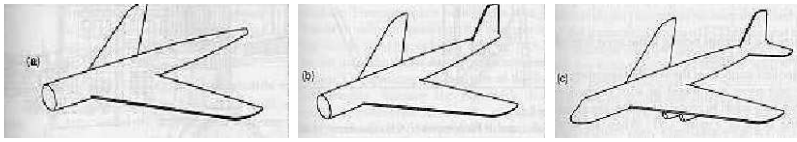


Figure 11.36: One approach to representation of complex 3D objects develops a complex representation from simple shapes called geons. Here, for instance, an airplane is built up from such simple shapes[13]. (redraw with car) (check permission)

Wearable technology. Glasses, watches.

Presentation of the self (5.5.1). Virtual fitting room.

Conductive fabric.

Monitor wearer. Sensors.

Augmented reality ((sec:AR)).

11.9.2. Tangibles

Objects in the world. Toys. Fig. 11.37. Types of tangibles. Remote telepresence with haptics. Marble answering machine with token encoding actions. Touch surfaces.

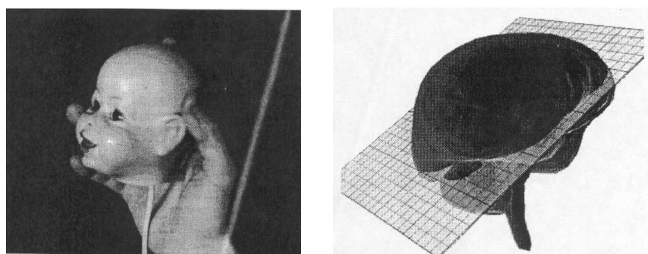


Figure 11.37: A tool for manipulating the location of a cross-section of the brain[18]. Moving the plastic head changes the position of the cutting plane and, ultimately, the view of a brain section. (check permission)

11.9.3. Ambient Design

Constructing environments with electronic displays.

Figure 11.38: Ambient design.

11.9.4. Internet of Things

Location management. Inventories. RFID.

Supply chain (8.12.1)..

11.9.5. Active Environments

Sensors in the environment.

11.10. Reality and Beyond

11.10.1. Mixed and Augmented Realities

While a virtual reality environment can be entirely fabricated, it is more common that virtual reality elements are coordinated with the natural world. We can call these environments "mixed realities". The uses and applications of mixed realities are practically unlimited; whole libraries of virtual objects can be assembled to facilitate the creation of augmented realities. This helps to open up many ways to augment reality. Hidden structural supports (figure). View management.

Media space ((sec:mediaspace)).

Metaverse. Sensors and GIS and lifelogging.

Audio augmented reality. Visual augmented reality. Cellphones for supporting augmented realities.

Difficulties of rendering complex environments for virtual realities with little lag.

11.10.2. Virtual Reality, Virtual Environments, and Virtual Worlds

CVEs (5.6.6).

Second Life. Project Wonderland.

Virtual economies (5.2.2). Governance of virtual worlds[16]. Validation of virtual worlds. What aspects make them seem real.

3-D Navigation (2.6.3).

Difficulty of real-time updates a complex 3D space.

Experimentation in the virtual space.

Virtual Rome (Fig. 11.39).

Figure 11.39: Virtual reconstruction of ancient Rome. (check permission)

Virtual crowds. Crowd dynamics.

Interacting with virtual worlds.

Scripting for virtual worlds.

11.10.3. Animated Characters (Avatars)

Avatars are simulations of living organisms, especially of human beings. The word "avatar" comes from the Hindi word for "spirit" or "essence". They build on the natural social interaction that comes easily for people. Indeed, they may provide an actual social presence (5.6.5) that has kept human-computer interaction relatively simplistic up to this point. Puppets as avatars.

Properties of avatar interaction. Aura is the region withing which one avatar will interact with another. Focus is the level of awareness of others within that aura. While nimbus

11.10.4. Conversational Agents

Conversation (6.4.0). Whether textual or verbal. Human animation (11.6.3).

Potentially, conversation is an effective user interface. However, full conversational interaction is difficult and success would mean meeting the Turing Test. Distributed agents (7.7.8)

Who initiates a conversation?

Natural language workflow for mobile telephones where no keyboard is available. Yes/No question interaction. Question categorization for question routing. Question routing as a service for sending traffic to an expert (e.g., a doctor).

Large sets of search results are a competitive advantage for search engine companies because they can be used to improve the quality of earch results.

Increasingly interaction is viewed as a conversation. User initiated, system initiated, mixed initiative. Interaction as conversation. System initiative is potentially intrusive. Increasingly, sensors support input devices for interfaces and they are cheap and widely deployed. Simulating gestures in conversation.

Conversational bots.

Ultimately there would be many applications for effective agents who could understand the nuances of conversation. However, there are huge difficulties in effectively understanding meanings.

Turing test.

11.11. Robots and Cyber-Physical Systems

11.11.1. Robotics

Robots of many forms and applications. Humanoid robots. Social robots.

Robots and manufacturing. Robots and employment (8.8.2).

Cooperation and coordination among teams of robots.

These are often inspired by the nature's solution to design challenges.

Figure 11.40: Robotic companion.

Robots who know their limitations. Many types of robots. Delivery. Symbiotic robots. Personal robotics. Laws of robotics[10] (Fig. ??).

1.	A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2.	A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
3.	A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

11.11.2. Cyber-Physical System

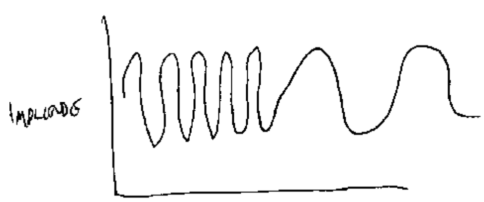
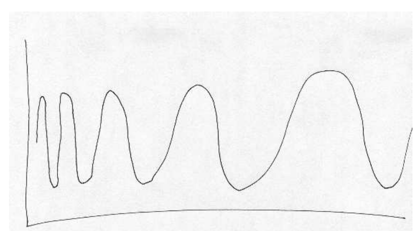
Exercises

Short Definitions:

Acoustics
Active environment
Agent-based simulation
Animation
Autonomous agent
Augmented reality
Audio contours
Avatar
CAD
Coarticulation
Color depth
Deterministic model
Disfluency
Digital talking book
Dissolve (video production)
Earcon
Focus+Context
Frame differences
Game
Gazetteer (spatial)
Georeferenced data
Gesture
GIS
Information visualization
Inverse kinematics
Hypermedia
Immersive virtual reality
Kinematics
Linguistic markers
Location-aware service
Mixed reality
Modeling
Monte Carlo simulations
Morpheme (speech)
Morphing
Orality
Periodic motion
Phoneme
Pitch
Pixels
Prosody
Range query
Rendering
Route finding
Schematics
Scenes and shots
Scene graph
Semantic zooming
Solid model
Sonification
Sound rendering
Spatial cognition
Spatialization
Spectrogram
Structured Query Language (SQL)
Telepresence
Visual language
Wayfinding
Wearables
Word spotting

Review Questions:

1. What types of material are better presented in an image and better in text. (11.2.1)
2. What are some difficulties for automatic recognition of objects from photographs? (11.2.2)
3. Image processing. ((sec:simpleimageproc), -A.2.3)
4. Thumbnail images are sometimes used as a surrogate for pages in documents. Describe what properties a thumbnail should have to be useful as a surrogate. (10.7.3, (sec:thumbnails))
5. In what sense are visual language like natural languages? (11.2.4)
6. Explain the difference between "information visualization" and "data visualization". (11.2.5)
7. What are the relative advantages and disadvantages of the bifocal and fisheye lens techniques? (11.2.5)
8. Draw the spectrograms for the sound waves shown in these figures (check): (11.3.1)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9. What are the characteristics of speech that distinguish it from other types of audio recordings. ((sec:sounds))
10. The optimal sampling rate is twice the highest frequency. CD music is sampled at 44KHz. What is the highest frequency that can be represented on a CD? (11.3.1, (sec:musicalnotes))
11. Give an example of structure in music. (11.3.2)
12. Aside from the words themselves, how do people convey meaning with spoken language? (11.3.3)
13. Pronunciation. (11.3.3)
14. How does the sound of your speaking change if you make a conscious effort to open your mouth more fully as you talk? ((sec:speechproduction))
15. Speech application. (11.3.3)
16. Motion analysis. ((sec:motionanalysis))

17. Give an example of each of the gesture categories described in Fig. 11.22. (11.4.1)
18. Video metadata. (11.6.2)
19. How is multimedia markup different from text markup? ((sec:multimediamarkup))
20. Games. (11.7.0)
21. What are some strategies for exploring data in more than three dimensions ((sec:3-Dvis))
22. What is the value of metaphor for the design of virtual environments. (11.10.2)
23. Distinguish between first-person and third -person viewpoint. Give an example. (11.5.0)
24. Virtual environments. (11.10.2)
25. Distinguish between "virtual reality" and "mixed reality". (11.10.2, 11.10.1)
26. Give some examples of mixed realities. (11.10.1)
27. Avatars. (11.10.3)

Short-Essays and Hand-Worked Problems:

1. Choose a picture that is accompanied by text from a newspaper or magazine and explain whether you believe it is well composed. How does it relate to the text in which it appears? (11.2.1)
2. If you had to develop a system for matching pictures in the newspaper with the text of the stories with which they were associated what would you do? ((sec:simpleimageproc), -A.2.3)
3. Describe how computer graphics and digital photography are merging. Hint: Think about object-level descriptions of images. ((sec:graphics))
4. In what ways are the mechanisms of retrieval from a text collection similar to retrieval from a collection of images? (Hint: Think about representations and queries.) ((sec:sketchinginterface))
5. What types of tasks would be suitable for a sketching interface for image retrieval? ((sec:sketchinginterface))
6. Do you agree with the statement: "A picture is worth 1000 words"? Explain. (11.2.4)
7. How would you apply the Gricean maxims to visualization systems. (6.4.1, 11.2.5)
8. Why is it more difficult to control acoustics at an outdoor concert than in an indoor concert? (11.3.1)
9. Why do you think people like music? Explain your answer. (4.6.2, 11.3.2)
10. Describe some of the problems of attempting to extract the lyrics from the music of a song. (11.3.2)
11. Describe an interface you might build for helping to teach students how to write a specific type of poetry (e.g., sonnets) or song lyrics. (11.3.2, 11.3.2)
12. Describe the components you would need for an audio-only query tune-retrieval system. (11.3.2)
13. Describe some of the difficulties in using tune matching for retrieval. (11.3.2)
14. Speech does not include explicit punctuation marks as does text. What are some of the features of speech that function as punctuation? (11.3.3)
15. Why is the "signal-to-noise-ratio" an important consideration for both music and speech recognition. ((sec:musicrecognition), 11.3.3)
16. Compare template models for visual recognition with template models for phoneme recognition. (11.2.2, 11.3.3)
17. Identify the phonemes in "dog," "cat," "apple," "tree," "comb," "bomb". (11.3.3)
18. What is the phonetic representation of "the Rain in Spain"? (11.3.3)
19. What are the characteristics of radio that make it a popular and economically successful medium. ((sec:radio)).
20. Describe an audio-only interface for accessing Web documents. ((sec:spokencommands))
21. Estimate how many telephone calls are made in the United States each day. Justify your estimate.
22. Estimate how many words are spoken by the world's population in a day. Justify your estimate.
23. Describe an audio collection you would like to develop. Describe the collection management procedures your would use. (7.2.2, 11.3.2)
24. Chose a short video and describe its structure. Create a storyboard for it by sketching the main scenes. ((sec:storyboards))

25. Video metadata. (11.6.2)
26. Suppose you wanted to enter graphical queries to a video retrieval system about the ways in which objects moved across the image itself (some objects might move fast, some slow, some in a smooth motion, and some in an erratic motion, etc.). Describe (and/or sketch) an interface you might develop for entering those queries. (11.6.2)
27. How might you build an interface to examine scenes to be returned by a video retrieval system? ((sec:videosearching))
28. Animation. ((sec:animation))
29. Affine equations. (11.2.2)
30. What aspects of gestures reveal emotion? (4.6.0, 11.4.1)
31. Is a smile a gesture? Why or why not? (11.4.1)

32. Hypermedia representations. (11.1.5)
33. Synchronization of multimedia events. ((sec:finesync))
34. Preservation of interactive systems. (7.5.5, 11.1.5)
35. Characterize an online game in terms of the dimensions in Fig. ??. (11.7.0)
36. 3-D object calculations. (11.8.1)
37. 3-D projections. ((sec:3-Denvironments))
38. Is "reality" subjective or objective? (11.10.2)
39. Suppose you were going to make a simulation of foot traffic on your campus. Describe how you could use an agent-based simulation. (9.5.0)
40. Suggest a critical question you might ask in a Turing Test. Why do you believe it would be effective? (11.10.4)
41. Describe a scenario for an interactive drama. (11.5.3)
42. Chose a character from history and describe an interaction with them. Describe what you would have to do to get a computer to produce those interactions. ((sec:syntheticinteractions))
43. Are you engaged in "mixed reality" during a telephone call? (11.10.1)
44. Suggest a novel application for wearable computers. (11.9.1)
45. List all computers in your home. Be sure to include those in hand-held games, appliance controls, and communication devices. How many of these computers are able to be directly controlled by users and how many are "embedded"? ((sec:pervasivecomputing))
46. Virtualized reality. ((sec:virtualizedreality))
47. What cues are most important for developing a convincing virtualized reality? What does it mean for people to "suspend disbelief"? ((sec:virtualizedreality))

Going Beyond:

1. Visual object recognition. (11.2.2, 11.2.2)
2. How does "compositionality" apply to visual languages? (1.1.3, 11.2.4)
3. How is visualization related to hypertext? To information needs? (11.2.5)
4. Describe a simulated audio environment you would like to develop. Describe some of the difficulties you would have and how you might overcome them. (11.3.1)
5. (a) Explain the principles of audio beam tracing. Develop a simple implementation of audio beam tracing. ((sec:beamtracing))
6. Music to complement lyrics. (11.3.2)
7. How could a thesaurus improve the recognition rate for a speech processing system? (2.2.2, 11.3.3)
8. Languages which are not written have many fewer words than languages that are written. Why is this? (6.2.1, 11.3.3)
9. What is an appropriate signal-to-noise ratio for preservation of music? ((sec:musicprocessing), -A.9.2)
10. Formants. (11.3.3)
11. Describe how music could be synthesized using a grammar. ((sec:syntheticmusic))
12. Ask two friends to read a paragraph of text into a tape recorder or speech capture system. Examine the samples to attempt to determine how the speech characteristics of your friends differ. (11.3.3)
13. Describe the similarities and differences between typing errors and speech errors. Develop a cognitive model that explains these differences. (4.3.3), 10.3.1, 11.3.3
14. Describe how a search engine for speech might be developed that would index and match the phonemes of speech without text representations. (11.3.3)
15. Propose a cognitive model for comprehension of speech. For instance, are spoken words and textual words simply converted to a common format and then processed the same way? (11.3.3)
16. Describe a business based on speech recognition technology. (11.3.3)
17. Describe some of the social changes we might expect if speech recognition is realized. (11.3.3)
18. Develop a simple HMM for processing speech. (11.3.3, -A.5.5)
19. How important is it to keep track of whether a group of songs appears together on a phonograph album as distinct from simply preserving the recording of the individual songs? (7.5.1, 11.3.2).
20. Describe the requirements for an audio editing system. (7.9.1, (sec:audioediting))
21. Describe some design principles for audio hypertext. ((sec:audiohypertext))
22. Voice mail indexing systems might use distinct speech patterns to extract the return telephone number in a voice mail message. Listen to several voice mail messages and determine some of these phrases. ((sec:voice-mailindexing))
23. Create a storyboard for TV sitcom you have recorded ((sec:storyboards))
24. Describe a language for video events and objects. (11.6.2)
25. Find an online video and develop a multimedia summary of it. (11.6.2)

26. Develop two simple wire-frame displays. Demonstrate morphing from one of the wire-frames to the other.((sec:wireframes), (sec:morphing))
27. Motion analysis. Affine equations. (11.2.2)
28. How do the gestures of television actors compare to the gestures made by ordinary speakers? Why do think there is a difference? (11.4.1)
29. Develop a temporal scripting language. (11.1.5)
30. Hypermedia applications. ((sec:hypermediaapps))
31. Why do relatively few women play video games? (4.9.1, 11.7.0)
32. How could you use hypertext and user models to develop adaptive games? (2.6.1, 4.10.2, 11.7.0)
33. Observe the discussion among the players in a multi-player game. What principles of interaction do you observe? How would this discussion be different if the game were conducted with audio-only communication? (5.6.5, 11.7.0)
34. If games are artificial environments, is it helpful to use them for education? Recall that we argued that education was best when it is situated in the environments to which it applies. (5.11.7, 11.7.0)
35. What standards might you apply to evaluate whether a game is fun? (7.10.2, 11.7.0)
36. Describe an online game based on railroad trains. (11.7.0)
37. 3-D objects, (11.8.1)
38. Virtual reality systems generally emphasize graphical interaction. They do not necessarily give a sense of the cultural assumptions or other contexts associated with an environment. How could these other factors be conveyed? ((sec:3-Denvironments))
39. The term "virtual reality" seems like an oxymoron. What might be a better term? (11.10.2)
40. Mixed and augmented reality, (11.10.1)
41. What are the attributes of effective shared virtual spaces? (11.10.2)

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Appendix

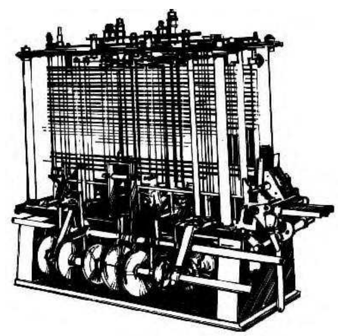


Figure A.1: The Analytical Engine developed by Charles Babbage is regarded as the first programmable calculating machine. (check permission)

A.1. Information Theory

We have defined information as something which changes the behavior of a system which receives it. It is difficult to specify exactly what those critical factors will be but to the extent that we can specify them, we may be able to figure out how to transit them. Information can also be defined as selecting one alternative from among several others. Transmission of representations though that isn't always transmission of rich information.

If we can figure out what needs to be transmitted, we can determine the number of bits required to transmit them optimally. Examples of the surprising-ness of information. Being notified that you have won the lottery is truly surprising since the chance of that is quite small. There is a wide range of applications for Information Theory. Though, it is difficult to understand how much information is being transmitted without knowing how the information is represented.

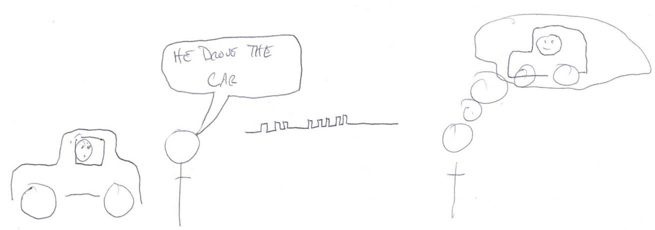


Figure A.2: At least representations can be coded and transmitted in terms of bits. If they can be unpacked as they were encoded, then there can be perfect information transfer. But, of course, not two people will not have the same encoding and decoding systems.

A.1.1. Measuring Information: Entropy

For communication systems, it is desirable to encode as much information as possible into a narrow channel. This was the basis of the simple information transfer model of communication. We want to determine the most compact representation for a message. This is useful for instance, for data compression, data storage, and for Hidden-Markov Models (11.3.3, -A.5.5). Given a vocabulary, we can calculate the fewest number of bits needed to transmit a message[68].

In complex environments, is it really possible to measure information?

Suppose we had a group of four people and we had to pick one of them (Fig. -A.3). Assuming they are equally likely to be picked, the probability would be 0.25. We would use $Code_1$ or $Code_2$ and we would know that $Code_2$ is optimized. Since the log is usually $base_2$, information is usually measured in bits. Indeed, the word "bit" is derived from the phrase "binary information unit".

$Distribution_1$			
Person	**Probability**	$Code_1$	$Code_2$
Abu	0.25	1000	00
Bob	0.25	0100	01
Cathy	0.25	0010	10
Dwayne	0.25	0001	11

Figure A.3: Two coding systems for identifying which of four individuals might be selected in a lottery.

The self-information of a message is related to probability of that message; that is, how likely or predictable that message is (Eq. -A.1).

$$I(m) = -logP(m) \tag{-A.1}$$

"Entropy" is a measure of the disorder of a system o set of messages (Eq. -A.2). For the data in Fig. -A.3, the entropy is $H = X$. Because each person is equally likely to be picked, we cannot do any better than chance in guessing who that person is. However, this also means that the codes we use to identify the person can be very efficient. For the probabilities in $Distribution_2$ (Fig. -A.4), the entropy is $H = 1.8$ and the codes to indicate which of them has been selected are not as efficient as those for $Distribution_1$.

$$H(X) = -\sum_{i=1}^{k} P(x_i)log_2P(x_i) \tag{-A.2}$$

$Distribution_2$	
Person	**Probability**
Abu	0.40
Bob	0.15
Cathy	0.10
Dwayne	0.35

Figure A.4: Unequal probabilities of being selected, as shown here, have lower entropy than equal probabilities (shown in Fig. A.3).

Perplexity.

Another way to think of entropy is as an indicator of the average "surprise" of the choices. When the probabilities of all choices are equal, as in $Distribution_1$, the level of surprise is maximized. Another way to look at this is ask what is the additional value contributed by a given source of information. Maximum entropy. Knowledge at the receiver's end can compress information much more.

$$H(X, Y) = \tag{-A.3}$$

Mutual information.

Information valuation. Bayesian models for deciding how much to value information sources.

A.1.2. Communication Channels

Once we have a measure of information, we can compare the amount of information able to be transmitted on different channels (Fig. -A.5). Communication models ((sec:communicationmdoels)). We might ask how much information can be transmitted with a fixed number of bits in a communication channel. The bits able to be transmitted per unit of time, is the channel capacity which is also known as the "bandwidth".

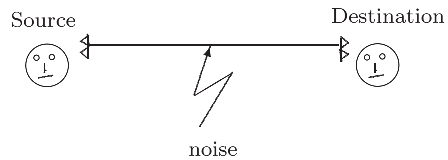


Figure A.5: Information transfer (adapted from[68]). (check permission)

It is possible to calculate bits of information based on assumptions about the receiver's capabilities. If the communication channel is imperfect (e.g., noisy), we could calculate how much information can be transmitted. Signal processing equations can be used to support tasks such as speech-processing (11.3.3) and evaluating the quality of machine translation (10.13.1). Specifically, we can model translation as a noisy channel between a source and a receiver[9].

A.1.3. Applications of Information Theory

Applications Sensor networks.

Can we really measure information and meaning in people's heads? Can we even usefully measure how much information there is in a complex information such as a book or a videotape by measuring the number of bits in a digital copy of that resource?

The Redundancy of Natural Language

Natural language is highly redundant. Put another way, every letter, phoneme, or word is not totally surprising. You should be able to make a good guess about the missing word in the sentence: "You are reading a book about Information ________". Redundancy in natural language prevents misunderstanding. the amount of redundancy in natural language is related to perplexity. Can we estimate the amount of redundancy.

Language is, effectively, a coding system. Several approximations to English are shown in Fig. -A.6. These approximations are based on the likelihood of letter and word combinations. One application is to machine language translation (10.13.1).

Level	**Example Approximation**
First order Word level	REPRESENTING AND SPEEDILY IS AN GOOD APT OR COME DIFFERENT NATURAL HERE HE THE A IN CAME THE TO OF TO EXPERT GRAY COME TO FURNISHES THE LINE MESSAGE HAD BE THESE.
Second order Word level	THE HEAD AND IN FRONTAL ATTACK ON AN ENGLISH WRITER THAT THE CHARACTER OF THIS POINT IS THEREFORE ANOTHER METHOD FOR THE LETTERS THAT THE TIME OF WHO EVER TOLD THE PROBLEM FOR AN UNEXPECTED.

Figure A.6: N-gram approximations to English[67]. (check permission)

N-grams are particularly useful for speech processing where the sequences of phonemes is highly predictive of specific words.

Example = Morse code

A.2. Compression

The content in almost all information resources is redundant and can be compressed. Most often this is done to reduce the amount of material which has to be transmitted or stored. Compression is a type of representation, but it is generally not a representation from which semantics can be easily extracted. Information theory (-A.1.0) can measure the effectiveness of the compression.

A.2.1. Issues for Compression

What Makes a Good Compression Scheme?

There are many options in compression; as with other aspects of information systems, the selection of these options depends on the requirements of the users. There is a close connection between compression and the preservation of meaning.

Efficiency Two main types of compression are termed lossless and lossy. If it is possible to get an exact copy of an image back after compression, then the compression is "lossless". If something is lost so that it is not possible to retrieve an exact copy, then the compression is "lossy". Most compression algorithms are lossy.

Codes and compression. Fixed code length versus variable code length.

We can measure compression by the "compression ratio," which is the ratio of the size of the file before compression to its size after compression.

Codebook.

Adaptive compressions. Self-correcting codes.

Content Dependencies Some compression schemes are good for specific content. GIF compression works particularly well for line drawings while JPEG compressions are especially good for full-color images. Compression needs for astronomy or medical images are very different from those for video games.

The amount of variability in content will affect compression needs.

Self-referential codes.

To the extent that a compression scheme captures semantically meaningful events.

some of the semantics can be extracted from the compressed formats. Therefore, the compressed representation may also be useful for retrieval.

Delivery, Storage, and Decompression Robust to packet loss.[??]

Some storage devices (e.g., CDROM) and some networks (e.g., modems on voice telephone networks) deliver fixed data rates. Other systems deliver variable-bit rates (VBR).

A system can provide real-time delivery, or may be real-time interactive.

Layers of multimedia are prioritized. Compression matched with priority for transmission.

The recipient has to know how to decompress the message.

Compression and decompression take up a certain amount of computational resources; the right approach can optimize results.

One might opt for software compression or hardware compression.

Tradeoffs are made regarding, for example, the amount of disk space used versus the speed of searches.

"Transcoding" is the transfer from one compression system to another one. However, there can be a substantial loss of quality in the process.

Two Paradigms for Compression

Compression may be thought of as a type of representation (1.1.2). An optimal compression would be based on human perception and information processing, but algorithmic compression may not seem to be based on the semantics of the material being compressed. The compressed signals necessarily follow the characteristics of the content. Speech signals in a telephone are based on the range of speech necessary for speech comprehension. Because compression often causes loss of content, the issue is how to minimize that loss in comprehensibility. These differences can be understood in terms of Information Theory (-A.1.0).

A.2.2. Text Coding and Compression

Compression of the message. Text compression tends to emphasize lossless compression techniques because there is relatively little data and any loss can be significant. However, there may not be too much need for this since is it cheap to transmit text.

Many coding systems have been developed. Huffman Coding and Huffman Trees. Earlier, we compared the entropy of coding two sets of events with a two-bit code (-A.1.0). Huffman codes attempt to match the length of a code with the frequency of its occurrence in the family of messages to be transmitted. If we are transmitting letters, given that the letter "e" is the most common letter in English, it would be the shortest term (Fig. -A.7).

A second version of this can be seen in Fig. **??**. Letter and frequency (Korfage example).

$Distribution_3$		
letter	**Probability**	$Code_1$
e	0.675	1
i	0.125	01
o	0.125	10
l	0.125	11

Figure A.7: An example of a Huffman Code in which high probability items are given short codes. (check values)

A.2.3. Image Processing and Compression

Coding — compression - formats. Pictorial material comes in many forms and the optimal coding for those varying schemes can be very different. A black-and-white line drawing will have very different compression characteristics from those of a complex colored photograph. Bitmaps of text as for OCR. [??] Displays and printing technology are described in -A.18.2.

Edge detection, shape detection, textures.

In run-length encoding, the sequence B,B,B,B,B,B,A,A,A could be encoded as 6B3A That is six repetitions of B followed by three repetitions of A.

The technology for handling still images is now fairly well established. They are easy to digitize, compress, transmit, and embed in documents.

Visual words.

Object detection techniques (11.2.2) are similar to those used for still images.

Digital Encoding of Images

In a black-and-white image, only the brightness of pixels is measured. Gray scale. Color depth (Fig. -A.8).

Pixels			
R	**G**	**B**	**Visible Color**
0	0	0	Black
256	0	0	Red
0	256	0	Green
0	0	256	Blue
256	256	256	White

Figure A.8: All possible colors can be coded as levels of Red (R), Green (G), and Blue (B). 8 bits is often used for each coding each of these base colors allowing 256 shades of each one.

As noted earlier (4.2.3), human color perception is complex. A variety of systems have been developed for coding colors. Some are based on the human perceptual system (such as HSL) and some are based on technological convenience (such as RGB). The most common system is RGB (red, green, and blue). The HSL system deals with hue, saturation, and luminance; some claim that it is closer to the human visual system as explained in 4.2.3, above. Still another system is YIV; Y stands for luminance, I for the red-cyan dimension, and V for the green-magenta dimension. YUV is used for broadcast television; here, Y = luminance, U = blue-Y, V = red-Y.

One element in color coding is the way the colors are distributed on the color space; another element, color depth, refers to the number of bits allocated for the representation of each color. One common system uses one byte (8 bits) assigned to each of the red, green, and blue channels. This allows encoding of 256^3 (65K) colors.

Image Processing of Pixels

This kind of processing is not object-based. The quality of the image can be improved by adapting pixels. From pixels to image processing.

Some specialized processing is model-based.

Noise suppression.

Get a signal![??]

Dithering

Image recognition.

Content based image retrieval. CBIR.

Image Compression

Image compression reduces the amount of data necessary to reproduce images. This facilitates storing data on a disk or sending it over a network. Ideally, we could find a small set of data and a few simple parameters that describe the complexity of an image. There is a great deal of redundancy in most images and this redundancy can be used in many ways to compress the image. Adjacent pixels are often similar in color. This can be used to take advantage of lossless compression with run-length encoding similar to that described for text (-A.2.3). TIFF compression is lossless.

Lempel-Ziv-Welch (LZW) GIF images use the Lempel-Ziv-Welch (LZW) algorithm which is based on probability functions.

Discrete Cosine Transformation (DCT) Discrete Cosine Transformation (DCT) converts the colors of the image to frequencies. DCT is like Fourier transformations (-A.2.4). Low frequencies encode the dominant colors and higher frequencies encode the transitions.

Wavelets Wavelets are similar to DCT in characterizing an image on its frequencies. They are also similar to Fourier compression (-A.2.4). However, DWT Wavelets are more flexible in representing objects than are the trigonometric functions in DCT.

Fractal Compression Fractal compression uses repeated application of an algorithm to approximate the original image (-A.10.2), which is generated by recursive application of the program.

Transformations: rotation, dilation, reflection

Image Formats

Beyond the compression algorithm applied to individual frames, a wide range of compressed image formats has been developed, a few of which are in widespread use. JPEG and GIF are the most common formats and will be considered here. Graphic Interchange Format (GIF) uses the LZW algorithm. The GIF specification includes composite images. These can be used to create apparent motion in an image and are known as animated GIFs.

The JPEG (Joint Picture Experts Group) format is blocky.

Typical compression ratios for JPEG are on the order of .[??] A 100KB file might be reduced to 10KB. There are several levels of quality for JPEG images and the quality selected will affect the amount of compression. JPEG is generally better than GIF for color pictures because the underlying DCT transformation allows a wider variety of transitions to be represented.

Transmission Progressive transmission allows displays of varying qualities as they are received across a network. Thus, a partial version of the image can be displayed before the transmission is completed. This sometimes works as interlacing.

Example: JPEG-1

8x8 pixel blocks. Slices,[73] has a detailed discussion of the JPEG standard and a good overview of other compression techniques. Discrete Cosine Transform (DCT, as described below). Quantized Q-matrix.

Example: JPEG-2

Object-based[??]

Scene Recognition

A.2.4. Audio Processing, Compression, and Coding

Audio Coding and Compression Algorithms

The choice of the coding algorithm depends on what is being encoded and the environment in which the it has to operate. The two most important applications for audio are speech and music. There are large differences in the encoding requirements between music and speech. Speech has a relatively narrow dynamic range while music may vary to a much greater extent. Some codes must operate in environments where some of the data is lost during transmission.

Sound waves are converted to analog electrical signals by a microphone. To create digital audio, these analog signals must be converted to numeric values. There must be an analog-to-digital conversion (AtoD). AtoD conversion is also known as Pulse Code Modulation (PCM); it involves two steps: sampling and quantization. Sampling is the number of times a signal is coded per second. To get a full coding of a signal, it must be sampled at twice its frequency. Once the signal is sampled, it must be assigned a numeric value which can be represented in a computer word. The code is usually linear, but can also be logarithmic.

Quantized digitized audio on a CD-ROM is not compressed; the quantized samples are just stored as they are coded. This simplifies the electronics and there is no need to control the rate of playback. When storage capacity is at a premium or network congestion is a problem, compression greatly reduces the amount of data to be stored. In contrast to compression, in which the number of bits is constant regardless of what is contained in the audio file, Variable Bit-Rate (VBR) coding uses total bits when

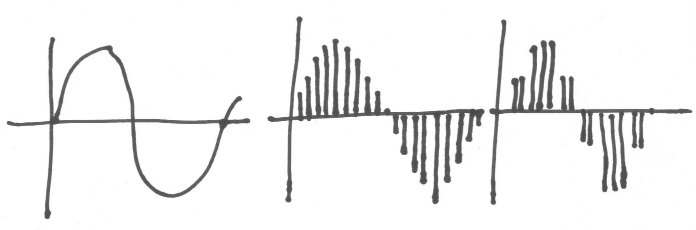


Figure A.9: An analog sound wave (left) can be digitized (center) and then it can be "quantized" to a limited number of levels (right).

the data are easily compressed.

As noted earlier, speech contains phonemes which appear as formants (11.3.3), relatively regular bursts of sound that are related to the meaning in the words. Linear predictive coding (LPC) estimates the pattern of these formants and codes them efficiently for transmission (Fig. **??**). These codes can be used to determine filters. A variety of systems have been developed to make LPC coding more efficient. For instance, DPCM (Differential PCM) encodes the differences between pulse code samples. If the tones are steady, then little additional information needs to be transmitted. DPCM is analogous to frame differences for video (-A.2.5).

Audio Processing

Fourier Analysis The French mathematician Joseph Fourier had the insight that complex waves could be described as a combination of regular sine waves. Because each sine wave has a known frequency, a Fourier analysis of speech shows the main frequencies in that speech. Fig. **??** shows the decomposition of a signal by Fourier analysis.

This is the analysis described in the spectrogram in Fig. 11.15. The frequency of speech changes rapidly as the person produces different sounds. Characterizing these changes in frequency is important for speech processing (11.3.3). A particularly useful function for determining the spectrum is the Fast Fourier Transform (FFT).

Compressed Audio Formats Beyond the specific codec used, data may be formatted so that it can be stored and transmitted. A CD has no compression; the physical design of a CD is described in -A.20.1.

Some common audio formats are U-law, WAV, and AIFF. While MPEG-2 is primarily a video standard, the MPEG-2 audio standard has been adopted for studio quality sound reproduction. It has 64kbits/s per channel with five main channels (left, center, right, and 2 for surround sound), and other specialized channels, such as one for low frequencies.

Secure Digital Music Initiative (SDMI)[??]

Specifically, MP3 is audio layer 3 of the MPEG2 standard. The popular MP3 music standard is part of MPEG2.

A.2.5. Video Processing, Compression, and Coding

Video requires far more data than audio; therefore, compression is particularly important for networking and storage. Additional discussion of video networking and video displays is found in (-A.18.2).

Frame Differences

In a video, one frame is much like the next. This means that they do not have to be presented separately. Frame differences in video often reflect the motion of objects. Because frame differences are widely used in compression algorithms, it is often possible to detect motions from compressed video. The top panels of Fig. -A.10 show an object moving from left to right. The middle right panel shows the overlap of the two positions of the object, and the lower right panel shows the frame differences.

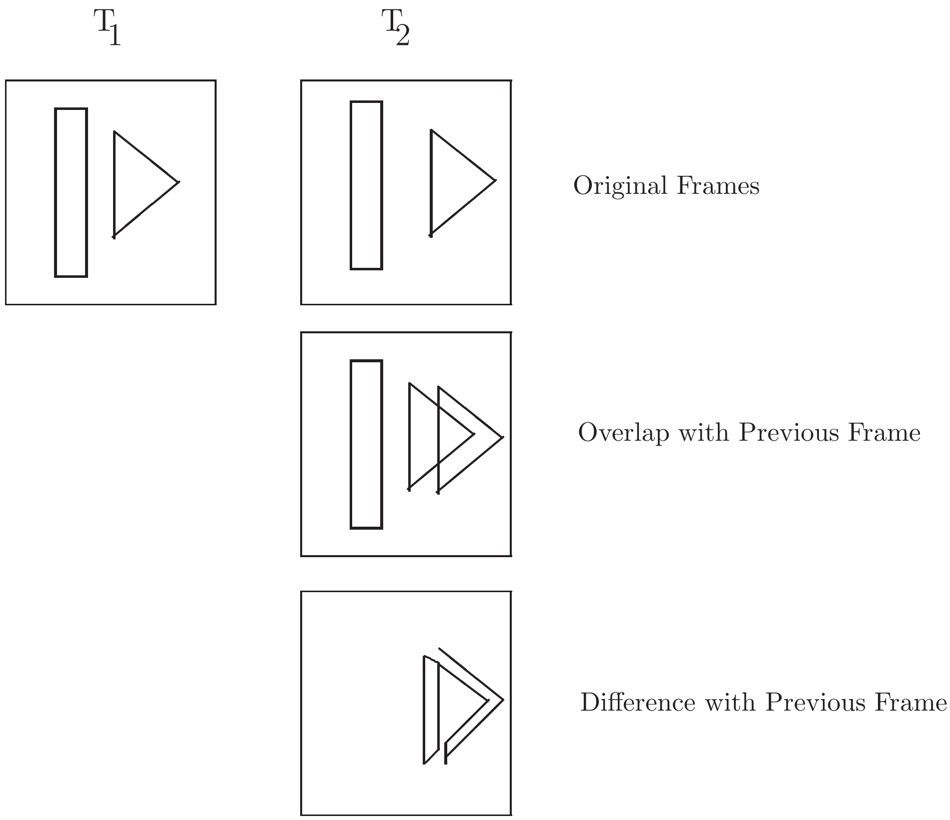


Figure A.10: Consider a two-part object that moves as shown in the top two panels T_1 and T_2. If all Panel T_1 is transmitted by video, then all of T_2 does not need to be transmitted; only the differences between the frames need to be sent. The panel in the middle row shows the two frames superimposed on each other and the bottom panel shows the differences in the two frames. Panel T_2 can be generated from T_1 by applying that difference. For this example, the area in the open trapezoid should be reset to white while the black area needs to filled in (lower panel). (smaller)

Digital Video Compression Algorithms

For digital video, the principles of color coding are similar to those for still images (-A.2.3), with the addition of a temporal dimension. Codecs for the compression and decompression of audio were described earlier; video is also compressed and decompressed by codecs.

The effectiveness of the codec depends on the context in which it is being used. If there is a lot of action in a video clip, then fresh frames may be most effective, but if the clip is just a head-and-neck-shot of a person talking, then frame-differences should be sufficient.

Forward DCT Only those pixels that change from frame to frame need to be updated. This allows only the differences to be transmitted rather than all the pixels for every frame. There may be drift from the original picture and the image will need to be refreshed by re-sending the entire current frame. This fresh frame is called a “key frame” (in MPEG, they are known as I frames).

DCT DCT is like still-image encoding. Entropy coding (-A.1.1).

3-D Fractal Video Compression Also combines with bin-trees.

Adaptive Algorithms As the name suggests, an adaptive algorithm adjusts to the type of content which is being compressed, and hence involves more content-specific coding. MPEG-4 ((sec:mpeg4)).

Digital Video

This section considers several different formats for digital video.

Version	Brief Description	Section
MPEG-1	1.5 MB/s video (PC quality)	This section
MPEG-2	Studio quality video (45MB/s)	This section
MPEG-4	Component descriptions	This section
MPEG-7	Video content description	11.6.2
MPEG-21	Framework for services	7.8.4
MPEG-A		
MPEG-V		

Figure A.11: Summary of MPEG standards.

The MPEG-1 standard is for PC-quality video (less than 1.5MB/s). Fig. -A.13 shows an EG1 stream of frames and frame differences. The standard specifies I, P, and B frames. The I frames are “key frames”; they are essentially JPEG images. The B and P frames are obtained from frame differences (Fig. -A.12). Decoding in software is practical; encoding is computationally expensive and often is not done in real-time.

Frame Type	Description
I frames	They are JPEG (-A.2.3) images and are high-quality reference frames. Transmission of these requires channel capacity. On some systems, these are called key frames.
P frames	forward compression
B frames	use bi-directional (both forward and backward) compression. These are particularly difficult to do in real time.

Figure A.12: Types of MPEG-1 frames as shown in Fig. A.13.

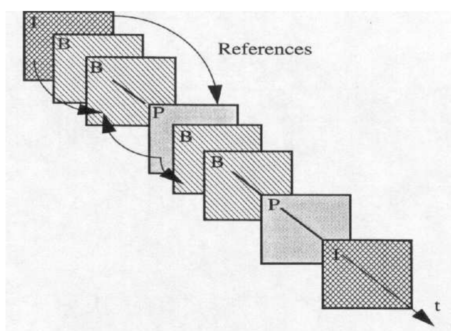


Figure A.13: Mix of frames in an MPEG-1 stream. (redraw-K) (check permission)

A.3. Graph Theory

We have seen many examples of graphs. Graphs are composed of two types of objects: nodes and links. We have seen applications of graphs across many of the topics in this book such as characterizing hypertext (2.6.3) and social networks (5.1.0). Along with state machines and grammars, graph theory is a part of a field called discrete math.

Facebook equation. Tie strength.

A.3.1. Types of Graphs

The macroscopic structure of the graph can become important for large graphs. Different types of graphs have different properties. When a number of nodes are connected by links, the pattern of the connections may be characterized. Links in graphs may be directed, that is, they allow connections in one direction but not in the other. The connections of pages on the Web form a "directed graph". If it is possible to get back to a node by some route once it has been left, then the graph is said to have cycles. If there are no cycles in directed graphs, they are said to be "acyclic" and the full graph is said to be a "directed acyclic graph" (DAG) (Fig. -A.15). Citation networks, for instance, are DAGs – time flows in only one direction.

Graph	Any set of connected nodes.
Lattice	
Directed graph	Edges have a direction.
Tree	Trees have only one path connecting any two nodes.

Figure A.14: Types of graphs.

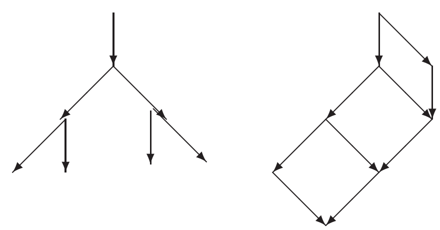


Figure A.15: Directed graphs. On the left, is an acyclic graph, in this case a tree. On the right, a cyclic graph, specifically it is a Directed Acyclic Graph (DAG).

Cliques. Two types of nodes. Bipartate graphs Fig. -A.16

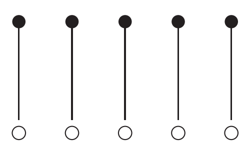


Figure A.16: Bipartate graph.

There are several types of trees such as ordered trees and minimum spanning trees. Trees may also be used to describe sequences of objects (e.g., PAT Trees).

A.3.2. Graph Searching

Many problems such as decision space or a problem space require search. Structured searching in data structures such as binary trees. If there is no index, the graph must be searched by following links and examining nodes. One common trade-off is between breadth-first and depth-first searching (Fig. -A.17).

Tree-searching is useful, for example, in parsing.

Several strategies for searching graphs have been proposed. AI as graph search (3.7.1, -A.7.3).

Heuristic. If value can be assigned at each point, take the one first (Fig. -A.19) but there has to be some criterion for what is the t. Min-max pruning.

The game of tic-tac-toe has a finite number of solutions. Fig. -A.20 shows a game tree. This forms a tree and positive outcomes can be searched. Symmetrical solutions are not shown. While the space for

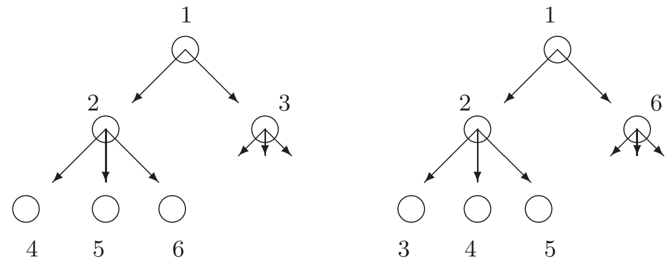
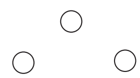


Figure A.17: Breadth-first (left) versus depth-first (right) searching. The numbers indicate the order in which the nodes are searched.

Figure A.18: If values are assigned to each node, those values can be used to guide the search. More complex than simple depth-first and breadth-first search described above, branch-and-bound is t-first searching. As the tree is explored, the likelihood of finding the target under each sub-tree is estimated and the node with the highest value is opened. (redraw) (check permission)



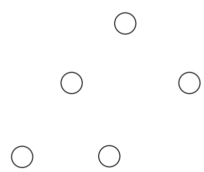


Figure A.19: More complex than simple depth-first and breadth-first search described above, branch-and-bound is t-first searching. As the tree is explored, the likelihood of finding the target under each sub-tree is estimated and the node with the highest value is opened. (check permission)

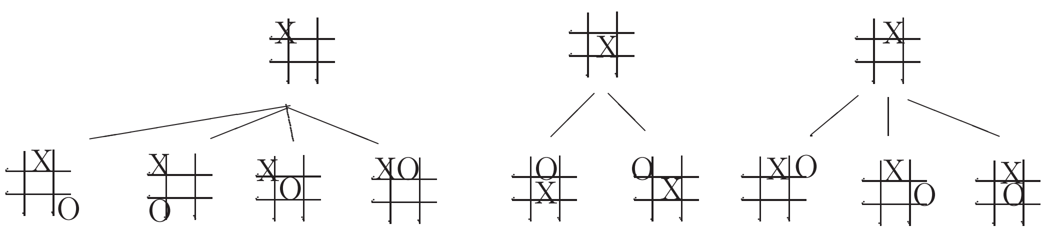


Figure A.20: Fragment for moves in for tic-tac-toe forms a “game space”. Here just the first two moves of a game are shown (other alternatives are symmetrical). We can estimate the value of each move by counting the number of outcomes which lead to winning.

tic-tac-toe is tractable, the game space for chess is far to large to even be calculated. Heuristics might help estimate the value of possible alternatives.

There are many criteria for selecting the value of nodes. Branch-and-bound (-A.3.2). MIN-MAX (-A.9.3). and selection of responses. Insurance.

Searching knowledge structures.

A.3.3. Graph Algorithms

There are many other topics in graph theory that we will consider briefly. General algorithms (-A.5.0). So, for Web characterization (2.6.3) or for validating the coherence of a Web site. Finding the paths through a hypertext. These problems may be viewed abstractly as the connections of nodes among them.

Graph drawing plans the layout of graphs [20]. For instance, when laying out a data map or a flow chart, the graph drawing procedure might attempt to minimize the number of crossings (Fig. -A.21) The goals would be to determine whether two graphs are identical in structure. This includes "graph matching," "graph homology," and "graph congruence"

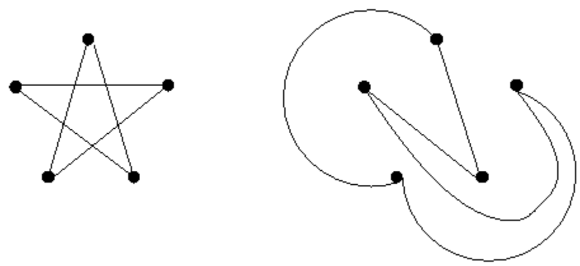


Figure A.21: Two ways of connecting five points. The approach on the left minimizes the length of the lines. While on the right the number of crossings is minimized.

Dynamic graph layout and interfaces. If a display is resized, what is the way to redraw a graph based on it. [45],[52].

One strategy for pruning would cut off those links that do not connect to other links (Fig. -A.22).

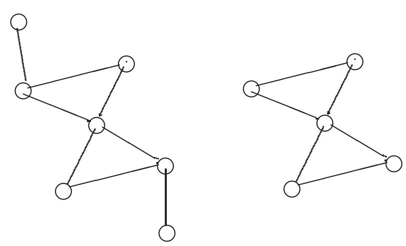


Figure A.22: The graph on the left can be "pruned" to create the one on the right by eliminating those nodes that are connected to only one other node. (check permission)

Beyond pruning to "graph partitioning" (Fig. -A.23). That is, find the place to cut a large graph into two parts. This has been applied to finding Web communities.

Finding the way to connect points in a graph. Spanning trees are trees which connect a set of points. A "minimum spanning tree" is the shortest possible spanning tree (Fig. -A.24).

Pathfinder networks (9.1.3).

A more complex problem is to find optimal paths through set of points. Traveling salesman problem.

A.3.4. Very Large Graphs: From Graphs to Networks

Increasingly, very large scale graphs are being evaluated. Thousands of nodes. A network is a graph in which we consider movement of entities between nodes. Networks may be characterized by some basic properties [8]. One of the most important properties is the distribution of the probabilities of connections between nodes. The simplest has random connection of network nodes. However, some networks have clusters of connected nodes. These are Small-world networks [38] (Fig. -A.25).

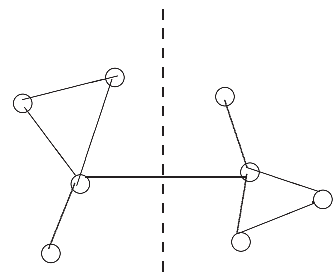


Figure A.23: A large graph may be broken up into small graphs. The partition breaks only one link and leaves roughly equal sub-graphs.

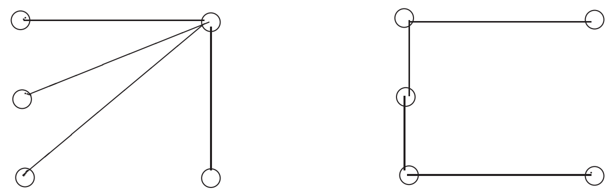


Figure A.24: A spanning tree connects a set of points (left). A minimum spanning tree (right) is the shortest possible tree that connects all the points.

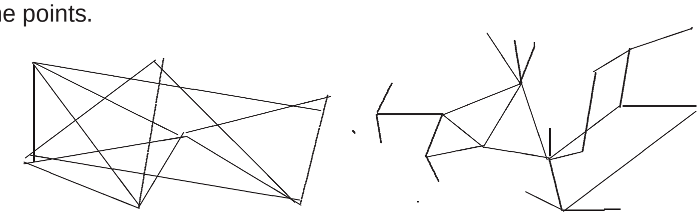


Figure A.25: Graphs differ in the number of short range connections. The graph on the left has random connections. The graph on the right has a preference for connections to some nodes this is typical of many applications such as the Web.

Scale-free structure of network connectivity. Relationship to Zipf's Law.

Graph Complexity

The management of complexity has been a recurrent theme in this text. System complexity (3.8.3). Visual complexity.

Complexity is a challenge. Complexity metrics. Entropy (-A.1.0) as a measure of complexity.

Graph theory (-A.3.0). In Fig. -A.26, the network on the right is clearly more complex than the one on the left. By one common measure, the complexity is X, Y, Z. Thus, complex can be a type of software code metric ((sec:softwaremetrics)). Complexity of software (number of branches and loops). Kolmogorov. Easier to develop and maintain software with less complexity.

A.3.5. Social Network Analysis

We have seen many cases of social information. Purely local interaction. Social networks. Can lead to emergent behavior. Takes a mathematical approach. Who talks to whom (5.1.0).

Characteristics of Social Networks Another type of problem is to determine how close any one item is to any other item in a graph (Fig. -A.28). Because of a classic social psychology experiment done in the 1950's, this is known as the "degree of separation" [50]. In that study, Americans were tested to see how many acquaintances linked people from different regions. This is a similar to the effect of the distance between Web pages (2.6.3). This depends on the "lumpiness" of the graph space. Citation

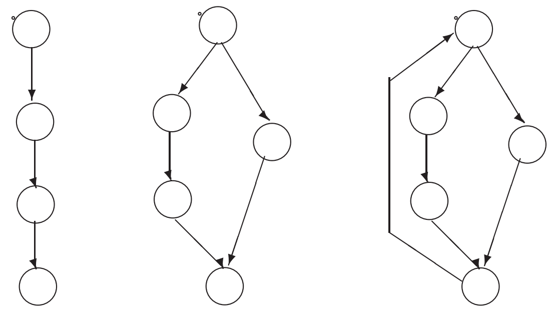


Figure A.26: Branching and looping can be used as a measure of the complexity of a graph. Here, the complexity increases from left to right.

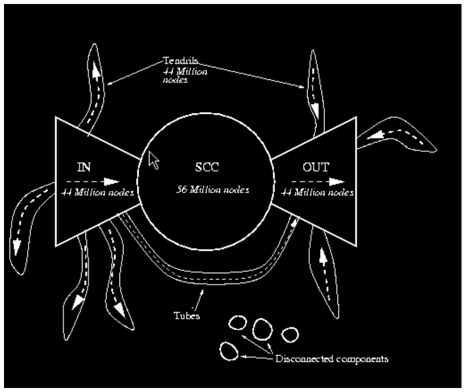


Figure A.27: Massive center for Web interconnections [?]. (redraw) (check permission)

analysis (9.1.2).

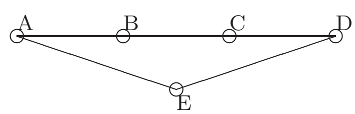


Figure A.28: The degrees of separation count how many steps there are between two points. C is 2 steps from A, but D is also two steps from A when connected by E.

Characteristics of the Social Network Someone at node D is better connected than a person at node J. Characteristics of the individual position in the social network and of the social network as a unit (Fig. -A.30). Consider the communicative patterns of people in the hypothetical communications ("kite") network (Fig. -A.29). In the figure, node "D" has high centrality and node E has high betweenness.

Additional parameters in roles, ease of flow, etc. Correlation coefficient[51].

Epidemics. Inoculation.

Indeed, a critical mass is needed or else, the disease will not be transmitted and will die out.

People on the web can be disambiguated through social networks. Pruning between-ness graph (9.1.3).

Related to PageRank (10.10.2).

Diffusion of Information and Innovation When a new idea or innovation pops up, it gets spread across groups of people. Diffusion of innovations (Fig. -A.32). This is closely related to the social network of

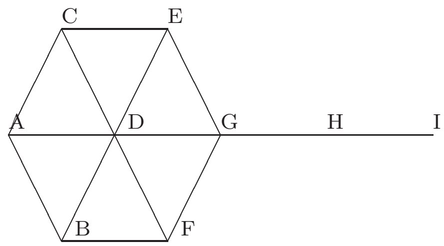


Figure A.29: An idealized communications network — called a "kite" — illustrates the different roles group-members can play in communications. For instance, Person H is essential for I and J to communicate with the rest of the group. (redraw)

Factor	Description
Properties of Individuals	
Centrality	How central is it among other nodes in the network.
Between-ness	Extent to which a node is between two other nodes.
Characteristics of Social Networks	
Density (Coherence)	What proportion of all possible links are actually present?
Cliques	The extent to which subgroups occur.

Figure A.30: Some measures of social networks.

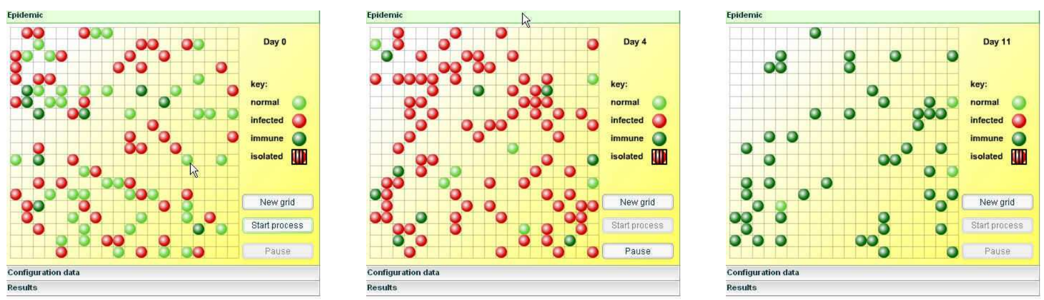


Figure A.31: Epidemic modeling. Normal, infected, and resistant agents are shown. (check permission)(redraw)

the interaction.

Patterns of diffusion. Not simple forwarding. Likelihood of retweeting of political messages. Stickiness and persistence.

In some cases, the forwarding can become a sort of contagion. These are also models for infection and epidemiology including the spread of computer viruses of the spread of human disease. We can talk about contagion and disease vectors. Moreover, these can be blocked with a type of inculcation. Contacts between computers which spread a virus. Following the notion of an epidemic, we can think of a software virus spreading as contagion and we could try to control it with inoculation. In the case of a computer virus, the inoculation might mean applying software patches.

Implemented as an agent-based simulation (9.5.1).

Improvisation as a dynamic model of interaction. Probability of message being accepted. Number of contacts about message. Networking and finding jobs [?]. Probabilistic models. This is too simple a model as the communication and individual action and it must be applied with caution.

A.4. More Models

A.4.1. More Data Models

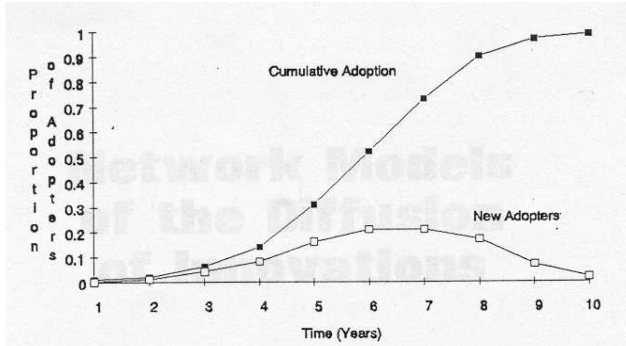


Figure A.32: Idealized curves for diffusion of innovations shows typical curves [?]. (create agent-based simulation). (redraw)

The Relational Data Model: Using Relational Tables to Organize and Merge Attributes

The Relational Model organizes sets of related attributes into tables. Fig. -A.33 shows tables with examples of the entity classes in Fig. 3.55. This use of tables is efficient because it keeps related attributes together. The attributes can be joining entries across tables as needed. Splitting attributes across several tables facilitates efficient storage by minimizing redundancy.

To respond to queries, the attributes often have to be re-combined from different tables. A “key” is an attribute of two or more entities or entity classes that forms a link between entities. In Fig. -A.33, StudioName is a commonality between the two tables; it is an attribute for both entities. Thus, StudioName is a “key,” and links the entities STUDIO and VIDEO, and consequently the tables VIDEO and STUDIO. The key guarantees there will be no ambiguity about which rows of the tables to link. The tables are usually optimized with a processes known as normalization. Moving from descriptions of entity classes to specific instances. Attribute value pair: Title=”North-by-Northwest”

VIDEO	**Title**	**Director**	**Year**	**StudioName**
	North-by-Northwest	A. Hitchcock	1959	MGM
	Toy Story	J. Lasseter	1995	Disney
	Crouching-Tiger	A. Lee	2002	Columbia

STUDIO	**StudioName**	**Phone**	**Email**
	MGM	800-555-1458	orders@mgm.com
	Disney	800-555-9783	orders@disney.com
	Columbia	800-555-9783	orders@sony.com

Figure A.33: Relational tables and sample values for the VIDEO and STUDIO entities.

Richer Data Models

RDF Data Model Linked data. Often looser structure than formal data models. This can be useful when there are inconsistent systems of metadata.

Temporal Data Models

Modeling Stream Data

A.4.2. Models

System Identification.

A.5. Algorithms

Algorithms describe procedures for accomplishing specific tasks. Algorithmic thinking should be fundamental for education. Algorithms and data structures (3.7.1).

A.5.1. Types of Algorithms

"Algorithms" are procedures for solving problems. Algorithms often need to be coupled with appropriate data structures ((sec:datastructures)). Algorithms have been developed for many of the techniques described in this book. Here we turn to the examination of those abstractions. We briefly discussed many algorithms in the early chapters, and in the more detailed discussions of this chapter we have already considered graph-based algorithms (-A.3.2). Fig. -A.34 shows a table of where some algorithm families are discussed.

Algorithm Family	**Section**
Dynamic programming	(sec:dynamicprogramming)
Encryption	-A.13.0
Graph algorithms	-A.3.2
Compression algorithms	-A.2.0
Machine Learning	-A.11.0
Parsing	-A.5.4
Text and Web Processing	(sec:moretextretrieval)

Figure A.34: Guide to the discussions of some major algorithm families.

There may be several algorithms for completing any given problem, and they may possess different degrees of efficiency in terms of computational cost, memory, or time. Since most interesting problems are complex, it is generally useful to find algorithms that are efficient even when the number of terms gets large. The extra effort required to do addition may increase linearly as the number of terms grows.

Global algorithms take all the data as a unit. These are often the more effective, but they can be very expensive computationally. Other algorithms such as neural networks are "local". That is, the calculations are obtained in steps. A similar dimension is whether the solution is found all at once or whether it is found in iterative steps.

A.5.2. Data Structures

A.5.3. Computational Complexity

For large problems, the complexity can make a big difference in whether a adequate solution can be obtained in the available time. Indeed, we measure the complexity of algorithms in terms of the amount of time they take to complete. Some problems, such as adding a constant to all the members of list are linear. Other problems, such as finding the sum of all pairs of numbers in a list are n^2. The most challenging problems are said to be "NP hard"; their difficulty grows as a polynomial function of their size. Combinatoric explosion.

Figure A.35: Comparing algorithm completion time.

A.5.4. Parsing Grammars

Structured objects. Here we explore additional details of the algorithms described earlier (10.4.2, 10.4.2) as well as some other parsing algorithms.

State-Machine Parsing

As noted earlier, natural language can be approximated by a state machine. Extended state machines (3.10.1) can be used for parsing. This works particularly well for formal and simple languages. Specifically, they need to expanded with recursion and otherwise augmented as ATNs.

Fig. -A.37 shows a fragment of a phrase-structure grammar, while Fig. -A.38 shows a very simple lexicon. Specifically, it shows rewrite rules for the sentence "The dog bit the boy". Fig. -A.39 shows the parse tree for this sentence. Collections of tree-structured data — in most cases parse trees — are called a treebank (e.g.,[15]).

Rewrite Rules		**Description**
LHS	**RHS**	
S	NP + VP	Sentences (S) are composed of Noun Phrases (NP) and Verb Phrases (VP)
NP	N, D + N	Noun Phrases (NP) can be composed of a Noun (N) or a Determiner (D) (i.e., 'the') and a Noun (N)
VP	V, V + NP	Verb Phrases (VP) can be composed of a Verb (V) or a Verb and a Verb Phrase (VP)

Figure A.36: Fragment of a phrase-structure grammar. LHS= Left hand side. RHS=right-hand side.

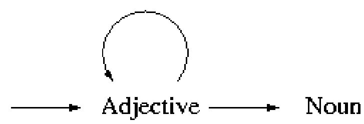


Figure A.37: State machine notation showing that one or more adjectives can be repeated before a noun.

Node	**Lexicon**
Noun	dog, boy
Determiner	the
Verb	bit

Figure A.38: Lexicon for simple phrase-structure grammar example.

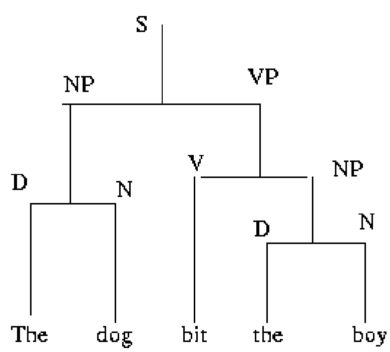


Figure A.39: Parse tree for "the dog bit the boy". (redraw) (check permissions)

"Garden path" sentences. These may require backtracking (3.7.1, -A.7.2).

Other Parsing Methods

Many additional algorithms have been developed.

Chart parsing. Recursive descent parsers. It helps to keep many versions of a parse active.

A.5.5. Hidden Markov Models

Could we formalize the insight we had in Fig. 10.12? Sequential models. Hidden Markov Models provide a statistical technique for modeling sequences. They are weighted automata (10.4.2). Indeed, HMMs may be thought of as a statistical version of grammars. Recall that we used Hidden Markov

Type	Term
S	NP+VP
NP	N, ART+N
VP	V+NP

Type	Term
N	rain, umbrella
ART	the
V	hit

Figure A.40: Simple re-write rules (left) and lexicon (right) for the example grammar.

Step	Description
1.	If the current state can be re-written, use-rewrite rules and increment level.
2.	If state cannot be re-written (at terminal node), check active word against type of the terminal node (active) word.
3.	If that matches, take new terminal word and pop up level and check to see that all tests have been performed there.
3a	If that matches, take new active word and pop up level and check to see that all tests have been performed there.
3b	If there is no match and the state cannot be re-written, back up to previous alternative branches until finding one where a match is possible.
4.	If all the active words have been matched, then the parse succeeds.

Figure A.41: Simple transition-network parsing algorithm.

Step	Active Word	Action/Comments
1	The	Start, expand S to (NP[1]+VP[1])
2	The	try NP[1] as (N[2]), no match, try next alternative for NP[1]
3	The	try NP[1] as (ART[2]+N[2]), match ART[2], next word, try NP[2]
4	rain	try N[2], match, next word, pop up to level 1
5	hit	try VP[1] as (V[2]+NP[2]), match V[2], next word, check NP[2]
6	the	try N[3], no match, try next alternative for NP[2]
7	the	try NP[2] as (ART[3]+N[3]), match ART[3], next word
8	umbrella	try NP[3], match, no more words, pop up to level 0
9	Done	Valid parse!

Figure A.42: Parse of the sentence “The rain hit the umbrella”.

The bear hug created a stir

Figure A.43: Parse for “The bear hug created a stir”. Note that a parser first tries to treat bear as a noun but then has to backtrack and treat it as an adjective.

Models can describe sequences such as the phonemes that represent a spoken word. We have seen many applications of HMMs. HMMs are a type of supervised learning algorithm (-A.11.3) in the sense that the training determines the values of parameters. We have seen applications for parts of speech 6.2.2, 10.4.1 and speech itself 11.3.3.

Selecting an HMM Architecture and Fitting Training Data to that Architecture

The first step is to select an HMM architecture by deciding what constraints can be placed on the HMM. For instance, for speech the models are fed forward. A typical HMM architecture is shown in Fig. -A.44.

The weights for HMMs are usually generated by a supervised learning procedure. Large corpora for training examples. Trying to fit the data into the model. We must have a tagged training corpus. The forward-backward algorithm or the more general, Entropy Minimization (EM) algorithm,[1] is used for training an HMM (-A.1.1) (Fig. -A.45). These combinations may make recognition. These are based

[1] This is also known as the Baum-Welch Algorithm

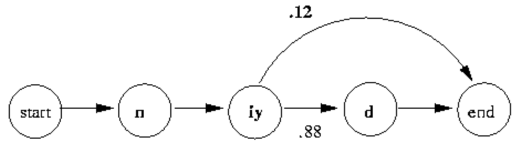


Figure A.44: Repeat of the HMM example which we saw earlier.

on dynamic programming. but they are probabilistic. The continuous stream of speech is difficult to segment into phonemes.

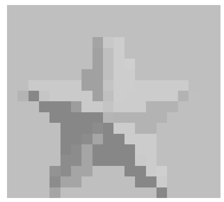


Figure A.45: Forward-backward algorithm for training HMMs.

Matching Sequences to the HMMs

Several HMMs may be developed; then speech samples can be matched to them. This is a kind of model-based recognition with HMM as the model. Specifically, the Viterbi algorithm uses a type of dynamic programming ((sec:dynamicprogramming)) to determine the t-matching sequence (Fig. -A.46). Source-channel model. Information theory (-A.1.0).

Figure A.46: Viterbi algorithm for matching HMMs.

HMMs are based on Markov models which, generally consider just one previous time step. Although HMMs have proven very successful, more than one time step may need to be considered.

Segment and deal with segments without consideration of the content of those segments. This allows sequential information to be considered. While we might want to use phrases, it may be better to simply use groups of words with a fixed lengths.

A.5.6. Configuration Rules

A.5.7. Optimization and Constraint Processing

Several types of problems.

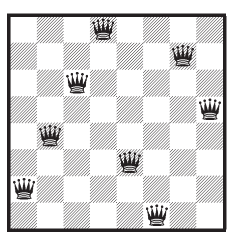


Figure A.47: The 8-queens problem demonstrates the value of algorithms to solve problems that are very difficult to solver by trial-and-error. The queens need to be lined up so that no two are on the same vertical, horizontal or diagonal row.

A.5.8. Version Tracking and Version Management

Keeping track of changes to a document. Fig. -A.49. Dynamic data. Files with periodic updates. Detecting differences in versions. Merge and split. Move. Keeping track of version history.

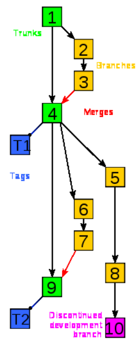


Figure A.48: Versioning. (under construction) (redraw)

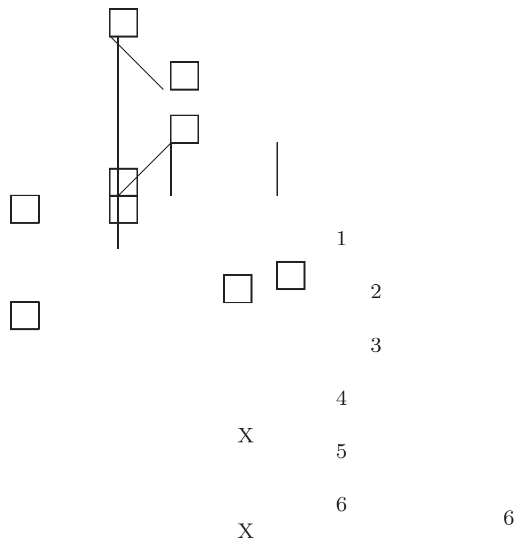


Figure A.49: Keeping track of versions.

Version management for software.

A.6. Additional Search Engine Procedures and Algorithms

A.6.1. Normalization

Preprocessing Text. Inverted indexing. Words (6.2.1). Tokenization, stemming, and normalization. Normalization.

A.6.2. Inverted Indexes

A.6.3. Calculating Term Weights in the Vector Space Model

As described earlier (10.9.2) a text may be represented as a "bag of words" in which the order of the words is not taken into consideration. Compositionality (1.1.3). Fig. -A.50 shows a term-by-document matrix for a hypothetical document collection dealing where each term is just three items.

Here, we use a very simple *tf* and *idf* as defined back in (10.9.2). The calculated values are shown in Fig. -A.51.

Similarity and Query Matching

Similarity of documents from word overlaps[75]. There are several ways to measure similarity between

Term		Document					df	Query
		D_1	D_2	D_3	D_4	D_5	df	Q_1
1	apple	1	3	2	1	3	5	1
2	banana	4	0	3	0	1	3	1
3	computer	1	4	0	2	5	4	0

Figure A.50: A simplified term-by-document matrix for a hypothetical collection. The number of occurrences of ten terms is shown for six documents. The total number of terms in the document is shown on the bottom line.

Term		Document				
		D_1	D_2	D_3	D_4	D_5
1	apple	1.0	3.0	2.0	1.0	3.0
2	banana	6.7	0.0	5.0	0.0	1.7
3	computer	1.3	5.0	0.0	2.5	6.3

Figure A.51: $tf * idf$ weighting of the documents from Fig. A.50.

two documents or between a document and a query. Some of these approaches simply count the number of overlapping words. Other techniques are based on a calculation of the distance between the documents.

For multi-word queries, a more formal definition of similarity is needed. The "cosine distance" between the query and the documents is calculated separately for each document following Eq. -A.4[2]

$$cosine\ distance\ between\ Document_D\ and\ Query_Q = \frac{\sum_{t=1}^{n}((tf{\cdot}idf)_{t_D} \times (idf)_{t_Q})}{\sqrt{\sum_{t=1}^{n}(tf{\cdot}idf)^2_{t_D}} \times \sqrt{\sum_{t=1}^{n}(idf)^2_{t_Q}}} \quad (\text{-A.4})$$

The match is $Document_3$ (Fig. -A.52). This is reasonable because it has a pattern of $tf{\cdot}idf$ scores that best matches the query idf. They can be improved with more complex tf and df.

Document				
D_1	D_2	D_3	D_4	D_5
0.79	0.36	0.92	0.26	0.46

Figure A.52: The "cosine distance" between the document $tf{\cdot}idf$ values (Fig. ??) and the query idf values. $Document_3$ matches the query t.

$$tf = \frac{log_2(number\ of\ times\ the\ term\ appears\ in\ the\ document + 1)}{total\ number\ of\ terms\ in\ the\ document} = \frac{log_2(t_d+1)}{T_d} \quad (\text{-A.5})$$

$$idf = log_2(\frac{number\ of\ documents\ in\ the\ collection}{number\ of\ documents\ with\ the\ term}) + 1 = log_2(\frac{D}{D_t}) + 1 \quad (\text{-A.6})$$

The basic $tf{\cdot}idf$ formula includes of the terms in different parts of the document search. However, there are other factors that can also be considered such as query term "prominence". Modern search engines employ other considerations such as term prominence.

[2]. This is derived from the inner product of the Document vector, D, and the Query vector, Q: $cos(\theta) = \frac{D.Q}{|D||Q|}$.

A.6.4. Dimensionality Reduction: Latent Semantic Indexing (LSI)

In many problems there are too many features. Dimensionality reduction reduces the number of features by combining them. The principle of dimensionality reduction has many applications. One useful example of dimensionality reduction is the text retrieval procedure known as "Latent Semantic Indexing" (LSI) which applied dimensionality reduction to the term-by-document matrix of the Vector Space Model (10.9.2). The term "boat" and "yacht" are similar enough that they could be combined. In effect, this creates a statistical thesaurus (2.2.2).

Like the Vector Space Model, LSI usually uses the cosine value for matching. LSI can be used for retrieval[24] and for filtering[29]. As a simple example, in a term-by-document matrix (Fig. -A.53), two clusters of terms may be seen.

	Document					
Term	D_1	D_2	D_3	D_4	D_5	D_6
boat	1	2	0	0	1	0
boats	3	0	7	0	0	0
sailing	4	1	1	0	1	0
water	2	5	3	0	0	0
car	0	1	0	0	6	2
automobile	0	0	0	4	0	5
highway	1	0	0	1	3	0
tires	0	0	0	4	0	2

Figure A.53: In this hypothetical example of a term-by-document matrix, two clusters of documents and terms may be easily identified. One set deals with boats and a second one deals with automobiles. Although the term "boat" does not appear in $Document_2$, the folding of the terms into the reduced-dimensionality LSI space will allow it to be associated with that document.

This procedure should eliminate spurious relationships among the words And focus on the most relevant relationships. As with the Vector Space Model, queries are matched to the documents by taking the cosine distances between the document terms and the query terms. Because this model produces a semantic space, some psychological models have been based on LSI, such as the Latent Semantic Analysis (LSA)[47] of human semantic memory.

Latent semantic indexing uses a linear-algebra technique which is known as "singular-valued decomposition" (SVD). This is related to other statistical techniques such as principle components analysis (PCA) and typically, a high-dimensional space is employed. SVD is also used for eigenfaces ((sec:eigenfaces)).

A.6.5. PageRank Algorithm

The links from one Web page to another provide evidence about similarity of the contents of those pages. Several algorithms have been proposed to demonstrate this (e.g. [**?**, **?**]). However, PageRank focuses only on "authorities".

Here we will consider the details of an algorithm for calculating this. Recall that in Fig. 10.51, we rated pages A and C highly if many other pages point to them. Moreover, if A and C are rated more highly, then B will also be rated highly.

The PageRank algorithm adjusts the rating of pages (nodes) based on the rating of their neighbors with a type of spreading activation (-A.10.3). This is calculated as shown in Eq. -A.7[54]. The Rank of a document, $R(D_i)$, is related to the Rank of all the

documents that are connected to it, $C(N_j)$, where d is a damping factor between 0 and 1. Specifically, the PageRank of P_0 is $R(P_0)$:

Where:
P_0: The target page
P_1,...,P_n are pages linked to P_0
L: outward links from P_0
d: Dampening factor

$$R(P_0) = (1 - d) + d(\frac{R(P_1)}{L_{P_1}}) + ... + d(\frac{R(P_n)}{L_{P_n}}) \quad (\text{-A.7})$$

We can see how this operates for the very simple network in Fig. -A.54 using the values in Fig. -A.55. The overall effect is that activation flows from weakly connected nodes to more highly connected ones.

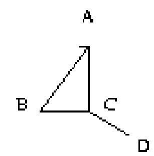


Figure A.54: PageRank calculated for a small network. (use example from MRS)

Node	**Initial Value**	**Ending Value**
A	0.4	x
B	3.1	x
C	1.1	x
D	3.3	x

Figure A.55: PageRank calculations. As would be expected, the activation in the small network accumulates on node A.

A.7. Logic

If we know that "All People Are Mortal" and we know that "Pat is a Person" then it is logical that "Pat is Mortal". Logic is a formal method that supports qualitative reasoning and inference. Logic is used to determine the "truth value" of statements given certain assumptions and inference rules. Like math, logic uses a formal notation and rules. Logic assumes a quantitative (often categorical) processing. Formal logic use ontologies for knowledge representation (2.2.2).

Fig. **??** lists some commonly-used logical symbols.

Types of logic: Description logic. We have seen several examples Knowledge representation. Deontic logic.

Logic is most applicable to discrete categories.

As we will see in (-A.8.1), probability can be used for quantitative inference. Logic versus argumentation (6.3.5).

A.7.1. Symbolic Logic

There are two fundamental types of inference: Deduction and induction. We are generally concerned with deductive inference. This type of logic was originally studied by Aristotle so it is called "Aristotelian logic". Propositional calculus includes deductive statements such as, "If X is true then Y is true".

Categorical Syllogisms

Syllogism is a particular illustration of deduction. For instance, we might attempt to determine the truth of the inferences of a syllogism (Fig. -A.56). Rules of propositional inference.

Statement Type	**Example**
Claim	if students work hard then they are happy
Assertion	all the students in the school work hard
Inference	therefore all the students are happy
Claim	
Assertion	
Inference	

Figure A.56: The first inference is valid (on the assumption that the premises are true) but the second is not.

Truth Functions

We introduced Booleans (3.9.2). Effectively, these are propositions such as "document has term X". We can view Booleans truth tables using the more formalized notation. The XOR relationship is more subtle. The output is TRUE if one or the other input is TRUE, but the output is FALSE if both inputs are TRUE or if both inputs are FALSE. The output is TRUE only if there is discrepancy between the inputs, otherwise the output is FALSE.

XOR		
Input 1	**Input 2**	**Output**
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	FALSE

Boolean expressions can be strung together as in the first line of Fig. -A.57. Sometimes, it helps to simplify these expressions into a "normal form". The Conjunctive Normal Form (CNF) .... While the Disjunctive Normal Form (DNF)...

(Chicken AND Dessert) OR (Beef AND Dessert) OR (Chicken AND Coffee) OR (Beef AND Coffee)
(Chicken OR Beef) AND (Desert OR Coffee)

Figure A.57: The expression on these two lines state the same relationship but the second, which is in Conjunctive Normal Form, is more concise.

Sometimes, it is most effective to use a tree to show complex combinations of Boolean relationships. The decision trees we considered earlier were binary OR-trees. They had only OR relationships, but it is also possible to have AND relationships in trees (usually these are indicated with a bar across the choices. Fig. -A.58 shows an AND-OR Tree for the CNF example in the previous table.

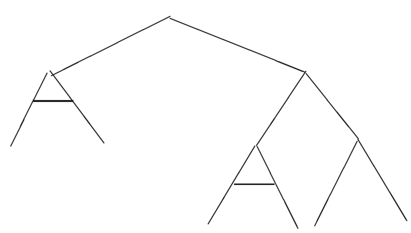


Figure A.58: And-Or trees. The cross-link indicates an AND relationship. (redraw).

Reasoning with Hierarchical Relationships

Inheritance as a model for reasoning (2.1.4).

Problems of multiple inheritance.

Predicate Calculus

Predicates describe the content of propositions. For instance, in the statement $a > b$ the $>$ is the predicate. Thus, predicate logic involves making inferences about statements that include attributes.

Statement	Description	Example
$p \rightarrow q$	If p then q	Apples have seeds.
p	assertion	There is an apple.
q	the conclusion	It has seeds.

Figure A.59: Inference rules.

This often includes the quantifiers "all" and "some". Fig. **??** shows some of the notation. Fig. A.60 gives an example. If M is a predicate "to be a man," then Mx would be interpreted as x is a *man*.

all students in the school work hard
$\forall x(Zx \rightarrow W)$

Figure A.60: An example of a predicate calculus expression.

Earlier, we introduced ontologies (2.2.2). In the more rigorous sense, ontologies provide the lexicon of the predicate calculus.

Assertion links.

Frames as a generalization of hierarchies.

Frames

Frames are a way of representing entity classes. However, unlike Entity Classes from the ER model, they usually apply to general world knowledge. Still, the frame-slots are a lot like attributes. Fig. A.62

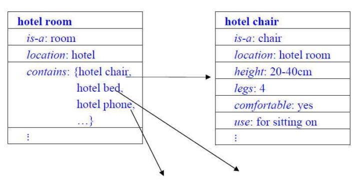


Figure A.61: Frames. (redraw)

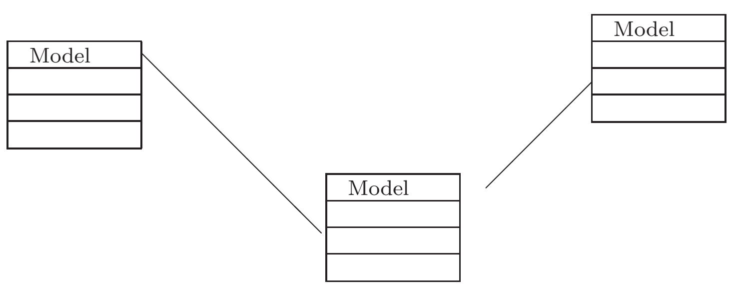


Figure A.62: Frames. (under construction)

Thus far, we described logic based on inferences involving evaluating the validity of statements about specific instances. This is "first-order predicate calculus". Second-order predicate calculus examines the validity of statements about relationships. Representing facts.

A.7.2. Complex Logical Inference

Implications such as double negative elimination.

Inferences create new propositions. Given a set of statements, we can try to "chain" them together to draw inferences. The objective is generally to find a path from the initial state to the final goal. We could start with the premises and build inferences toward a goal (forward chaining).

Or, we could start with the goal and attempt to reason backward (backward chaining). Forward chaining expands all propositions in order to find all possible implications. Backward chaining identifies the goals and then progressively decomposes those goals into sub-goals Fig. 3.40. This process is similar to "means-ends analysis" (3.7.1). These can also be viewed as examples of bottom-up processing and top-down processing (10.1.5).

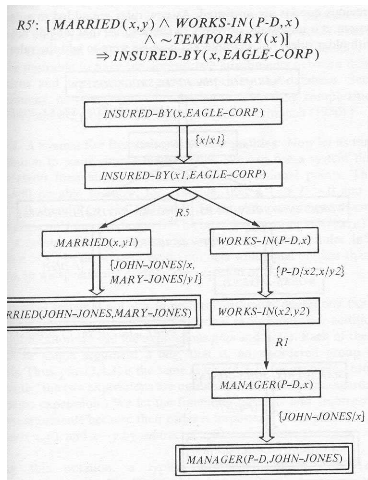


Figure A.63: Backward chaining. (check permission)

A.7.3. Knowledge Representation and Logic Programming Languages

Knowledge representation (2.0.0). Formal languages for knowledge representation and logical inference.

Declarative Logic Programming Languages

Several logic programming languages have been developed. Fig. A.64 shows some examples of Prolog statements about kinship. Given these definitions and assertions, we could answer questions such as "Is there a child whose parent is Eve?"

Statement	**Explanation**
woman(eve)	Declare there is a woman named Eve.
man(adam)	Declare there is a man named Adam.
child(abel)	Declare there is a child named Abel.
mother(M,C):-woman(M), parent(M,C)	Define that a mother is a woman who is a parent.
father(F,C):-man(F), parent(F,C)	Define that a father is a man who is a parent.
mother(eve, abel)	Declare that Eve is the Mother of Abel.
father(adam, abel)	Declare that Adam is the Father of Abel.

Figure A.64: Prolog is a computer programming language design to perform logic operations.

Procedural Models: Production Systems

Approaches such as Prolog are "declarative" These may be distinguished from "procedural" models (Fig. **??**). Declarative specifies rules: this includes logic. Procedural is a specification for what is legal such as production systems.

Production systems are based on Condition-Action pairs. That is, if certain conditions are met, then the production "fires" and the action is executed. Productions may also be thought of as sets of IF-THEN statements. SOAR[46] is another production system language ((sec:productionsystem)) that allows decomposition of goals and selection of rules. Fig. -A.65 traces the steps of a SOAR program as it is executing. Potentially, the priority of SOAR rules can be "learned" by storing those productions for later use that were most effective. SOAR allows machine learning (-A.11.0). by chunking (4.3.5).

```
0: ==>G: G1
1:    P: P1 (farmer)
2:    S: S1
3:    ==>G: G3 (operator tie)
4:      P: P2 (selection)
5:      S: S2
6:      O: O8 (evaluate-object O1 (move-alone))
7:      ==>G: G4 (operator no-change)
8:       P: P1 (farmer)
9:       S: S3
10:        O: C2 (move-alone)
```

Figure A.65: SOAR Problem Space Computational Model trace[46]. There are Goals(G), Proposition(P), States(S), and Objects(O). (check permission)

Expert Systems

Expert systems use inference and reasoning for practical applications. These are often 'rule-based, that is they are based on logical inference. For instance, they may such as production systems to inference. Unfortunately, expert systems tend to be "brittle". That is, they may work well for the situation for which they were developed, but do not generalize well to new situations. These can also be decision support systems (3.4.2) decision support systems but there is a danger of inappropriate inference. Furthermore, they may exceed the application domain of the system. For instance, the Aegis attack (Fig. -A.66).

Technology failures ((sec:techfailures)).

Figure A.66: Aegis.

Fuzzy logic and probability of belonging to a set (Fig. -A.67).

Figure A.67: Normal local (left) and fuzzy logic (right).

A.7.4. Representation and Reasoning with Beliefs

Earlier, we discussed beliefs as an aspect of social psychology (4.5.0). In one of the senses of formal description of beliefs.

In a model with several agents, those agents may have models the world, of each other, and other agents views of the world. (Fig. -A.68). A person may believe something that is not true. Or, it may simply be impossible to verify. If I believe the world is flat...
I believe in dragons....

Belief is different from confidence.

Propositional attitudes[19].

Logic and beliefs[28]. Reasoning about uncertainty[36].

John knows his name. John believes that today is Tuesday.

Belief vs. belief systems.

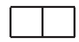


Figure A.68: Beliefs.

Confidence in results.

A.8. Probabilities and Probabilistic Inference

Alternatives to logical inference which was discussed in the previous section. Toward plausible reasoning. Induction. Uncertain results. Sampling. Hypothesis testing.

A.8.1. Basic Probabilities

While logical inference is based on symbolic inference; it is also possible to make a probabilistic inferences. Let us briefly review probability. Eq. -A.9 shows the product of two probabilities. This essentially an AND operation. For instance, this probability of getting a 2♣ AND 3♠ in one draw is 1/13 + 1/13. Eq. -A.9 shows the sum of probabilities. This is essentially an AND. For instance, the probability of getting a K♣ AND Q♣ in successive draws is 1/13 * 1/13 (assuming you the cards are replaced after each draw). Note that the symbol $\cap$ is the same as *and*.

$$P(A\ and\ B) = P(A \cap B) == P(A) * P(B) \qquad (\text{-A.8})$$

$$P(A\ or\ B) = P(A) + P(B) \qquad (\text{-A.9})$$

We can also define conditional probability which is, for instance, the chance of "Event A given Event B" that can be written as $P(A|B)$.

$$P(A|B) = \frac{probability\ of\ both\ Event\ A\ and\ Event\ B}{probability\ of\ Event\ B} = \frac{P(A \cap B)}{P(B)} \qquad (\text{-A.10})$$

A.8.2. Bayesian Prediction

Learning conditional probabilities. This is a common technique for machine learning (-A.11.0). It can also be seen as a type of knowledge representation.

Bayes Rule

If we have expectations about how attributes predict membership in a category we may also be able to determine that likelihood that objects in the category will show possess those attributes. Specially, if we know P(A—B), P(A), and P(B), we can determine P(B—A). This is known as Bayes Rule and it is the basis of learning about the features relevant for doing categorization.

$$P(A|B) = \frac{P(A \cap B)}{P(B)} \qquad (\text{-A.11})$$

$$P(B|A) = \frac{P(A \cap B)}{P(A)} \qquad (\text{-A.12})$$

$$P(A \cap B) = P(A|B)P(A) = P(B|A)P(B) \qquad (\text{-A.13})$$

Suppose there is a 0.5 probability documents with the word "training" in them also have the word "education" and the probability of the word "education" occurring in the documents is 0.8. If we know the word "education" is in a document, what is the chance that the word "training" is in that same document? Eq. -A.14:

$$P(\text{"}training\text{"}|\text{"}education'') = \frac{P(\text{"}training'' \cap \text{"}education'')}{P(\text{"}education'')} = \frac{0.5}{0.8} = 0.625 \quad (\text{-A.14})$$

Bayesian Classification

Bayes Rule can also be applied to categorization. Thus, if we know the frequency of a set of categories and we know the frequency with which terms occur in documents belonging to those categories, then we determine the probability of a new document belonging to a category given the terms it includes.

If we know that an object has a certain attribute value, we might ask "what is the probability that object or event belongs to a given category?" This can be determined with an extension of Bayes Rule (Eq. -A.15). For instance, Eq. -A.15 shows the probability of belonging to Category 1 (C_1) given that Attribute 1 (A_1) has Value 1 (V_1).

$$P(C_1|A_1V_1) = \frac{P(C_1 \cap A_1V_1)}{P(A_1V_1)} \quad (\text{-A.15})$$

This may be generalized to multi-attribute categories[26] (Eq. -A.16).

$$P(C|A_1V_1, A_2V_2, ..., A_NV_N) = \frac{P(C_1 \cap A_1V_1, A_2V_2, ..., A_NV_N)}{P(A_1V_1, A_2V_2, ..., A_NV_N)} \quad (\text{-A.16})$$

Bayesian Networks

Attribute-based conditional probabilities.

Updating causal networks[57].

Used in text retrieval Fig. -A.69

Figure A.69: Bayes Network visualization.

Information gain in Bayesian calculations.

A.8.3. Case-Based Reasoning (CBR)

Case-based reasoning (CBR) attempts to find relevant examples to generalize from rather than trying to develop a comprehensive statistical model[17]. For instance, when modeling the path of hurricane, it may be more useful to examine previous similar hurricanes rather than trying to rely on complex simulations. The researcher must still find effective features and representations (Fig. -A.70). Retrieve, re-use, revise, return. Sets of examples may be maintained in case libraries.

Formal Descriptions of Cases

Setting, Actor, Goals, Sequence. Case-based reasoning (-A.8.3).

Characterize problem to be solved

↓

Find similar, problems in the corpus and how they were solved.

↓

Adapt the procedure for the previous problem, apply, and evaluate results.

↓

If successful, add to corpus.

Figure A.70: Path of case-based reasoning.

A.9. Formal Models for Decision Making

Choice and decision making have appeared earlier (3.4.1).

Logic, Inference, Planning, and Learning.

The contents of representations are sometimes presented directly to the user. In many other cases, they must be reassembled. Doing things with representations.

Algorithms for both recognition and generation.

The simplest task is making binary YES/NO decisions. For instance, we could detect the possibility of a terror attack from a cumulative set of data.

A.9.1. Signal Processing

A signal carries information in the information theory sense (-A.1.0). A signal can be lost if there is too much noise. As an example, think about trying to listen to radio station when there's static. You need to concentrate to detect the music. The simplest approach to determining whether a signal is present or absent. Fig. -A.71 shows distributions of signal and noise. The signal-to-noise ratio determines the ease with which the signal can be detected. Consider trying to hear a telephone ring in another room of your house. It is much easier to detect the telephone when there is not any background noise such as the radio playing or the shower running.

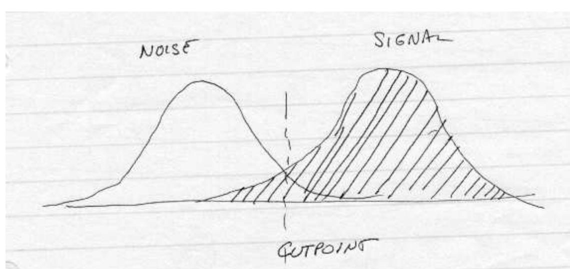


Figure A.71: Distribution with overlap and a decision threshold. If the threshold is moved to the left, more signal events can be detected but more errors are also made. However, it the threshold is moved to the right, fewer errors are made but more signals are missed. (to be rendered)

A.9.2. Signal Detection

Detection is simply a decision whether a signal is present or absent. If the signal and noise are similar, it may be difficult to tell them apart. Success in monitoring the occurrence of events (signals).

A measure of the success of detecting signal is developed as follows. Fig. -A.71 also shows signal and noise distributions. Also shown is a cut-point, which is the threshold at which an observer would decide the signal (i.e., the telephone ring) was present or absent. There are four possible combinations of signal and user responses (Fig. -A.72). The cut-point is normally selected to minimize the number of errors, but other strategies for placing the cut-point could also be considered.

		Actual Signal	
		Present	**Absent**
Observer's Judgment about Signal	**Yes**	Hit	False Alarm (False Positive)
	No	Miss (False Negative)	Correct Rejection

Figure A.72: 2x2 table for signal detection. The observations might not be accurate since they might be due to noise, as suggested by Fig. A.71.

This is a type of classification problem.

It is harder to understand somebody when they are talking in a noisy environment than in a quiet place. The level of the signal compared to the amount of noise is known as the "signal-to-noise ratio". Two factors determine the signal-to-noise ratio: The difference between signal and noise and the observer. This statistic is known as d'.

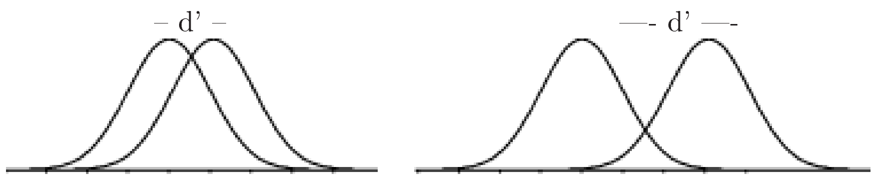


Figure A.73: Sometimes the noise is similar to the signal (left) and sometimes it is clearly different (right). When it is similar, it takes a very sensitive detection device to accurately separate the noise from the signal. (label distributions)

We should keep the ratio of False Positives and False Negatives constant. We can do characterize observers as to whether they have a bias toward false positives or false negatives. Compare the two distributions and determine how good is an observer at telling the difference. Response operator characteristic (ROC) curves (Fig. -A.74).

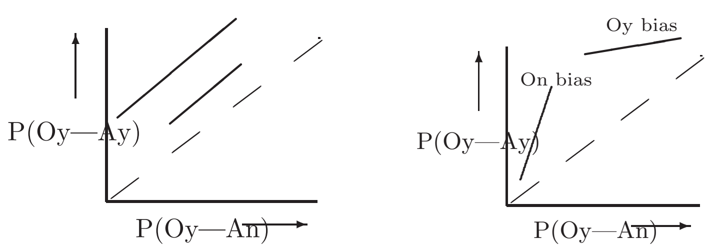


Figure A.74: The Response-Operator-Characteristic (ROC) diagram shows how an observer responds given varying probabilities of Yes and No responses and the signal is varied. The diagonal represents chance performance. As shown in the ROC diagram on the left, the further the ROC curve is from the diagonal, the better the discrimination. The diagram on the right shows an analysis of whether the operator has a bias toward responding "present" a bias toward responding "absent".

E-measure for information retrieval.

Generally an issue for recognition processes. Signal detection is closely related to categorization. It determines whether an object belongs to a given group or not[35]. The properties of signal detection.

Recognizing Category Membership

As we have seen, categories are widely used in information systems (3.9.1, 4.3.0). We briefly discussed choice strategies earlier (3.4.1).

Decision Networks

A.9.3. More Game Theory

A well-known collective action game is the Prisoner's Dilemma, which is illustrated by the values in Fig. -A.75. Imagine two prisoners A and B, who were partners in the same crime but who are being interrogated separately by the police. If they both confess, they may get a moderate punishment (-3), but if one prisoner confesses while the other does not the one who confesses will get a light punishment (-1), and the one who does not will get a heavy punishment (-5). However if neither talks, there is no direct evidence and they might both go free (+5).

		Prisoner A	
		A does not talk	A talks
Prisoner B	B does not talk	5/5	-1/-5
	B talks	-5/-1	-3/-3

Figure A.75: In the "prisoner's dilemma," the payoffs for each prisoner depend on the behavior of the other prisoner. The cells of the table shows payoffs to each of the two prisoners.

Game theory can also be used to explain long-term interaction[65]. During the Cold War, the theory of Mutually Assured Destruction (MAD) developed based on game theory. the claim was that the only stable equilibrium was the point at which each side could destroy the other. Collective action games seek to analyze the decisions made by individuals when the outcomes of those decisions are affected by the decisions of other individuals. In many cases, one person or the other will have a clear advantage. However, the players and will tend to stabilize at an equilibrium point that has advantages for both players. The Nash equilibrium is the solution for which the players would not change their strategies even knowing the choice of the opponent.

		Country A	
		No Bomb	Use Bomb
Country B	No Bomb	0,0	-1000,10
	Use Bomb	10,-1000	$-\infty$,$-\infty$

Figure A.76: Game theory table for Mutually Assured Destruction (MAD). (revise)

Strategies in risky situations. The most directly applicable competitive strategy for making decisions involving other individuals and/or imperfect information is one that picks outcomes that maximize the benefits and minimize the risks. This is known as a "min-max" strategy. A person who has to make a choice among a number of approaches may analyze the chances of favorable and unfavorable outcomes. This is reasonable since it assumes that the opponent will also attempt to maximize his/her benefit.

Max-min as a fairness strategy.

		Payoff			
		A	B	C	D
Possible Outcomes	Gain	+3	+5	+6	+6
	Loss	-4	-4	-5	-6

Figure A.77: According to a min-max strategy, the options with the minimum loss are selected and from those, the options with the maximum gain are selected. Thus, option B would be selected. This has the minimum loss for that gain and the highest possible gain. However using a max-min strategy, C would be selected. This has the minimum possible loss and the maximum possible gain.

A.9.4. Subjective Multi-Attribute Utility

People may have their own utility for different attributes and we should include these subjective utilities in our models the choices those people will make. Getting reliable values of subjective utility is not easy[27]. This is an example of "scaling" (e.g., [?]).

$$value\ of\ object_i = \sum_{j=0}^{j=N} (attributeValue_{ij} * utility_j) \qquad (\text{-A.17})$$

We would like to estimate utility when multiple attributes are involved. If we know preferences, we can work backward and estimate the utility. Multi-attribute decision theory is a mathematical means of analyzing decisions in which there are several competing variables to consider. In multi-attribute decision theory (or multi-attribute utility), each variable is assigned a particular utility value according to its importance and they are all plugged into a mathematical formula to determine what combination of variables produces the most desirable outcome. For instance, a person might chose between two models of cars based on their attributes (see Fig. -A.78).

	Type of Car		
Dimension	Compact	Sports Car	Sedan
Price	3	1	2
Fun	1	3	1
Safety	2	1	3

Figure A.78: Several attributes of cars could be assigned values based on their favorability. A score of "1" is low on that dimension and a score of "3" is high.

	Type of Buyer	
Dimension	**Yuppie**	**Family**
Price	1	2
Fun	3	1
Safety	2	3

Figure A.79: Subjective utilities for two types of buyers. Higher numbers mean that the dimension is more important for that type of buyer.

	Yuppie			**Family**		
Dimension	Compact	Sports Car	Sedan	Compact	Sports Car	Sedan
Price	1*3	1*1	2*1	3*2	1*2	2*2
Fun	1*3	3*3	1*3	1*1	3*1	1*1
Safety	2*2	1*2	3*2	2*3	1*3	3*3
Overall preference	10	12	11	13	8	14

Figure A.80: The Yuppie buyer will prefer the sports car while the Family buyer will prefer the sedan.

A.9.5. Voting Systems and Elections

Voting involves the allocation of units decision units across candidates and rules for combining those units (8.4.3). A voting system needs to accurately reflect the voters' preference. Perhaps surprisingly, that does not always happen with simple majority rules ting. Fig. -A.81 shows one example of a complications introduced in three-way race. To solve this problem, a variety of voting criteria have been developed (Fig. -A.82). These may allow multiple votes per individual and preference rankings of several candidates[62]. End-2-End (E2E) electronic voting security. Open source voting software.

Elections

System of voting and related procedures for determining government officials. Non-partisan supervision of elections.

Candidate	Strength of Preferences			
	$Voter_1$	$Voter_2$	$Voter_3$	Mean
A	0.40	0.05	0.35	0.27
B	0.35	0.30	0.30	0.32
C	0.15	0.45	0.25	0.28

Figure A.81: Majority rule may not result in the most preferred (on average) candidate being elected. If each voter is allowed to cast only one vote, Candidate A would be elected as the top choice of the majority of the voters. However if voters cast votes in proportion to their preferences, Candidate B would win.

Type	Description or Example
Majority	One vote per voter. Winner needs more than 50%
Plurality	One vote per voter. Winner is the candidate with the highest number of votes.
Borda	Voters rank order the alternatives. Candidate with the highest average rank wins.
Approval	Cast one votes for each candidate the voter would accept. The winner is the candidates with the highest number of votes.
Cumulative	Each voter has multiple votes. These can be cast all for one candidate, or spread across candidates. The winner is the candidates with the highest number of votes.
Instant run-off	Successive run-offs narrow the field of candidates.

Figure A.82: Several types of policies and criteria for elections.

A.10. Mathematical Models

We have discussed many types of models and mentioned mathematical equations. Discrete math versus continuous models versus continuous models. Relationship between mathematical models and scientific models (9.2.3). Thus, an important distinction is between linear and non-linear models. These differ in the power of the representation (1.1.2). Machine learning, clustering and neural networks (-A.11.0). Models in science (9.2.2). Deterministic versus probabilistic models. To an extent, all models can be thought of as mathematical functions. Levels of models. Ordinal, Interval, For instance decision trees are qualitative models. These are representations based mathematical functions. Free parameters. Over-fitting. Fitting data: Model + error.

A.10.1. Linear Models

If we believe that some simple linear process accounts for an effect, we might attempt to fit the data for that to determine the parameters. the linear model from the some data. An effective approach is often to find the line that is the least-squares distance (Fig. -A.83). Underlying linear model plus error in measurement.

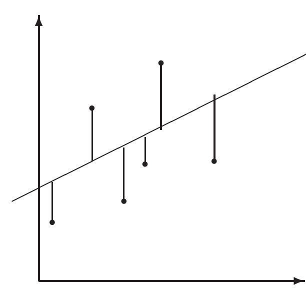


Figure A.83: A straight line is fitted to a data points. A common approach is fitting with "least squares" which finds the line that minimizes the sum of the square of the distance from the data points.

Even simple models can provide immense analytical help. Fig. -A.84 illustrates how simple algebraic models can be used to determine what is the combination of production capacities to produce two separate products. The two left panels describe the production capacity of two types of cars (product 1 and product 2). The right panel then uses linear algebra to resolve the constraints posed by factors of production.

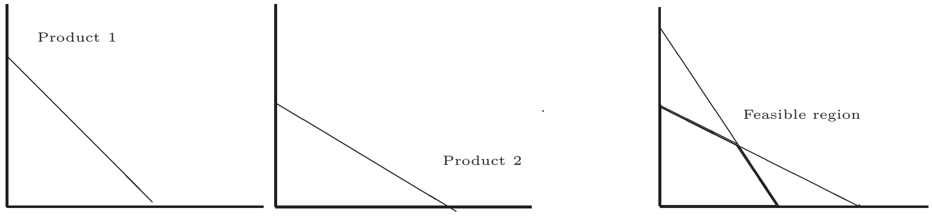


Figure A.84: Linear models can specify constraints and simple combinations of these constraints can be calculated. On the right, the two linear constraints are intersected. If the first line shows the maximum level of X and the second line shows the maximum level of Y, then the combination of the two shows the "feasible region" BELOW the intersecting lines. In other words, that area within which parametric tradeoffs are possible.

A.10.2. Non-Linear and Dynamical Models

In some cases, the interaction between the components is often very unpredictable. When two adaptive systems interact, they form a "dynamical system". These are also called "co-evolutionary" or "mutually-causative" systems. The evolution is determined by the direction the pair of systems take. An example would be a person interacting with another person — the actions of each affect the other. While some of these systems are chaotic, others are stable.

Sometimes linear equations are good representations for a process; sometimes a more complex, non-linear equation works better. We have already seen non-linear models used for mathematical simulations (9.5.4). While linear systems are very powerful, many systems are non-linear. The representations are mathematical equations. Linear modeling, which assumes that all effects can be modeled with straight lines, is effective only to a point. Equations with exponents. These models are the foundations of complex systems.

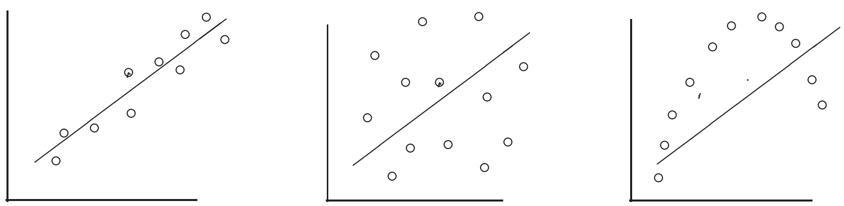


Figure A.85: A straight line can be an effective representation to describe a set of points (left). However, the line is less satisfactory if the points are scattered (center) or if a curved line may be a better representation (right). A representation that allows curved lines will also be more complex.

Power Laws

These are a family of common non-linear functions. For instance, the long-tail (8.12.5) follows a power law.

$$y = x^z \qquad (\text{-A.18})$$

Some typical power law curves are illustrated in Fig. -A.86

Figure A.86: Power laws.

80-20 rule.

More about the long tail (8.12.5).

Long-Tail Distributions

Praeto

Figure A.87: Long tail. (redraw)

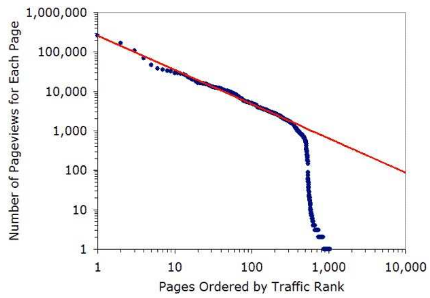


Figure A.88: When we expect data to fit a power law, deviations from the predicted pattern may indicate underlying problems. Here, a drooping tail in eCommerce data suggests that the may not be enough representation of low-frequency items. (check permission)

Zipf's Law Closely related is a simple mathematical function known as Zipf's Law (Eq. -A.19) gives accurate descriptions of word frequencies. Zipf's Law states that the frequency of observations for a word of a given rank number P_r, is equal to a constant, k, divided by the rank, r:

$$P_r = \frac{k}{r} \tag{-A.19}$$

Application of Zipf's Law. Example of word frequency. Fig. **??**.

1.	the
2.	
3.	

Figure A.89: Example data for Zipf's Law.

Fractals and Self-Similarity

Chaotic systems have no stable solutions. However, some do exhibit a property known as "self-similarity". Self-similarity suggests that there is a repetition of a pattern across several different scales. Fig. -A.90 gives two examples of this property. The self-similarity in some of these patterns generates complex patterns. There are applications of fractals in image generation and compression.

Simulation of non-linear and complex systems. Simulated annealing.

Set point with a comparator.

There are systems with the factors are interlocking. Simple feedback with a controller. Control theory (Fig. **??**). Such models are too simple. Unlike adaptive models in which the representation itself changes.

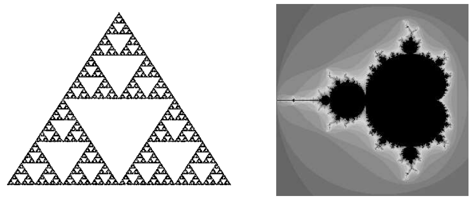


Figure A.90: Self-similarity is illustrated on the left in the Sierpinski triangle in which equilateral triangles are carved out of larger equilateral triangles[32]. (check permission) On the right is a fragment of the Mandelbrot Set which shows a more complex self-similarity. Zooming in shows essentially identical patterns that are repeated at the finer levels of granularity.

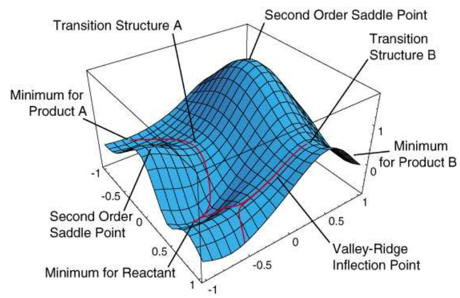


Figure A.91: Energy surface. Finding an energy minimum. Simulated annealing.

Sometimes we need several interacting equations to model a system, These form "dynamical systems" Sometimes these equations converge to a solution and a system with feedback will maintain homeostasis around a control point. In other feedback systems diverge and no solution is possible. Those that converge reach a single "fixed-point" equilibrium are said to be attractors (Fig. -A.92). Sometimes the equations do not converge to a single point but follow a regular pattern across several solution points. In a few cases, there is no simple pattern to the solution.

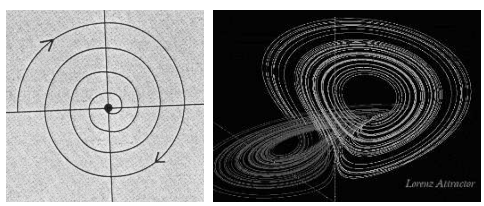


Figure A.92: Trajectories of an attractor (left) and a strange attractor (right)[32]. (check permission)

There are sometimes complex systems. Chaos comes from large differences due to small changes in initial conditions. An example is the "butterfly effect" in which an apparently insignificant event in one part of the system can be amplified to have a major impact later in the system's evolution.

Critical phenomena. Emergent phenomena.

Punctuated equilibrium.

Sometimes simulations are used to model these systems but one has to be careful about the accuracy of the simulation.

Hysteresis.

Dynamical Systems

Non-linear systems with feedback. These are sometimes called "co-evolutionary systems". System dynamics (-A.10.2). The two components interact together and their combination reaches a unique state.

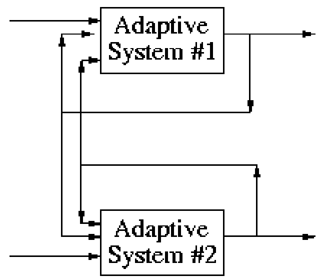


Figure A.93: A pair of interacting adaptive systems can be treated as a single complex system. The output of one system forms part of the input for the other system. (re-orient horizontally)

Some equations model how a system changes through time. Some of these consistently converge to a single point across many trials; other systems diverge. It is possible to describe complex interactions with sets of equations. These are relatively easy to solve when the functions are all linear, However, the solutions are more complicated when the equations are non-linear.

System Dynamics

System Dynamics include feedback but also "stocks". For instance, in a supply chain analysis (8.12.1) the goal might be to keep an inventory of parts roughly constant while they were being used in manufacturing. Or, as illustrated in Fig. -A.94, the level of population could be modeled as it is increased by births and decreased by deaths. Moreover, there is a positive feedback such that the more people there are, the more births there will be. On the other hand, the more deaths there are, the fewer deaths would be expected in the future.

The interlocking feedback loops often make change extremely difficult.

This is like a data flow diagram (3.10.1). Such models can provide insight into why some processes are so resistant to change[66].

There is no exact computational solution for these models. Numerical analysis.

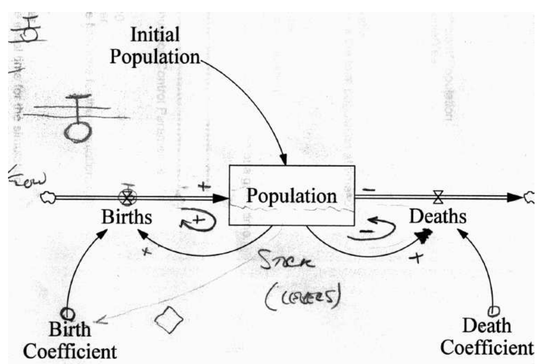


Figure A.94: Flow in a population-growth diagram. As the population increases, both births and deaths will increase. (redraw)

Exampless of supply chain applications (8.12.1).

Causal Models

System Dynamics Models An important class of models are those which can represent rates of change, in other words, for models which are highly non-linear. For instance, we might like to model how population size changes as food supply changes. These have feedback. These are more difficult to model.

Because of the interaction of factor approximation must be done by numerical analysis. System-dynamic models (-A.10.2). Simulations (9.5.0). Causal loop diagrams (Fig. -A.95). Complex systems (-A.10.2).

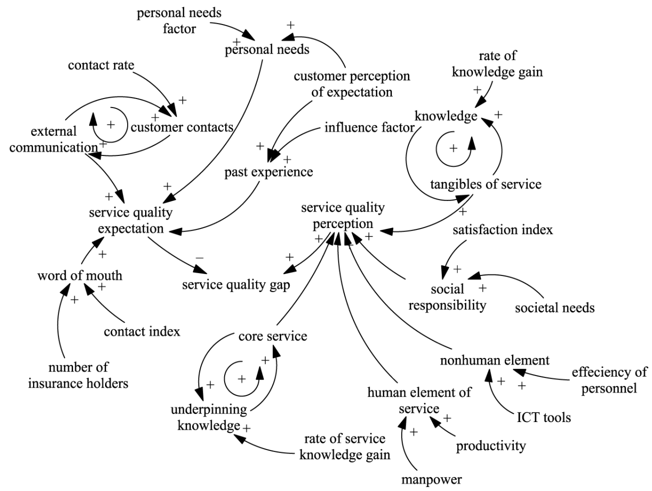


Figure A.95: Qualitative causal loop model. (redraw)(check permission)

Causation is intergral with explanation (6.3.4)especially explanation in science ((sec:sciexplanation)). Implications for social science (4.4.2). Bayes models for causation.

Structural Equation Models Causation (4.4.2) can be inferred based on a model. For instance, in Fig. -A.96 Compare to DAGs and Bayesian Networks.

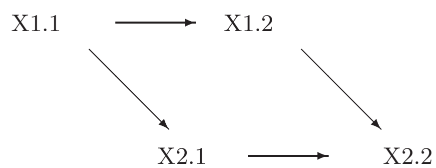


Figure A.96: Structural equation models can help to validate assertions made about causal relationships.

Determining latent variables[6].

A.10.3. Network Flows and Related Problems

Flow in a Network

One application of graphs (-A.3.0) is to examine flow through the network. Queuing theory. Calculating costs of routing. Traffic on city streets (Fig. -A.97). Predicting congestion. Volume and ease of flow. Dynamic models for optimizing flow. This also has implications for Social Network Analysis.

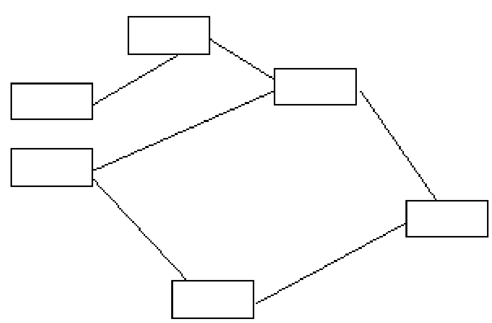


Figure A.97: Network flow. (redraw by hand)

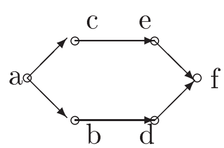
A related problem is based on the arrival time by cars at a toll booth and how long they have to wait. Queuing theory.

Internet routing tables. Packets in a network.

Spreading Activation

Because so many systems are modeled as graphs, we can explore the spread of activation. The nervous system can be thought of a network in which neurons (nodes) are connected by links. When a person thinks about one concept, related concepts often seem to come to mind. For instance, if I think about my dog, I might also think about the park near my house where I walk the dog.

This priming effect could be modeled with activation which spreads across the graph. Suppose there are six nodes connected as in Fig. -A.98. An impulse starting from neuron a would go to both b and c. In turn, the impulse would be transmitted from those two nodes on to nodes d and e and then finally to node f. Suppose further that only 70% of the activation gets through with each hop so that 0.49 * 0.70 = 0.24 and then 0.24 + 0.24 = 0.48. Many additional parameters could be applied to this model such as only on/off neurons, a transfer function (including a maximum activation), and speed of decay of the activation.



	time step		
neuron	1	2	3
a	1.00	1.00	1.00
b	0.00	0.70	0.70
c	0.00	0.70	0.70
d	0.00	0.49	0.49
e	0.00	0.49	0.49
f	0.00	0.00	0.48

Figure A.98: The spread of activation from neuron a to neuron f across three time steps.

A.10.4. Agent-based Models

Using independent agents with local rules to obtain a stable solution in a complex system. This is a natural extension of social networks (5.1.0).

One strategy for this uses cellular automata. Some simulations is best done with connected "cells". We call simulations with these "cellular automata". Computer models used for weather forecasting are extremely complex.

Agent-based simulations.

One example of a cellular automata is the Game of Life[30]. (Fig. -A.99).

1.	If a cell is dead and if three of its neighbors are alive then it comes alive.
2.	If a cell is alive and are two or three are alive, it stays alive.
3.	Otherwise, a cell dies or remains dead.

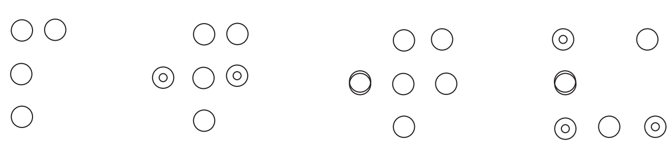


Figure A.99: Rules for the Game of Life (top) and an example of its use. The filled circles are newly born.

Artificial life models are artificial systems that behave in a fashion similar to the organisms. Random mutation and natural selection are elegant means by which individual organisms, species, and ecosystems interact to produce structured change at all levels and, typically, increasing complexity. The field of artificial life uses these same principles to design "environments" in which programs interact to produce change in themselves and the environment itself. This is an example of cybernetic evolutionary modeling.

Computer viruses as a form of artificial life.

Axelrod

Cellular automata can be used to take the modeling of living organisms more literally, "artificial life". Analysis of biological processes (Fig. -A.100).

Figure A.100: An example of artificial life. (check permission)

Swarm Intelligence.

Self-organizing systems.

A.11. Learning Mechanisms and Machine Learning

We have already explored learning in several places. For instance, we have considered human learning (4.3.5) and other adaptive systems. Cognition and learning (4.3.5). By "machine learning" we mean algorithmic learning. Simple categorization is sometimes considered learning; however, here the focus is on learning in which an entirely new representation is developed. In most cases, the machine learning algorithm is trained in one phase and its performance is tested in a second phase. Generally need large datasets for statistical approaches to linguistics. Generalization. Over-learning.

A.11.1. Learning Mechanisms

We have learning processes in many places. Learning as taking advice. Coaching.

We briefly described human learning earlier (4.3.5); we can look more closely at learning. According to a behaviorist definition, human learning can only be demonstrated as a change in behavior since we can never be sure what representations people use.

Types of learning can be based on the conditions in which they occur. "Learning by doing" or "Learning by observation" Another strategy for discussing learning is to focus on changes in representation. unsupervised and supervised. There are many possible applications such as grammar induction or learning how to recognizing speech acts. Furthermore, machine learning can be applied to adaptive interfaces.

For human learning, we cannot know in detail how human learning occurs by inspection develop a model for it (4.3.5). However, we may program a computer to do simple learning.

Reinforcement learning. Some tasks such as learning language seem to involve feedback. Learning language from positive examples.

Conditioning. Loud noises and bright lights have a direct physiological impact as an "unconditioned stimulus". Other stimuli may be conditioned by association with the UCS.

Reflection and consolidation seem to be important for human learning (5.11.2).

Here, we will focus on unsupervised and supervised learning.

In some cases, a short-cut can be learned. Chunking. Learning patterns of checkers[63].

Game space (-A.3.2). Skipping a deep search in a game tree. Parameter learning.

A.11.2. Unsupervised Machine Learning

The classification processes discussed earlier assumed a predefined category system. Unsupervised learning systems attempt to "discover" the structure of the underlying similarity of a collection of objects. For instance, sets of abstracts for documents might be identified. We might think of this as creating plausible categories.

Agglomerative clustering versus partitioning approaches.

Classifier.

Emergent concept learning (1.1.4).

Quantitative and Hierarchical Clustering

Hierarchies are particularly effective for organizing information. Cluster analyses tries to find a hierarchy to fit data. A graphical presentation of the output of a hierarchical cluster analysis called a "dendrogram" (Fig. -A.101).

From clustering to classification.

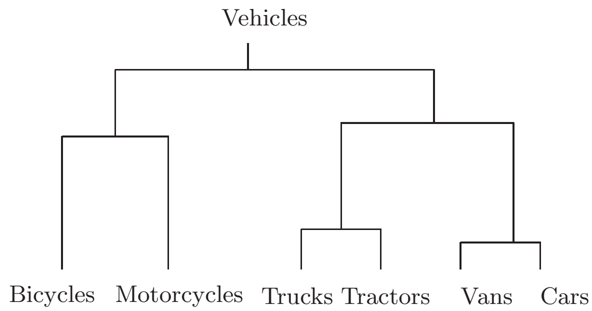


Figure A.101: Dendrogram that might be obtained from a hierarchical cluster analysis on the distance between six types of vehicles. Ideally, the clustering will end up with cleanly separated categories.

Qualitative Clustering and Decision Trees

While the most common type of clustering is qualitative, other clustering techniques have been proposed which are based on quantitative attributes. Decision trees were introduced earlier (3.4.1). Simple decision trees can be created by hand, but more complicated ones are better made with specialized tools. Two of the better-known approaches for developing decision trees are Classification and Regression Tree Methodology (CART)[22] and ID3[58]. This proceeds in merging from the bottom up (Fig. -A.102). These methods work well for data sets that are linearly separable but models such as back-propagation (-A.11.4) are better for problems where non-linear partitions are possible.

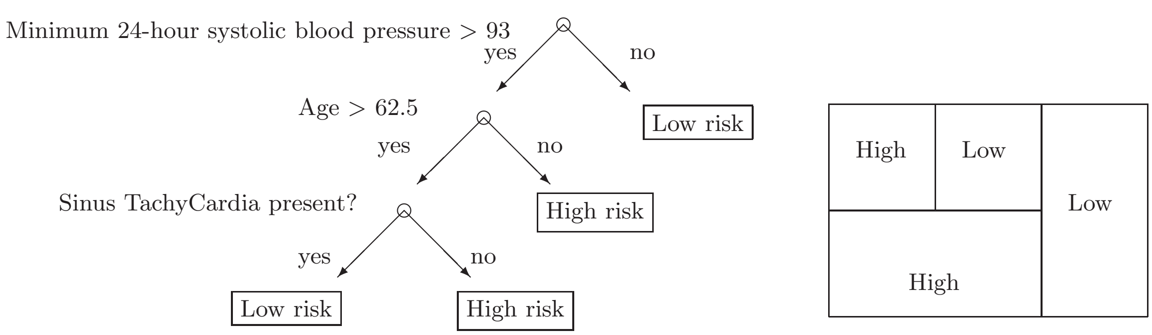


Figure A.102: CART decision tree for[21] and a schematic of the partitions it makes for treatment of hospital patients.

Scaling

Measurement (9.3.0)/ Metric and non-metric measurement.

Transformations.

Transitivity.

Multidimensional Scaling (MDS). Multi-Dimensional Scaling (MDS) is related to cluster analysis. MDS attempts to find the fit of data of high dimensionality into a quantitative method which can be used to form non-hierarchical clusters a lower-dimensional space.

Self-Organizing Systems and Maps

When a crystal forms, the atoms or molecules in it align themselves in highly-ordered patterns. This is a type of self-organizing system. Typically, these have local units that organize into larger, more coherent patterns. Society, the Web, and life itself are all generally considered to be self-organizing systems. This is a type of unsupervised learning.

FMRI evidence for concepts separate from language [**?**].

A.11.3. Supervised Machine Learning: Learning Category Membership and Similarity

Supervised learning algorithms use feedback about the results of an action from the environment to improve performance. Because classification is so ubiquitous, we often think of learning as improving the quality of classification. Supervised learning requires a representation to be updated so that the next time the behavior is emitted, it is done better.

This is sometimes called learning by trial and error. From design to requirements.

Active learning. A process of improving categorization. For instance, we might select the optimal training set.

Feedback can be either positive or negative. Instrumental learning is learning which helps a person to accomplish some goal.

The procedures also differ in their representation. This section focuses on neural networks, but other well-known supervised learning procedures include genetic algorithms (-A.11.6), Hidden Markov Models (-A.5.5), and Bayesian learning (-A.8.2).

For instance, text categorization (10.6.1) might use Bayesian techniques.

Issues for Supervised Learning. How much training? How good is generalization. Transfer (4.3.5).

Classifiers.

Supervised algorithms generally require several training cycles. By gradually improving the model, the algorithm may be able to perform better on later tasks. This is a process known as "hill climbing". Not every task is amenable to every supervised learning algorithm. For instance, if the process of gradually improving the weights reaches a local minimum which the algorithm cannot pass to reach the global minimum.

Supervised learning algorithms use feedback. Some algorithms will not necessarily converge and show an improvement. Measures of learning include generalization to new situations. Another problem is over-generalization, which is learning about the details of a specific training set and missing effective generalization.

Training strategies. Training the network. Successive approximations and learning.

When there is a complex model, This is known as "credit assignment". Sometimes, it may be difficult to determine which factor contributes to the result. Therefore, it will be difficult to update the right part. Changing the model.

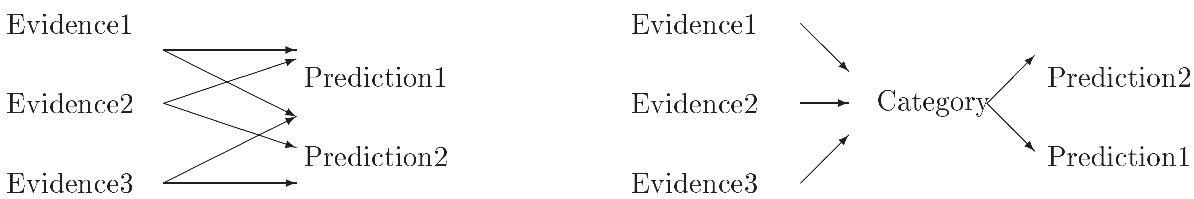


Figure A.103: For some types of predictions, it is helpful to categorize the input values but in other cases, using numerical values without categorization is more effective.

A.11.4. Learning in Neural Networks

Neural networks may be thought of as a style of computation. Some approaches to learning are modeled loosely on biological systems that show learning.

Neural networks are computational models which can be applied to learning algorithm in which the computation and representation are distributed across interconnected nodes. Neural networks are loosely modeled on neurons in the nervous system. Each neuron is a very simple processing unit. Typically, each neuron is active and makes a contribution. Thus, the computation is parallel and emergent. Neural networks are numeric and do not explicitly model symbols and concepts. Thus, they provide an alternative to symbolic processing models. It remains unclear whether these system can learn to manipulate symbols.

Neural nets and pattern recognition. Modeling the responses of conversational agents. Neural networks are used in many ways including classification. This can be used in general data mining (9.6.5).

Figure A.104: Distributed representations. (redraw)

Learning Different Types of Representations

Overview of Neural Networks

The basic neural network model is composed of neurons connected by activation pathways. Each neuron combines the inputs from the activation paths and applies a transfer function to determine how much activation will be presented. The neural networks can learn representations that characterize the patterns of inputs they have received.

Most retrieval systems employ indirect indexing terms to point to the content. An alternative is to have the content serve as its own index. Content-addressable memories.

"Neurons that fire together wire together." Typically, information is represented in the neural networks by the weights and activation algorithms. The representations developed by neural networks are distributed and difficult to examine. They are an excellent example of non-symbolic processing. However, neural networks have been criticized for not being able to yield explanations for how they reach decisions. More often, supervised learning algorithms gradually change the weights. Neural networks support associative learning (4.3.5). A simple assumption, which is known as Hebbian neurons, states that when two neurons are both active at the same time (i.e., associated), then the strength of the link between them is increased[37] (Fig. -A.105).

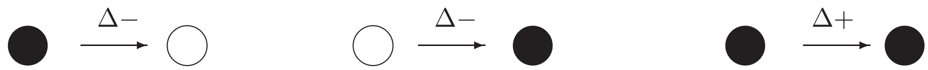


Figure A.105: According to the Hebbian learning model the weight, or strength of association, between two neurons should be increased (Δ+). when the neurons are reacting the same way. That is, when they are both ON (filled circles) (left). If they are reacting differently (center and right), the strength of the association between them is decremented (Δ−).

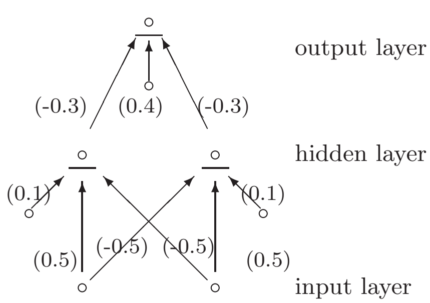
Back-propagation Algorithm

To demonstrate even simple reasoning, a learning system should be able to at least learn basic Boolean operations. The Boolean XOR is similar to the Boolean operations described earlier (3.9.2). The XOR was originally believed not to be learnable by neural networks. The back-propagation algorithm[61] became particularly well-known when it was demonstrated that it could learn the XOR logic function (Fig. 3.58). This is a type of non-linear regression.

There are many ways collections of neurons may be connected. This is the foundation for the representation. Fig. -A.106 shows a simple three-layer neural network. The input values are shown by the weights of the links, which connect them to the hidden-layer neurons. This is, essentially, a bottom-up process (10.1.5). The three-layer model is particularly effective for data reduction in which the number of hidden units is small compared to the number of inputs or outputs.

The basic idea is that the weights are updated so the network is more likely to produce the desired result after the update. Each training trial has two phases. The forward-propagation follows a type of spreading activation network (-A.10.3). However, the basic spreading activation approach is adapted with the inclusion of bias units, negative weights, and synapses with transfer functions (Fig. -A.106).

The level of activation on the hidden layer is determined by a simple formula which integrates the activation from the inputs. The same process is repeated starting with the hidden units to obtain the activation on the output. For a network which has already been trained, the output values should match the targets.



		Pattern			
layer	**neurons**	**activation**	**activation**	**activation**	**activation**
input	left	0.0	1.0	0.0	1.0
	right	0.0	0.0	1.0	0.0
hidden	left	(0.1) 0.0	(0.6) 0.8	(-0.4) 0.2	(0.1) 0.0
	right	(0.1) 0.0	(-0.4) 0.2	(0.6) 0.8	(0.1) 0.0
output		(0.4) 0.2	(0.8) 0.9	(0.8) 0.9	(0.4) 0.2
target		0.0	1.0	1.0	0.0

Figure A.106: Forward-propagation in three-layer neural network. Note that the weights (shown in parentheses in the schematic) are preset to value which solve the XOR. The activation spreads from the input layer through the hidden (middle) layer to the output layer. Activations are collected at synapses, which are shown by horizontal lines. A transformation is applied to the synapse activation shown in parentheses in the table to produce the neuron activation.

For the neural network to demonstrated learning (i.e., for the weights to be updated) we can use the difference from the target along with the strength of the activation on each weight by a small amount. These corrections are made on the weights from the outputs back to hidden units and then on the weights back to the input units.

A.11.5. Deep Learning

Feature extraction.

A.11.6. Genetic Algorithms

DNA is the representation for adaptive biological systems. In the biological systems, learning is accomplished from mutation followed by natural selection. Since we know that biological species adapt through evolution, it may be possible to imitate them. This process can be simulated with binary strings representing a gene pool (Fig. -A.107). Changes are introduced by mutation of the binary string. "Cross-overs" are a type of mutation in which segments of two strings are swapped (Fig. -A.108). Natural selection can then be simulated by selecting those mutated segments that provide better responses to the problem the initial patterns.

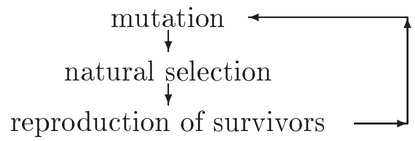


Figure A.107: Steps in evolution are emulated by genetic algorithms.

Initial Patterns	**Ending Patterns**
1 1 | 0 0 0	1 1 | 0 1 1
1 0 | 0 1 1	1 0 | 0 0 0

Figure A.108: In genetic algorithms, new bit patterns may evolve by a process of "mutation" and "natural selection". An example of crossover from a genetic algorithm is shown; the last three bits have been flipped.

A.12. Biological Basis of Human and Social Information Processing

A.12.1. Biological Bases of Social Behavior

Social brain. Aggression. Empathy.

Animal models for social behavior. Fig. **??**.

Figure A.109: Chimp grooming. (check permission)

A.12.2. Brain Science

Why brain science is relevant for information science.

While we have generally focused on the use of information rather than the underlying infrastructure. For human information processing we have considered cognition (4.3.0) but not the brain. Here, we investigate that. Neurology. Cognition systems. Hierarchical sensory processing. Metabolic cost for cognition.

Scenario visualization [**?**].

Plasticity. Language learning up to a certain age. Sensory and brain development.

Figure A.110: Basic brain structures.

Cognitive metabolic costs. Metabolic costs in multitasking. Motor behavior (4.2.4).

Perhaps some overlap of brain inputs helps to give people the distinctive capabilities[64]. Face blindness.

Spatial Brain

Spatial brain. Grid cells for location.

Brain Structure

Modularity of brain structures.

Left-handedness.

synapses > neurons > network > maps > nervous systems

Macro Structure Regions for vision, emotions, motor control.

There is some cross-talk among neurons in the brain. Priming. Even apparently cross-talk between structures. Holding a hot cup of coffee affects rating of the warmth of other people.

The human brain is vastly different from silicon computers and their programming. The brain is a mass of neurons which are inter-connected by an even larger number of axons.

The physical structure of the brain shows a lot of specialization. Right brain versus left brain [**?**]. identifying brain function of different brain hemispheres. Left brain tends to be logical and the right brain tends to be intuitive.

Hippocampus. Spatial neurons.

Social brain. Face recognition. Empathy.

Fear and aggression. Emotion from the amygdale.

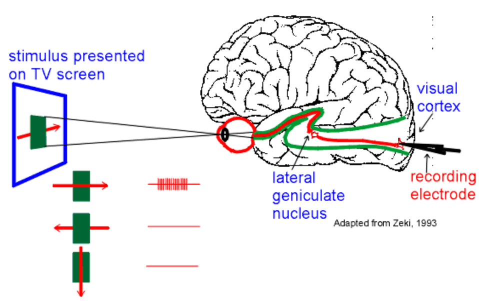


Figure A.111: Hubel and Wisel neurons. (check permission)

Mirror neurons and empathy.

Motor behavior (4.2.4) and sensation (Fig. -A.112).

Micro-structures. Mirror neurons.

Brain science and language learning. Broca and Wernicke's Areas are important in language.

Figure A.112: Brain motor behavior.

Neurons Neurons.

Synapses are adaptive. Neurotransmitters. Dopamine.

The ability of the human brain to develop new representations seems to change with growth.

Brain Function

Furthermore, the functions of many regions of the brain can be clearly identified. Right brain versus left brain[11]. The left hemisphere of the brain is generally associated with speech. One part, Broca's Area, is involved in speech and language production. While another part, Wernicke's Area, is involved in speech understanding. Moreover, these may be related to language difficulties such as dyslexia (4.9.3).

Unreliable components (i.e., neurons) produce generally coherent thinking.

Visual features and visual search.

Magnetic resonance imaging (MRI) fMRI which measures increased blood flow for different cognitive activities.

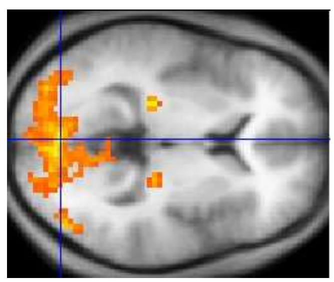


Figure A.113: Functional magnetic resonance imaging (FMRI) has proven very useful for determining which parts of the brain are most involved in high level cognitive processing. (check permission).

Some of these studies have revealed specialized structures of the brain. Regions of the visual cortex specialized for faces, places, bodies[41] (Fig. -A.114).

Hippocampus and episodic memory.

Expert chess players versus novices show activity in different regions of the brain when playing chess.

Neural plasticity.

Mental imagery and vision.

Pain.

Music[48].

Category-specific cells. Grandmother cells. Grammar cells. Cells which respond to stimuli which have been attended to a lot.

Consciousness and intentional behavior.

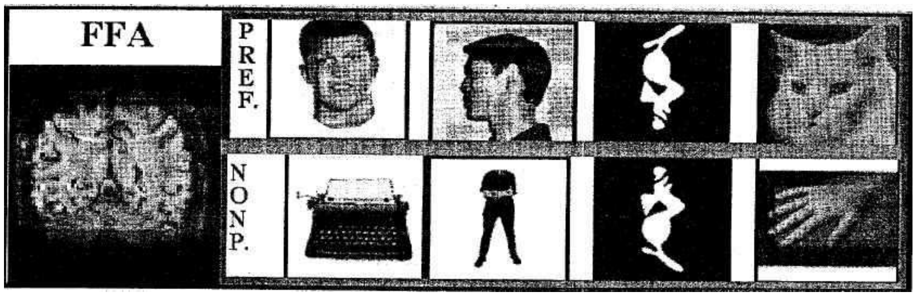


Figure A.114: Face detection cells vs frequent item cells.[41]. (check permission)

Neural network models (-A.11.4) and broader modeling of neural circuits.

Modular system with lots of feedback[70].

Sleep and memory consolidation[7].

Multiple memories. Amnesia difficulties of forming long-term memories.

A.12.3. Affect and Emotion

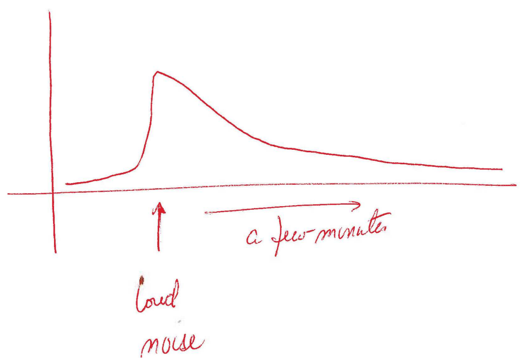


Figure A.115: Typical time-course for physiological arousal. A loud noise may cause an "fight or flight" reaction". (redraw)

Oxytocin.

Addiction

Multiple competing forces. Opponent process model of addiction. Pleasure and stress.

Figure A.116: Model for addiction.

A.12.4. Learning

As with the complexity of neurons themselves, there are many mechanisms for learning. There is both plasticity and wired-in learning. Some studies show that neural organization of information continues as late as 18 years of age.

A.12.5. Brain Simulation

Machine learning (-A.11.0). .

Neural Prosthetics Neural prosthetics.

Neuro-technologies.

Moral judgment,

A.13. Encryption and Cryptography

Encryption is a foundation for information security and applications such as privacy (8.3.1) and ecommerce (8.12.5). We briefly introduced encryption earlier (-A.13.1); here we extend that. These algorithms are triggered by a "key" which is a large number that sets the algorithm. Many of the most robust encryption protocols are based on the difficulty of factoring combinations of prime numbers. Amount of comutation is a consideration for routine use. Brute force attack to break encryption.

Figure A.117: Bletchley house: The site of British code breaking work during World War II. (check permission)

Hidden Markov models (-A.5.5) can be useful for code-breaking. Specifically, they can help to identify non-random processes.

A.13.1. Encryption

Encryption is a base technology which can facilitate security. Encryption scrambles data, making it difficult to intercept and read. Encryption supports for information assurance. When important data can be easily and illegitimately copied, and other information can be as easily forged, it is natural to look for technological solutions to the problems raised by such activities. For all practical purposes, modern encryption algorithms cannot be broken. In a sort of arms race, sophisticated technologies for protecting information often produce sophisticated attacks by people seeking to breach those safeguards. The encryption algorithms may be embedded in a service to aid in information security.

Secret Codes

Codes and encryption protect information from being seen by people who do not know the key. Some of the simplest codes are "substitution codes" in which one letter is replaced by other letters. The code shown in Fig. -A.118 is formed by shifting each letter 13 positions in the alphabet. These rotated letters are substituted for the original letters. We might easily guess that the rotated letters v, b, and a are among the most common in the language since they appear twice in the coded word. In fact, we see that these letters represent i, o, and n. With sufficient samples of text, such simple codes are easily broken.

e	t	a	o	i	n	s	r	h	l	d	c	u	m	f	p	g	w	y	b	v	k	x	j	q	z

Figure A.118: Rank order of the letters in the English (Latin) alphabet based on their frequency.

original	i	n	f	o	r	m	a	t	i	o	n
ROT13 coded	v	a	s	b	e	z	n	g	v	b	a

Figure A.119: The letters of the word in the first line are shifted by 13 letter positions (ROT13) in the second line.

Single-Key (Symmetric) Encryption

Modern encryption schemes are much more difficult to break. One family of encryptions is symmetric; that is, the same algorithm key can encrypt and decrypt these codes. The Data Encryption Standards (DES) (-A.13.2) is called "symmetric" because the encryption and decryption keys are the same (Fig. -A.120). Without knowing the key, the only practical way to break these codes is by testing all possible values for the keys. Whether, and how quickly, the algorithm can be broken depends on the size of the factors and the speed of the computers trying to break it.

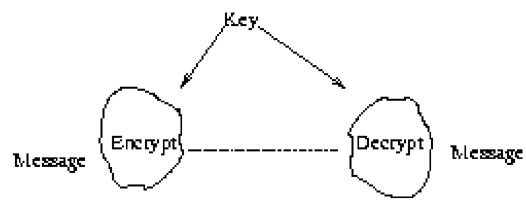


Figure A.120: Symmetric-key encryption uses the same key for encryption and decryption.

Public-Key (Asymmetric) Encryption and the Public Key Infrastructure (PKI)

The public-key algorithm uses two asymmetric keys. One of the keys encrypts messages while the second decrypts them. The details of the algorithm are given in -A.13.3. Most often, the public key algorithm is used to prove that information is from an authentic source. It could be a digital signature or a stamp to validate a Web site. In this type of application, the encryption key is kept secret and the decryption key is made freely available. If a Web site is able to be read using the decryption key they we can be confident it was encrypted by the holder of the private key. It is also possible to publish the encryption key and keep the decryption key secret. In this latter approach, anyone can encrypt a message and send it to the holder of the decryption key, but only that person can read the message. Signing certificates.

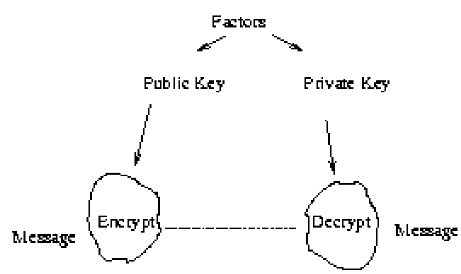
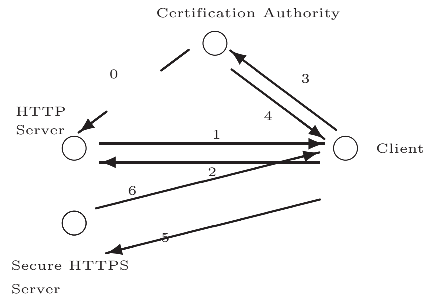


Figure A.121: Public-key encryption is asymmetric with one key to encrypt (write) the file and a second key to read it.

Beyond encryption algorithms, an infrastructure is needed to allow distributed computers to exchange information securely. A certification authority guarantees that a public key actually belongs to a certain organization (Fig. -A.122). Specifically, the certification authority provides an electronic certificate which can validate a public key (Fig. -A.123); it also sets time limits during which a certificate may be active. It provides its own encryption and a temporal window in which it can be used. Message authorization code.

Key Management and Encryption without Transmitting Keys

Procedures for secure management of keys remains difficult. The key needs to be delivered to the correct recipient. If the keys are distributed by an insecure channel, they could be stolen. Because of the difficulty of key management, a procedure that creates an encrypted channel without transmitting keys can be useful. The Diffie-Hellman procedure (-A.13.2) can be used to exchange information securely because the keys are never transmitted in the open. This is the principle behind SSH.



Sequence	Description
0.	Certification authority sends private key to HTTP server. This is often done when server site is set up.
1.	User contacts merchant's HTTP server.
2.	HTTP server suggests switching to secure server.
3.	User asks for merchant's public key from certification authority.
4.	Certification authority replies with merchant's public key.
5.	User merchant's contacts secure server.
6.	Secure server responds and user can decrypt page with public key.

Figure A.122: The steps in authentication with a certification authority. (FIG)

Field	Description
Version	Version
Serial number	Unique serial number
Signature	Algorithm used to sign certificate
Issuer	Trusted entity
Validity	Dates for which the certificate is valid
Subject	Name of the certificate holder
SubjectPublicKeyInfo	Algorithms for which the certificate is valid
IssuerUniqueID	ID of trusted entity
SubjectUniqueID	ID of certificate holder
Extensions	Extensions

Figure A.123: The main fields of an electronic certificate (adapted from[3]).

Digital Signatures and Digital Time-Stamps

Hashing is a procedure generally produces an index number from complex number. This unique number can be used as a digital signature. Time-stamps are an application of digital signatures which describe when an information resource was created. An inventor might want to be able to verify the date on which his or her invention was created, or a hospital may want to confirm the time and date when an X-ray of a patient was taken. Secure hashing, which is similar to encryption, generates a unique hash code for the object; this can be widely published so that its time cannot be disputed. Simply including a digitized time in an ordinary encryption is not proof because that time-stamp could have been forged before the encryption. This can be a technique for authentication.

A time-stamp system is based on publishing a rolling hash code (Fig. -A.124). Provides trust (5.2.3). Content encrypted with that key must have been in that sequence based on a reconstruction of the sequence of values. The result is published in a newspaper classified advertisement. Because the newspaper is dated and widely distributed, the time stamps must have been generated on that date.

Encryption Policies

Encryption attempts to scramble messages so thoroughly that they cannot be decoded except by someone with the key. This technology may be abused; it could enable criminals to communicate without any possibility of detection. The U.S. government has attempted to control the distribution of encryp-

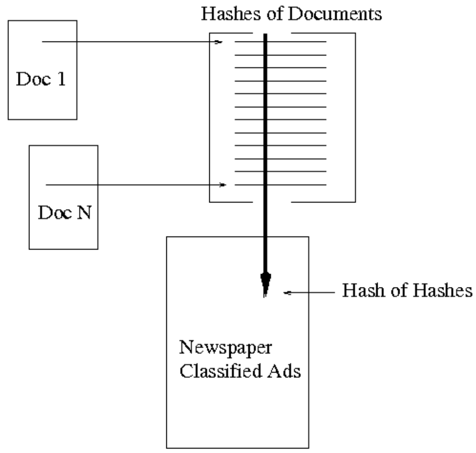


Figure A.124: Steps in time-stamping digital objects. The documents are hashed and the hashes are stored in a list. This list is hashed and the resulting hash code is published in a newspaper. As with any public-key system, the list can be read, but the time-stamp agency can prove that only they could have produced that hash. (FIG)

tion technology by prohibiting its commercial export. Critics of this policy argue that the encryption technology should be freely available. However, that effort has not been generally successful and the debate has shifted to whether there should be a way for government officials to over-ride the encryption in some cases. Privacy advocates disagree with the inclusion of an over-ride capability. Current encryption technology is so good that for all practical purposes it cannot be broken. The most serious problems with credit card authorization on the Web have not been with the algorithms, but with the control of decrypted card numbers that were stored in a database.

A.13.2. Digital Encryption Standard (DES)

DES is the basic procedure for symmetric key encryption. It proceeds through a series of permutation, rotation, using the Boolean XOR operator (3.9.2). This is fairly fast and is reversible, but can be difficult to crack depending on the number of bits in the XOR. A schematic of the steps is shown in Fig. -A.117.

1 10111000	00101110
2 -	-
3 -	-

Figure A.125: Simplified version of DES using eight bits, rotation, and XOR.

A.13.3. Public-Key Encryption Algorithm

Applications of public-key encryption were described earlier (-A.13.1). Here we explain the RSA public-key encryption algorithm following[69]. This is sometimes called a "trapdoor" or "knapsack" algorithm because it is easy to go in one direction but difficult to go in the other direction. This is especially true for very large values. Begin by selecting two prime numbers, p and q and an encryption key, e. Those values can be used to derive the decryption key, d (Eq. -A.20).

$$(d * e)\ mod\ ((p-1)(q-1)) = 1 \qquad (\text{-A.20})$$

A message, M, can be encrypted to a cipher, C, with Eq. -A.21. When we want private encryption of messages, e and $p * q$ together can be used as a "private key".

$$C = M^e\ mod\ (p * q) \qquad (\text{-A.21})$$

The cipher can be decrypted using Eq. -A.22 based on p, q, and d. While d and $p * q$ may be known, as long as the individual values of p and q are private, it is extremely hard to find e.

$$M = C^d \; mod \; (p * q) \tag{-A.22}$$

As an example, if we took two prime numbers, $p = 11$ and $q = 3$ and we select $e = 13$. d can be calculated from Eq. -A.20.[3]

$$(d * 13) \; mod((11 - 1)(3 - 1)) = (d * 13) \; mod \; (20) \quad = \quad 1 \tag{-A.23}$$

$$d \quad = \quad 17 \tag{-A.24}$$

For instance, this might be the ASCII code a text message. Now, imagine that we want to transmit the number “9” as a message, M. The cipher can be calculated with Eq. -A.21 along with the values of e. [4]

$$C \quad = \quad 9^{13} mod(33) \tag{-A.26}$$

$$C \quad = \quad 15 \tag{-A.27}$$

The receiver can then decode the cipher using the decryption key, d and the value of $p * q$ and Eq. -A.22 to recover the value of the message, M.

$$M \quad = \quad 15^{17} mod(33) \tag{-A.28}$$

$$M \quad = \quad 9 \tag{-A.29}$$

Because the public-key calculations are computationally expensive, an entire message is typically not encrypted with this technique. Rather, the DES algorithm may be used to encrypt the message and only the DES key is encrypted with the public key algorithm.

A.13.4. Public-Key Infrastructure (PKI)

Certification Authorities and Electronic Certificates Fig. -A.123 shows the steps required by a certification authority.

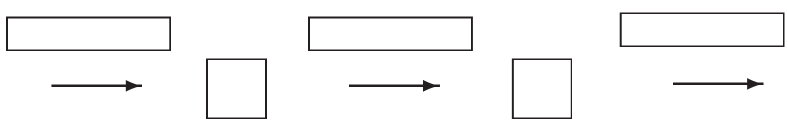


Figure A.126: Stream cipher.

A.13.5. Cryptographic Protocols

Encryption can be the foundation of low-level protocols. For instance, employing middleware to provide anonymity.

The encryption procedures just described can be applied in many ways, Cryptographic that manages different types of interaction. Determining the highest salary among a group of people without being able to identify who has it.

Encryption is possible solution to security rather than a system solution.

“Pseudonym” systems.

---

[3] For large values, this calculation can be simplified with Euclid’s theorem.

[4] Note that even for small values these exponents will overflow most computers. The computation can be made more tractable by decomposing the exponents. For instance:

$$9^{13} mod(33) = [9^6 mod(33) * 9^5 mod(33) * 9^2 mod(33)] \; mod(33) \tag{-A.25}$$

Compared to credit cards, cash provides anonymity because there is no electronic trail.

Secure multiparty communications. Protecting privacy (8.3.1) and data mining. A bank can guarantee a payment without the source of the funds being directly identified. This provides about the same level of anonymity as cash (Fig. -A.127)[23].

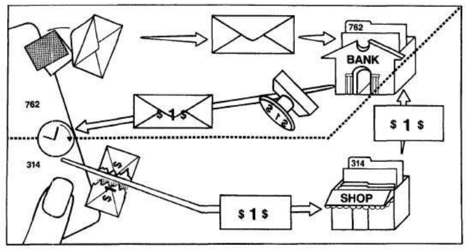


Figure A.127: An example of a cryptographic protocol for ecommerce. In the top panel the user requests a certificate from the bank for a fixed amount. In the bottom panel, the certificate is given to a merchant. (adapted from[23]). (redraw)

A.14. Servers and Networks

We have seen range servers from databases, to Web sites, to repository servers. In middleware (7.7.1). A server is a networked computer that specializes in delivering data and information. Network security. Peer-to-peer.

This does not include the human or organizational issues.

We have touched on servers in many sections.

A.14.1. Database Systems

Database management systems (DBMS) ((sec:dbmsbasic)). Indeed, these may be federated systems in which case they would are distributed databasemanagement systems (DDBMS).

While we emphasized databases for retrieving information, many databases also need to store information received from users.

Unitary transactions. ACID: Atomic, Consistency, Isolation, Durability

CRUD: Create, Read, Update, Delete.

Transaction Management

Nested and distributed transactions.

Database transactions. Lock to make sure the cannot be changed by another process. Prevent conflicts of two disk activities at the same time.

Several transactions may occur simultaneously. Concurrency control. Suppose you are online and browsing for an airplane ticket. You would be very annoyed if you have picked a flight and seat but before you complete the purchase somebody else slips in and purchases that seat. This problem can be helped by creating a lock on the seat one you request it. While the lock in effect nobody else can select that seat.

Avoid conflicts and deadlocks.

Rollback points.

Check-in and check-out to make sure the do not overlap.

Two-phase locking (Fig. -A.128). Growing phase and shrinking phase. Locking phase and release phase.

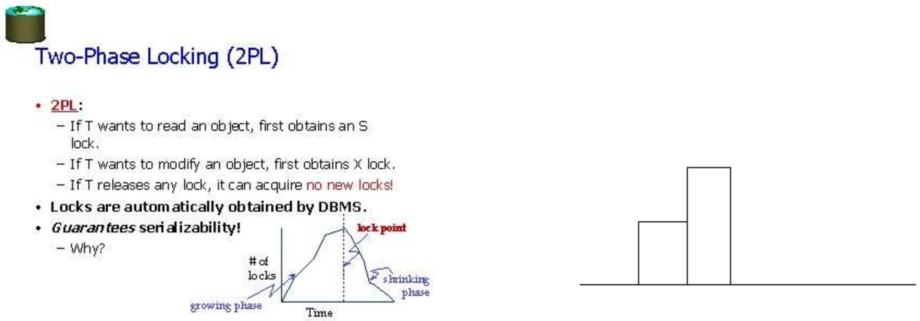


Figure A.128: Two-phase locking. (redraw)

Network Databases

The Web is highly distributed and there are no guarantees as to information being available.

A variety of systems have been developed for managing the coordination of the network infrastructure.

Placement in the Network There is often a tradeoff between disk storage and network usage. Frequently accessed content can be made available. Mirroring[??]

A.14.2. Web Servers

From Web servers to repository servers and content management systems (CMS) (7.8.0).

Web Server Logs

Servers record a great deal of information about each transaction (Fig. **??**).

Tools for analysis and improved advertising. Able to find IP addresses.

208.219.77.29 - - [17/Aug/1999:11:57:58 -0400] "GET /robots.txt HTTP/1.1" 404 207
208.219.77.29 - - [17/Aug/1999:12:01:38 -0400] "GET /snews/ HTTP/1.1" 200 822
208.219.77.29 - - [17/Aug/1999:13:59:46 -0400] "GET /snews/ HTTP/1.1" 200 822
208.219.77.29 - - [17/Aug/1999:14:24:38 -0400] "GET /snews/browse.html HTTP/1.1" 200 665
208.219.77.29 - - [17/Aug/1999:14:36:24 -0400] "GET /snews/form.html HTTP/1.1" 200 1080
208.219.77.29 - - [17/Aug/1999:16:16:51 -0400] "GET /snews/form.html HTTP/1.1" 200 1080
208.219.77.29 - - [17/Aug/1999:16:24:29 -0400] "GET /snews/MDUD/pageImages.html HTTP/1.1" 200 856
208.219.77.29 - - [17/Aug/1999:19:26:07 -0400] "HEAD /snews/MDUD/pageImages.html HTTP/1.1" 200 856
208.219.77.29 - - [17/Aug/1999:19:28:10 -0400] "HEAD /snews/NYBE/pageImages.html HTTP/1.1" 200 425

Figure A.129: Web Server log files. Each of part of the Web page to be retrieval such as individual figures is recorded separately.

Anonymizer.com

Caching of Web pages depends on Web usage patterns. It can be on the browser or in the networks; for example at a proxy server.

A.14.3. Link Resolution for Digital Libraries

Some links may be context sensitive. For instance, links for an appropriate copy may depend on contracts. Links in the local context.

One strategy for organizing virtual or distributed collections employs "Digital Object Identifiers" (DOIs). These unique codes are composed of a prefix that describe the directory and publisher, and a suffix that assigns the object a code of the publisher's choosing.

Manage access rights. Digital object identifiers (DOIs) (-A.14.3).

The “appropriate copy” linking service[55] uses the Handles protocol[40] (-A.14.3). It is an “appropriate copy” in the sense that a contrast or license exists for accessing that content. This is also termed “context-sensitive linking” (Fig. -A.130). From DOIs (-A.14.3).

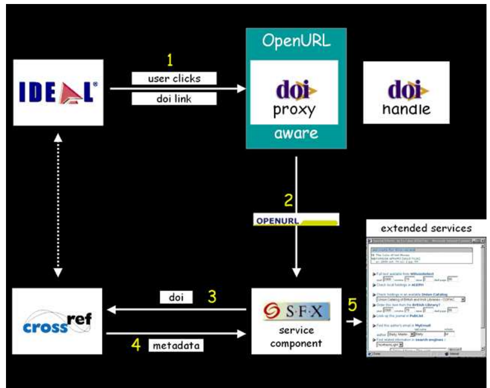


Figure A.130: Context-sensitive linking[12]. (check permission)

A.15. Transmission and Networking

It is not the intention of this text to provide a general course on transmission; rather, we focus on data transmission. Ideally, transmission should be fast, flexible, and real-time. This can greatly affect multimedia presentations.

Figure A.131: Telephone lines in rural Virginia (from LC)

Distributed protocols.

A.15.1. Data Transmission

Data has to get from one place to another. Transmission costs are falling rapidly and increasing in portability.

Digital versus analog. Asymmetric links. The back channel does not necessarily have to be as high bandwidth. Symmetric network, have sources equal to sinks.

Broadcast and Wireless

There are many technologies and many ways of delivering content. In a broadcast transmission, an antenna sends signals into the air; broadcast is widely used by traditional analog radio and video stations. Broadcast normally sends signals to anyone with an appropriate receiver.

Spectrum The electromagnetic spectrum includes radio frequencies used for communication service. Different parts of the spectrum are useful for different applications. These are licensed to avoid conflicts in communication. This licensing regulates, for instance, the number of broadcast television stations in a region. In the U.S. permission in allocated by the Federal Communications Commission (FCC). In some cases, the spectrum is quite valuable and it is generally auctioned to the highest as a public resource. Different parts of the spectrum are suitable for different applications. Fig. -A.132 shows how the spectrum is divided for communications.

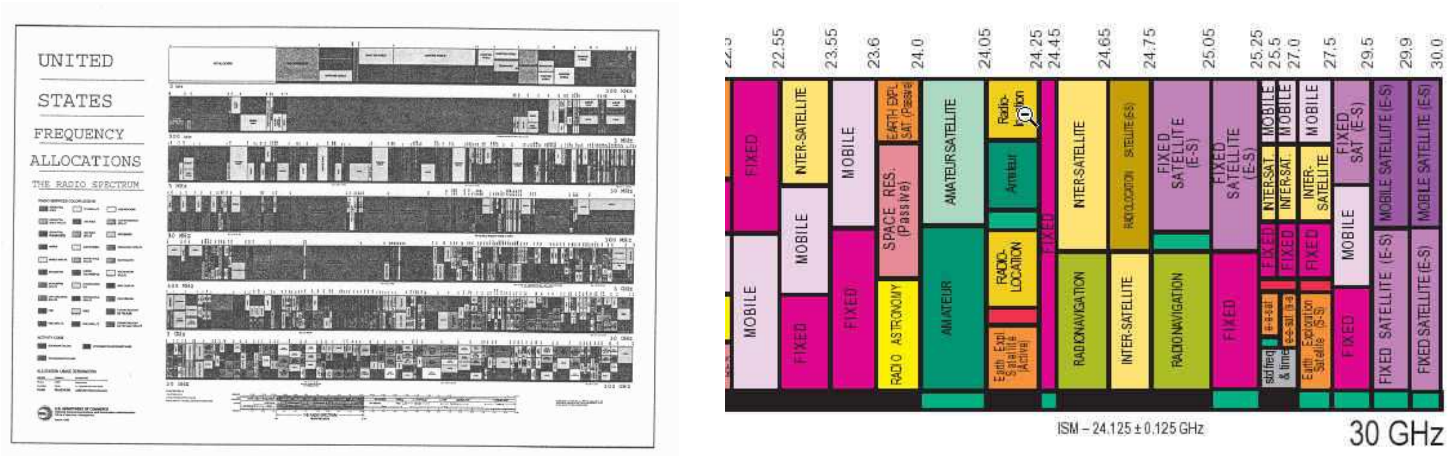


Figure A.132: Chart showing the allocation of electromagnetic spectrum for communication in the U.S. (left) and a detail of the chart (right)[53].

Wireless Wireless transmission allows for portable, and hence nearly ubiquitous, dissemination of information. When broadcast is used for personal communications. Analog versus digital radio versus IR transmission microwave.

Who owns wireless spectrum. Is it a public resource. Commons wireless networks. Sharing bandwidth. For instance, garage door openers share a spectrum with fighter aircraft.

Wireless and mobility of services.

This has the potential to make highly portable services.

Cellular – what is a cell. Microcells. Fig. ?? shows how cells work in a cellular telephony system.

Coordination between cells.

Figure A.133: Cellular telephony.

Multimedia over wireless poses substantial bandwidth difficulties.

Spread Spectrum With traditional radio, the broadcast is on a single frequency. However, it is also possible to spread information across different wavelengths of the spectrum (Fig. -A.134) [?].

Satellite Relay Satellites provide communication coverage in remote locations. Several generations of satellites have been deployed. One important difference between them is their orbits. "Remote sensing" satellites. There are two fundamental types of communications satellites, those in Geosynchronous Earth Orbits (GEOs) and in Low Earth Orbit (LEOs). The GEOs stay in one position above the earth. GEOs at X KM (24K miles). footprints. LEOs are not geosynchronous. Several sets of LEOs such as Teledesic and Iridium are being deployed. Delay in satellite communications makes two-way voice links difficult.

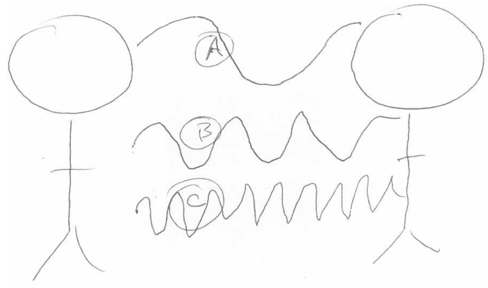


Figure A.134: In spread-spectrum communications, parts of a message are communicated on different wavelengths. Because different wavelengths are used, the message can be robust and difficult to intercept.

Location Technologies

For games and for mobile services. Coupon alert during shopping,

Providing better bus services. How to optimize bus services for times. Auctioning spaces (perhaps by better prices.

Managing location with tradoff of bandwidth and energy use.

Location-related search. Walking routes by mining previous trajectories. Finding a stationary object.

Global Positioning System (GPS) Fig. -A.135 illustrates how a GPS can calculate the position of an object on earth based on the difference in the timing of signals received from the two satellites. Better resolution, including 3-D position, can be obtained by using the signals from three or four satellites.

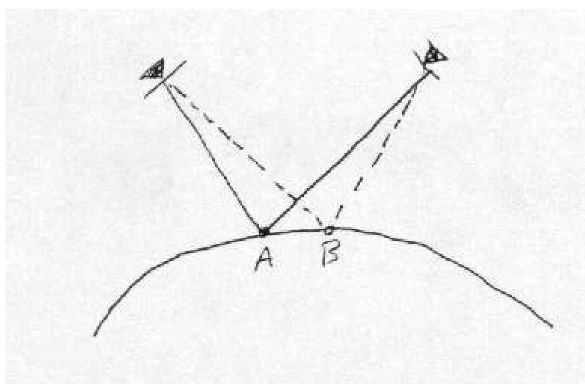


Figure A.135: Global Positioning System (GPS) position is obtained from satellite positions.

Indoor Location Properties of waves. Wave propogation method of location.

Signal strength-maps. Know characteristics of of the signals in a building. Problem of people walking around buildings. Very costly and time-consuming. Privacy problems in all this monitoring.

Navigation Based Position Accuracy Navigation through space. Inertial navigation systems (INS) Can use navigation for Compass, Accelerometer, Gyroscope.

Coordinating locations with camera or image processing.

Understanding the meaningfulness of behavior. Judging a person's intentionality for their motion.

A.15.2. Digital Networking

Digital networking makes distributed information systems possible. The information revolution depends on getting the information there. Internet versus the Web.[??]

Error control in networks.

Packets and Routing

A distributed network is designed can be robust to failure. In a centralized network consider what happens to a failure at the central node.

Packets are really sets of electrical pulses.

Sniffing.

Local Area Networks (LANs) The configuration of the network reflects the Robust networks (Fig. -A.136). This is analogous to social interaction (1.2.1). How best to get from one place to another.

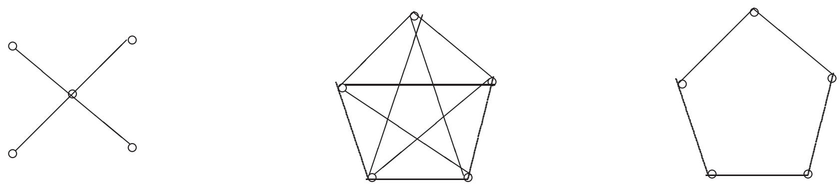


Figure A.136: Three local area networks are illustrated. In a ring (right) the packets will be sure to reach all nodes. The other networks require routing. The distributed network should be more robust to failure than the “star” network.

Ring network.

Circuits and Networks

In traditional telephony, there is an electrical circuit between the mouthpiece of one telephone and the receiver of the other telephone. This discussion focuses on packet networks. A packet is a collection of electrical signals that carries both header information and data. The header information describe the destination of the packet and the type of protocol it follows.

Ethernet is the most common packet network but many others have been proposed. Ethernet is the primary example of CMDA (collision networks) but increasingly it is being adopted by wireless systems. This provides robustness, but not if saturated. Ethernet on a single network. Gigabit Ethernet.[??] VBR (Variable Bit-rate Transmission), ATM layers — physical layer, ATM layer, adaptation layer.

Non-CDMA networks.

Addresses and Ports

In a circuit where several machines are connected, the machines must be given addresses to distinguish them from each other.

Addresses and Domains Typically, networks are interconnected. To go beyond a local network requires gateways for routing to other networks. IP and Class B, C, D address,

There are many policy issues surrounding internet naming [?].

Packet Protocols

A protocol is a standard for communication to ensure that a transmission goes to the right place. There are the IP-level protocols.[??] Service protocols, such as http, are discussed above ((sec:http)).

The Internet is a harsh environment for packets (-A.15.2). If key data is in only a few packets and those are lost due to congestion, serious problems can ensue. Often an adaptation is made to network environments by dropping frames. In current implementation, all packets are given equal priority.

A.15.3. Multimedia and Hypermedia and Networking

Multimedia networking has special requirements. Even small delays can make a difference in transmissions, so scalability is important.

Networking and Special Effects

Where in network are special effects completed? Reconstruct fades later locally [?]. Real-time interaction.

Network-Scalable Multimedia Services

A traditional video stream has fixed-rate bit streams. However, interactive multimedia services are often "bursty" (Fig. ??).

A.15.4. Audio Delivery

Because it has lower bandwidth requirements, audio services are easier to develop in the short term than are video services.

Internet telephony. This can mean many things to many people. ITU H.323. The problem of congestion along routes can be a significant factor. However, many internet telephony services run P2P protocols.

The telephone is a real-time multimedia service. Indeed, the real-time restrictions are stricter here than for delivery of audio or video; very little delay can be tolerated.

Repair of audio, In many cases, audio is fairly predictable. Thus, if a packet and its data are lost a good guess can be made about how to replace it.

Communication services such as live telephony have very stringent network requirements. VOIP, voice over IP.

Figure A.137: VOIP.

A.15.5. Video Delivery

S-Video, Composite video[??]

Video Broadcast and Networking

Video is not one technology but many. There is a fundamental distinction between analog and digital transmission. You are probably most familiar with analog video, which is broadcast or delivered by cable to your television. Most new video technologies are digital. Digital video allows pictures to be computer-processed. Special effects can be generated and frame rates and compression can be easily controlled. Digital video generally requires very large amounts of data compared to images and even audio. Low-level networking issues and video hardware are discussed in -A.18.0.

Digital video also allows for delivery of video by packet networks. In the near future, broadcast quality video is not likely to be carried on the Internet because of the large amounts of data involved. As gigabit networks and satellite delivery are more widely deployed, this may become common.

Analog Broadcast Video

Broadcast television started as black-and-white.

As color television was developed, it was necessary to allow the large number of existing black-and-white television sets to be able to received programs transmitted in color and to allow color television sets to receive black-and-white programs. Thus, the color signal was superimposed on the black-and-white signal. SMPTE (Society of Motion Picture and Television Engineers) standards were established to do this, and to handle the special cases of color superimposed

on an analog broadcast signal.

There are two widely used broadcast formats: NTSC and CECAM-PAL. NTSC is used in North America while CECAM-PAL is used in most of the rest of the world.

High-definition television (HDTV) is a widely discussed standard.

Digital Video

There are many ways of transmitting data by wire. In addition, digital video can be processed in other ways. Video on demand is one service that can be provided with this technology.

Digital video is delivered over the network or by wireless. Digital Video Broadcast (DVB) can be of higher quality than analog. The ATSC (Advanced Television Standards Committee) establishes criteria for DVB.

In streaming video, frames are sent and viewed consecutively as they arrive. Streaming may be more efficient; viewing of a video can start sooner because one does not have to wait for an entire file to download. One limitation with streaming is that there may be congestion in the network and some frames may arrive late or not at all. A second limitation is that streaming video is usually unicast, that is, only one client is connected to the server at one time. Multicasting allows many people to be served by a single a video source while minimizing network load.

Combining video with many other services.

Multicasting may also be used for other services such as distribution of audio and games.

A.16. The Internet

The Internet is the international collection of packet networks which implements the Internet Protocol (IP). It was designed as a distributed network to promote robustness and survivability. During the 1980's private networks grew but many of these used proprietary protocols and were interconnected.

The Physical Internet While we have focused on protocols, but, of course, the Internet is made up of communication lines and routers. Avoiding congestion (-A.16.0). Map of the Internet

While it is relatively easy to provide high speed network connectivity on major trunks. Feeding that connectivity out to individual locations. Last-mile problem.

Layers of Service Layering is a good strategy for managing complexity (7.7.1). Fig. -A.138 shows the ISO Open System Interconnect (OSI) layers for services. Layering for separating the complexity (7.7.1). This specification is focused on the network and not on the services. Ideally, the layers should be independent of each other. Reference model for how a network should be built.

Layer	Description	Example
1	Application	
2	Presentation	
3	Session	Circuit connection
4	Transport	TCP
5	Network	IP
6	Data Link	binary data
7	Physical	cables

Figure A.138: The ISO OSI 7-layer model. Each layer is designed to operate separately from the others.

Screendump of router se up.

A.16.1. Internet Economics and Policies

Information networks are embedded into the social fabric.

Economics (8.7.0). Network economics.

Moving computing or moving data.

Packets and network economics[76]. Impracticality of charging per packet. Peering.

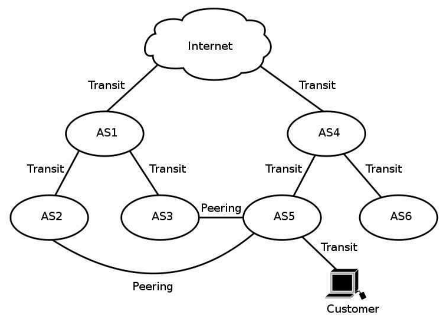


Figure A.139: Internet peering. (redraw) (check permission)

Boundary gateway protocol (BGP).

Internet structure is described in (-A.16.0). The flat-rate business model was instrumental in generating business. Business models for the Internet. Measuring traffic. Pricing. Net neutrality. Dark networks.

A.16.2. Regulating the Internet

Controlling Internet activities by national laws[33].

Government regulation. Cross-border regulation.

Real-Time Services on the Internet

The Internet transmits packets but they may be delayed or destroyed. For instance, if too many packets arrive at a switch at a given time, the buffer may overflow and some of the packets might be discarded. Even if they are not discarded, they may be delayed.

For email, these delays are not significant but for real-time interaction, only minimal delays can be tolerated. While the Web is mostly text and images, as we have seen throughout this book, multimedia is constantly increasing.

A variety of new Internet services have been proposed, including IPv6. Charging and wireless.

Buffering of transmitted information![??]

Real-Time Protocols A variety of protocols for real-time IP services have been proposed. UDP packets are sometimes preferred for multimedia because of the speed.

Robust IP Multicast.

Quality of Service Guarantees The Internet is highly distributed and has many bottlenecks.

Quality of Service (QoS) guarantees and multimedia (blocking and latency). Requires cooperation from routers.

Problem of congestion from packets on the network.

Alternatives to real-time Internet delivery.[??]

A.17. Computing Architectures and Operations

A.17.1. Theory of Computation

What is the way to organize components such as switches and memory to do complex computation. Turing[74].

Interactive computing[5].

The basic units of a Von Neuman computer [77]. 1. Arithmetic unit, 2. Memory 3. Control 4. Input/Output (Fig. -A.140).

Instruction space:	Memory space:
x=x+1;	x
z=x+y;	y
	z

Figure A.140: Stored programs need both instruction-memory space and a data-memory space.

A.17.2. Computer Programming Languages

Effectiveness.

Machine Language

Instruction space and data space.

Formal Properties of Programming Languages

One attribute of a programming language is the ability to express complex material. The ability to do any type of computation is known as being “Turing complete”.

Useful for applying algorithms for completing certain tasks.

Formal languages (6.5.2). Parsing and compiling,

A.17.3. CPU Architectures

The complexity of the algorithms wired directly into a CPU chip affects its size, speed, and the heat it generates. Thus, chip designers have two approaches.

Booleans are the basis of the gates used in digital logic (Fig. -A.141). (3.9.2, -A.7.1).

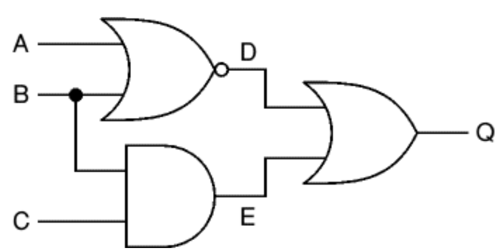


Figure A.141: Logic circuits. The OR gates and the AND gates. (redraw)

A computer may be called on to do a wide range of calculations. When designing CPUs, there was a tendency introduce instructions for and many of those computations as possible. This resulted in so-called Complex Instruction Set (CISC) chips.

However, the CISC chips were more difficult to manufacture, were more specialized, and consumed more heat when operating. Thus, the chip makers decided it was better to simplify the number of instructions. This resulted in Reduced Instruction Set (RISC) chips.

Reconfigurable computing.

Graphics computing. Cell processor.

A.17.4. Distributed Problem Solving

A.17.5. Parallel Computing

A distributed system has several computer processors connected by a network while the network connections are fairly fast, they are not nearly as fast interconnected systems with a shared bus. These centrally connected computers are call "parallel". There are many ways they can be inter-connected. Fig. -A.142 shows multiple streams with crossovers. In this configuration, the results for each stage are passed to all processors active in the second stage. "pipeline" model.

Mesh networks.

Cell computing.

Coordination and computation.

Parallel algorithms.

For some other problems, arbitrary exchanges between processors (Fig. -A.143). There are several different architectures.

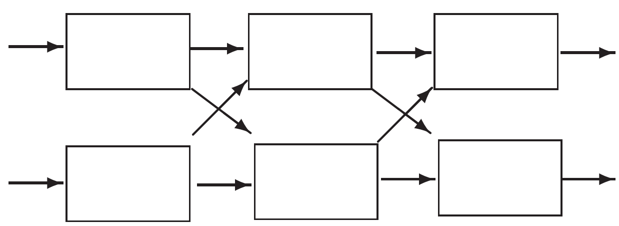


Figure A.142: A parallel computer has multiple connected CPUs.

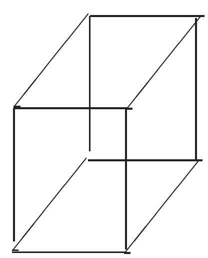


Figure A.143: A cube architecture allows the shortest path for communication among the nodes. We can easily visualize a 3-D cube but it is also easy to wire nodes into higher-dimensional cube, "hypercube," architectures.

Specific algorithms can match these architectures.

Multicore processors.

A.17.6. Grid Computing

We briefly considered grid computing (7.8.1).

Networking, storage, and concurrency.

Large Scale Distributed Storage

Delay across storage.

BigTable.

Storage resource broker[13]. Rule specification. iRODS.

Peer to peer system for storage. LOCKSS Preventing groups from. Grid computing, the storage resource broker[14].

"The SDSC Storage Resource Broker (SRB) is client-server middleware that provides a uniform interface for connecting to heterogeneous data resources over a network and accessing replicated data sets. SRB, in conjunction with the Metadata Catalog (MCAT), provides a way to access data sets and resources based on their attributes and/or logical names rather than their names or physical locations". QUOTE

Move data around the net based on cluster analysis of how it is used. Importance of keeping a single master copy. Data storage (Fig. **??**). Difficulty of updates.

Figure A.144: BigTable.

A.17.7. Models of Computation

Blackboards.

Neural networks (-A.11.4).

Autonomic Computing

Get the system to optimize itself. Self-aware, self-healing[2].

A.18. Input/Output Devices

Although digital processing is increasingly important, it is often necessary to understand the effects of physical processes. Input/output devices.

A.18.1. Audio Devices

Transducer for audio[??]

Microphones

A microphone converts sound in air to electric signals. Directional microphones. Cone of sensitivity.

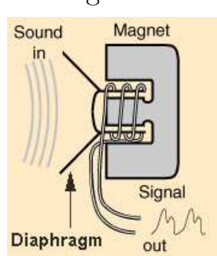


Figure A.145: Microphone. (re-draw-K)

Speakers

Speakers create pressure waves from electrical signals; a speaker's sound box can provide resonance. Different speakers are used for different pitches.

Specialized Audio Processing A-to-D, Digital Signal Processing (DSP) chips[??]

A.18.2. Visual and Video Devices

How to capture and present an array of signals. Here, we briefly survey several technologies. Digital cinema.

Printing Technology

Paper and ink. E-Ink figure. (Fig. -A

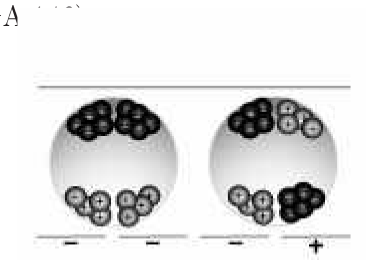


Figure A.146: Black-and-white balls with different electrostatic charges are placed in a clear larger ball. Applying an external charge causes the balls to separate[4]. (check permission)

Cameras and Scanning

Charge coupled devices (CCDs) — solid state cameras. Scanning is the usual approach for digitizing a paper document or picture. It may be done at different resolutions; after scanning, the bitmap can be compressed. Once scanned, images can be archived, distributed, or processed.

Scanners or digital cameras digitize and analyze small areas of a picture and measure the brightness or colors in that small area.

Effectiveness for reproducing readable text. The quality of the scanning for the resolution is shown with the "quality index" (Eq. -A.30). [42]

$$Quality\ Index = h * dpi; \tag{-A.30}$$

For fragile materials, it is necessary to employ non-destructive scanning.

Video Displays

Refresh rate. Number of pixels on a standard television display[??] The "aspect ratio" of a video display is that of length to width. Larger over smaller. Fig. -A.147 contrasts the aspect ratio of television (A, B) with the aspect ratio for cinema (C).

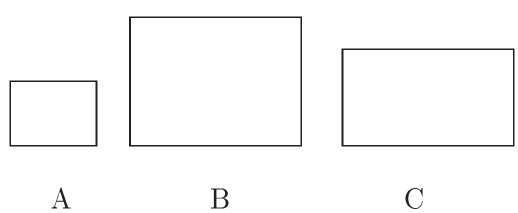


Figure A.147: The aspect ratio is the ratio of the width of a display to its height. The ratio remains constant although the absolute size may change. The ratio 4-to-3, as shown in Panels A and B is the standard for video. While the ratio 16-to-9, as shown in C is used for cinema.

LCD displays, plasma displays, interlacing. The picture is presented on the screen with rasters. Vector graphics. Raster.

Broadcast video. Vertical blanking interval. Difference in frame rates, color depth, etc.

Readability of displays (10.3.1)[34].

Rather than creating a sharp boundary at the edge of a character, which often appears as jaggies, anti-aliasing makes the boundary with a gradual fade to gray. Fig. -A.148 shows anti-aliasing.

Figure A.148: Rather, than a sharp edge, pixels in a display create a jagged edge (left). To create the appearance of a smoother edge, the edge pixels are grayed out.

Pen tiling of display colors.

BitMap Displays

(Fig. -A.149)

Figure A.149: Memory management for bit-map displays.

Overlapping Windows.

Other Types of Displays

Stereoscopic 3-D A variety of technologies have been developed to make stereoscopic 3-D presentations.

Head-Mounted Displays and Head Tracking Head tracking.

Technologies for Personalized Displays Retinal painting[??]

Immersive Display Technologies

Displays cannot have the same degree of fidelity as reality. In one study of a virtual reality system[56], the display was 0x120, 93-degrees by 61-degrees.

Volumetric Display

Volumetric displays[16]. Painting into plasma.

Printing Technology

Resolution, DPI (dots per inch)[??]

CMYK color, a variation of RGB (-A.2.3), is used for printing.

3-D Hard Copy [1]

A.19. Sensor Technology

Sensors are, typically, simple devices which detect attributes of a system's environment. Attributes such as motion, sound, temperature, air quality, and light are all easy to monitor. Bio sensors. Like you own eyes or ears, typically, sensors have relatively little complex processing capability of their own.

A.19.1. Sensor Devices

Sensor detect properties of the physical world. There are many types of sensors such as body sensors.

Transducers.

Bar Codes

Low cost way to detect portable objects. Laser scanning and reflection. Bar codes (Fig. -A.150). The spacing of the lines. A space can represent a binary code. There are different coding systems. One common system is The Universal Product Code (UPC) was developed to identify production. QR codes. Near-field communication (NFC).

Figure A.150: Bar codes represent numbers with a binary code.

Radio Frequency Identification (RFID)

Passive chip sensor which responds to an external field with coded information (Fig. -A.151).

Near-field communication. Affected by interference.

EPC - electronic product codes.

RFIDs have many applications. Use of RFIDs in hospitals in order to locate patients. Threats to privacy.

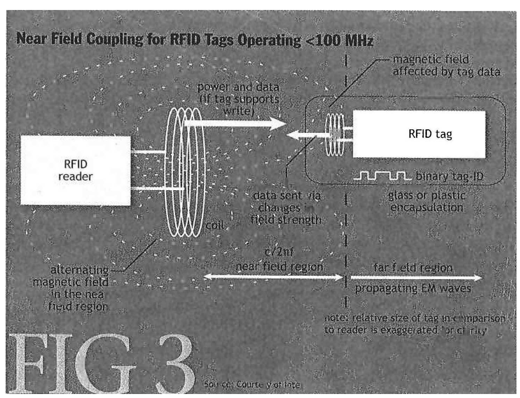


Figure A.151: How an RFID sensor works[10]. (check permission)

A.19.2. Sensor Networks and Sensor Fusion

Sensors can be connected in networks.

Typically they have simple processors, limited memory capacity, and limited power.

Here we consider two specific systems. The signals from these sensors are processed by sensor fusion (-A.19.2). Hierarchical fusion versus mesh or grid fusion. Fusion of similar data versus fusion of dissimilar data.

This often means that low-level information is processed within the network. Sensor fusion combines information from many sources (Fig. -A.152). There is a challenge about how to weight the information appropriately.

Hierarchical sensor networks and communication in sensor networks.

Many applications: Sensor fusion for emergency room data. RFID (-A.19.1).

Generating too much data. We need to automatically filter the data. We attend to (4.2.2) to significant information.

This is often noisy information with ambiguity. During the Cold War, the U.S. Navy maintained an array of sensors in the North Pacific. These sensors had to be able to distinguish submarines from whales swimming in the ocean.

Distributed decision making.

Scientific instruments and data storage.

Privacy issues from potentially invasive sensor networks.

One approach is hierarchical summarization Fig. -A.152.

There can be local interactions among the units such as excitation or inhibition of neighbors. Sensors and feedback. Parallel computing (-A.17.5).

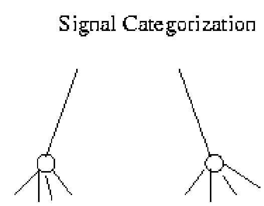


Figure A.152: Data from many sources needs to be combined. Hierarchical organization of sensors.

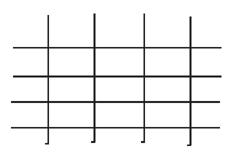


Figure A.153: A “sensor grid” is composed of sensors arranged on a grid. The first level of processing can be communicating and combining evidence with neighbors.

A.20. Storage Technology

A.20.1. Storage Media

Magnetic Storage

Helical scan video. Many formats[??]

Iron-oxide. heads.

There are many media for storing digital information; here, we consider magnetic tapes, magnetic

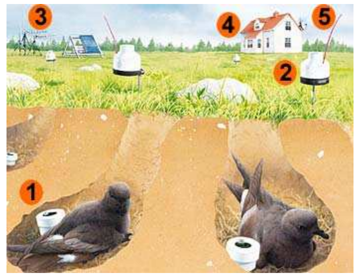


Figure A.154: Ecological sensor network in Duck Island Maine. (check permission)

disks and optical storage. Storage systems must be reliable. Although many technologies have been developed, magnetic disks are so widely deployed that they are hard to beat.

The oxide on recording tapes has a lifetime of about 10 years, after which it becomes unstable. Old tapes may be baked before being played which causes the oxide to adhere.

Many television programs are mastered on film to better preserve them.

Optical Storage

Lasers allow fine resolutions of data to be made on a metallic surface, as, for example, on a CD.

There is about 650 MB of space on a CDROM. This is about 68 minutes of sound recordings at constant bit rate. 16-bit encoding on a spiral track![??]

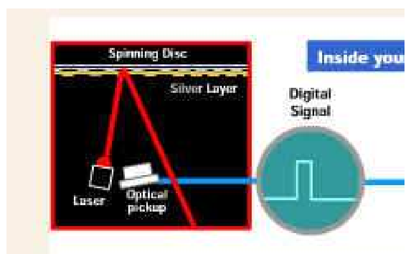


Figure A.155: Reading from a DVD. (check permission)

The digital video disk (DVD) can store 4.4 GB per disk. It has a double layer of reflective material and is double sided. It also improves the density of storage by using a blue laser for reading the disk rather than the red lasers used by the CDROM.

A.20.2. Low-Level Data Storage

Parity and Check Sum

Check that the data has not be corrupted when it is transmitted on a network or stored on a disk. Checksum for credit card verification. Fig. -A.156. If any of the bits in the data have been corrupted a recalculation of the parity bit may flag the problem.

Error-correcting codes.

Data	**Parity bit**
0 1 0 0 1 1 0 1	0
1 1 1 0 0 1 1 0	1

Figure A.156: A parity bit is calculated as a count of the number of even or odd bits.

Placement of Content on Disk Drives

There are physical restrictions on how data can be placed on a disk. The data must be placed on tracks, and the heads must be positioned above those tracks in order to read the content.

When multimedia content are stored on a disk.

Striping, Speed of streaming.

Disk caching. Random positions are better than standard placement.

Archival Storage

All physical storage media are unreliable. We want to be sure that one reliable copy of a document is preserved. Digital preservation earlier (7.5.1). How to be sure that the originals are not able to be easily corrupted. LOCKSS protocol (Fig. -A.157). When numerous sites are polled, they can essentially take a vote to determine whether any of the copies has been corrupted. If a corrupted file is found, the good version can replace it.

Figure A.157: In the LOCKSS protocol, a target version of a document can request that a comparison be made with other stored versions of the same document[59]. If a discrepancy is found a voting procedure determine which copy has, most likely been corrupted. (redraw)(check permission)

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