Chapter 1.
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.

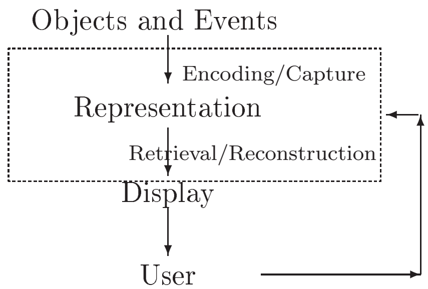

Figure 1.2: The components of a very simple information system. Information processing occurs both during encoding and during retrieval. The box shows the "model" which is the combination of the representation and associated information processing.

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.

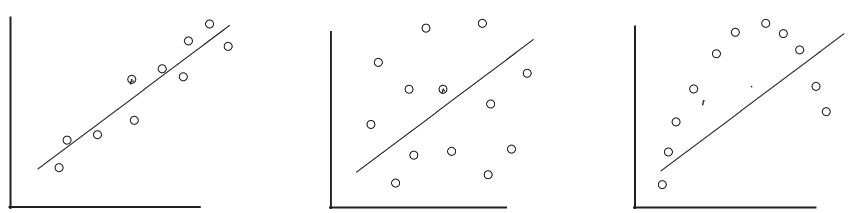

Figure 1.3: A straight line can be an effective representation to describe a set of data points (left). However, the line is less satisfactory if the points are scattered (center) or if a curved line may be a better representation (right). A representation that fits curved lines will be more complex.

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.

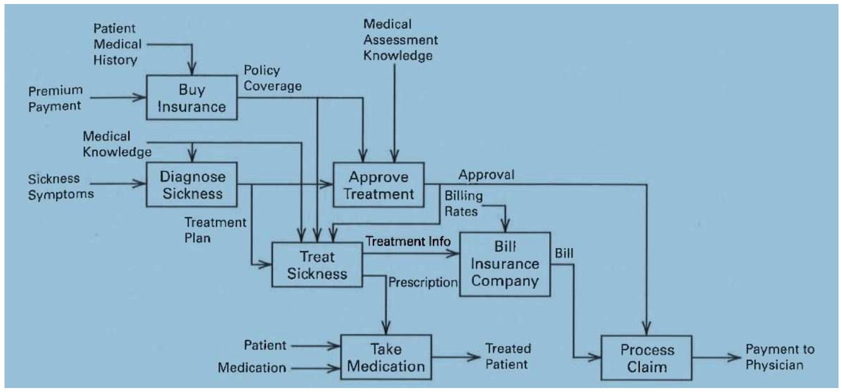

Figure 1.4: Modeling tools may also be used to complete specific tasks without emulating a natural processes. (check permission)

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.

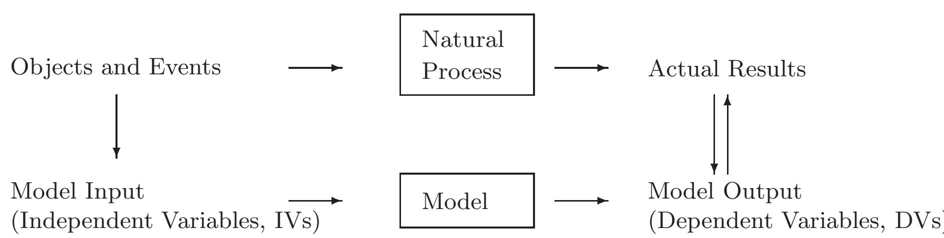

Figure 1.6: A simple model may emulate a natural process. Given the same input (the IVs), the output of a model (i.e., the DVs) should match the output of the natural process it is emulating.

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

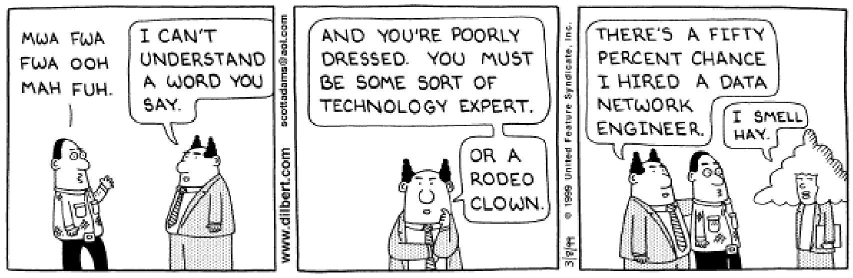

Figure 1.7: Note how much context must be inferred to understand the pictures. (redraw)(check permission).

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.

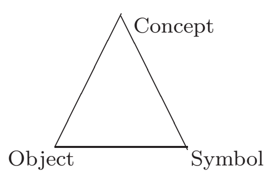

Figure 1.8: here is a view of the relationship of symbols, objects, and concepts. Meaning triangle (adapted from Sowa). In this viewpoint, symbols are distinguished from Concepts. However, other models do not propose such a strong separation of concepts from symbols.

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.

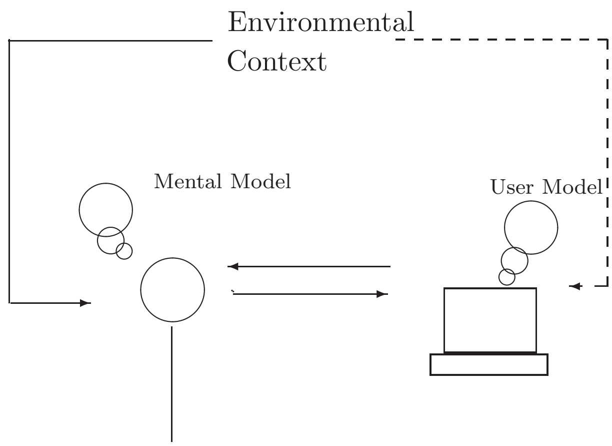

Figure 1.9: In a conversation, each participant between a user and an information system. The user and information system may tailor their responses to each other. Moreover, they may be affected by the environmental context. We would say the user has a mental model of the computer and that the computer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

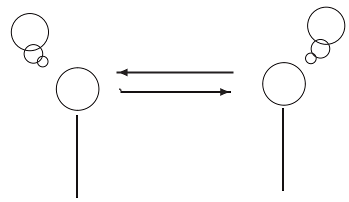

Figure 1.11: Communication is an exchange of information between people, but it does not result in both participants having exactly the same interpretation. One part of the interaction is consideration of the motives of the other participant in the interaction.

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.

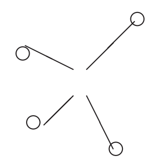

Figure 1.12: Constraint network. (redraw) (check permission)

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.

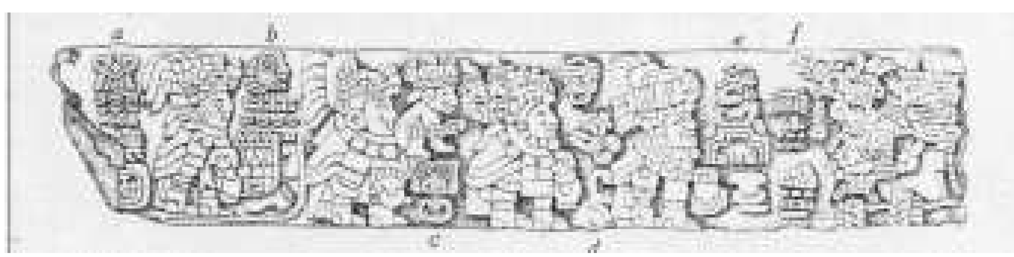

Figure 1.13: Written language is associated with the development of complex social structures. In this case, written Mayan, accompanied urban development in Central America. (check permission)

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.

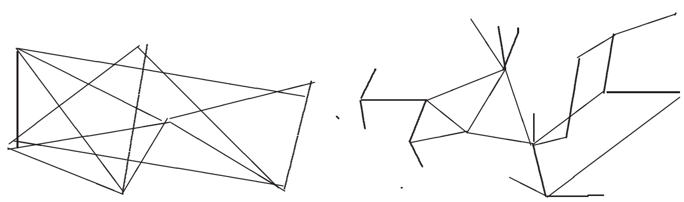

Figure 1.15: A closed system (left) has clear boundaries whereas an open system (right) interacts and merges into its environment. A organization situated in society is an example of an open system in which the external forces of the society affect the organizational processes. (check permission) (redraw)

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).

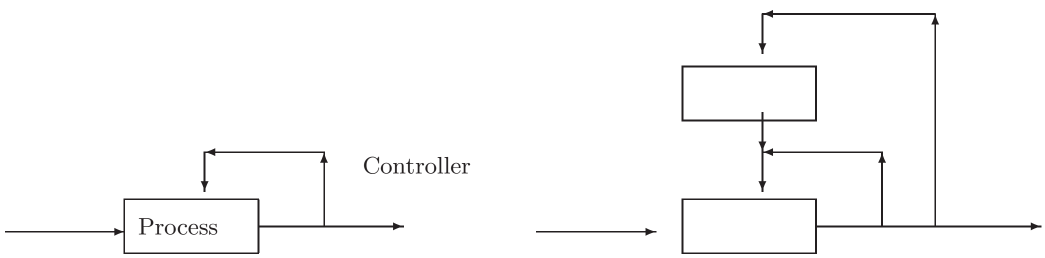

Figure 1.16: Feedback uses the output of a process to affect how to control that process. In simple feedback systems such as a thermostat, the controller has a highly predictable control function. However, many complex systems have adaptively at many different levels. One way that might happen is with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

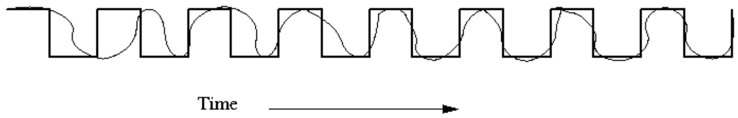

Figure 1.17: Imagine a system that produces a regular pattern (dark line) across time and a model that is trying to adapt to it (light line). The model will be successful at matching the target only if it has an adequate representation and learning algorithms. In this example, by the end of the sequence,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

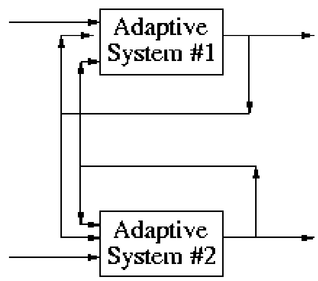

Figure 1.18: Co-evolving systems.

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.

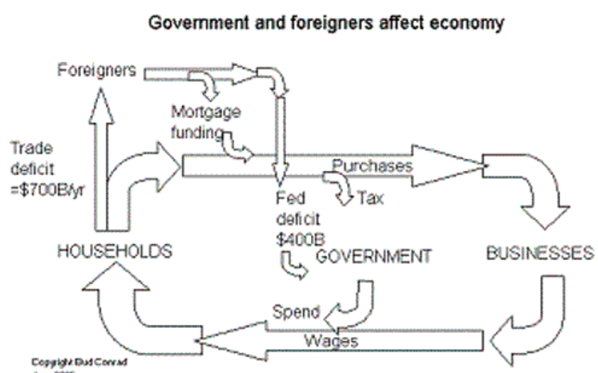

Figure 1.19: A small example of complex system. Complex systems have many feedback loops and non-obvious behavior. Indeed, these systems behave like multi-loop feedback mechanisms. They adapt in a way that maintains the overall stasis; but when change occurs, it is precipitous. (check permission)(redraw)

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 dataflow 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

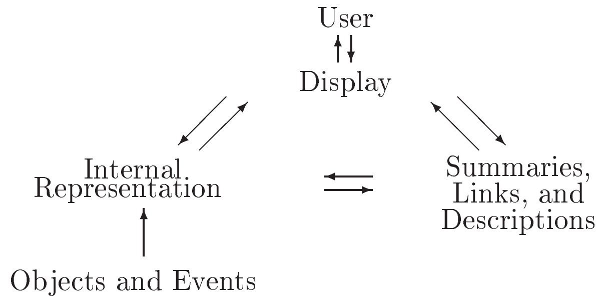

Figure 1.23: Related information resources are collected and aids like summaries, links, and descriptions are useful in retrieval of resources from those collections. Multiple representations.

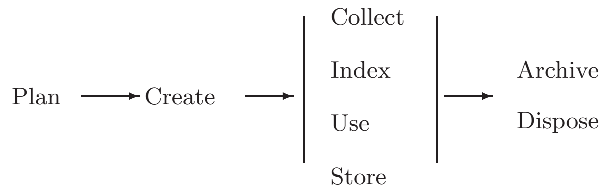

Figure 1.24: Information resources have a lifecycle which starts with planning and ends with disposal of the resource (though a small amount may be kept forever). In some cases, an old version is replaced by newer versions. In a broader perspective, parts of the older documents documents are reused and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

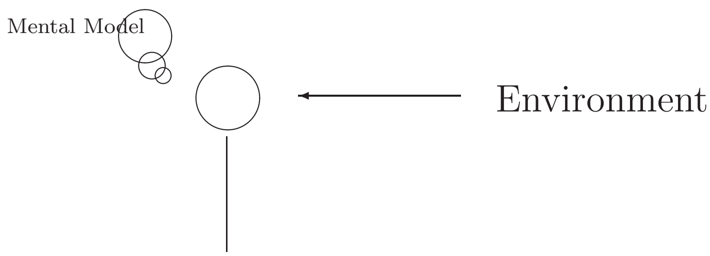

Figure 1.26: People actively interpret what is going on in the world based on their experiences. (Add "action")

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.

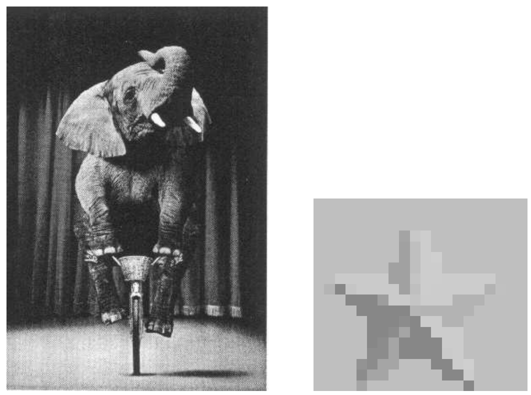

Figure 1.29: An obvious fake[2] (left) (check permission - HP) Other fakes are more nefarious (right) and may be the result of systematic dis-information efforts.

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

G

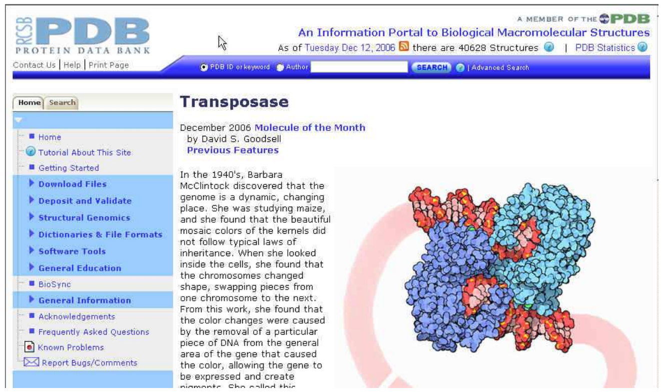

Figure 1.31: The Protein Data Bank (PDB) is a database with many facts about specific proteins. (check permission)

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

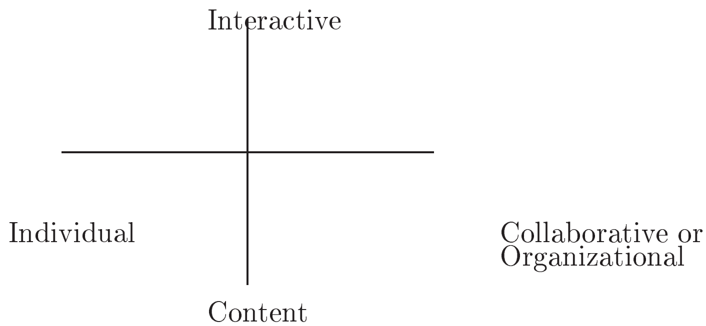

Figure 1.33: Dimensions of information systems.

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.

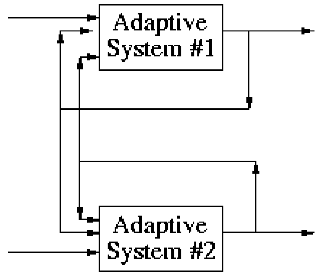

Figure 1.37: Socio-technical co-evolution.

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.

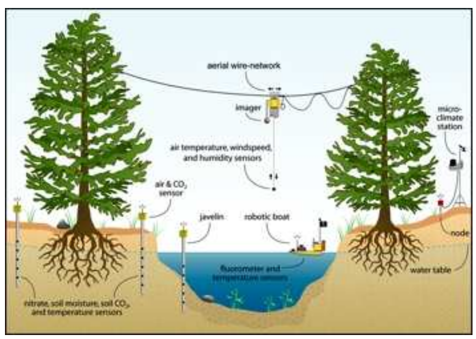

Figure 1.38: Sensors collect information from their environment. Here, a network of sensors monitors conditions in a forest. (check permission) (redraw)

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

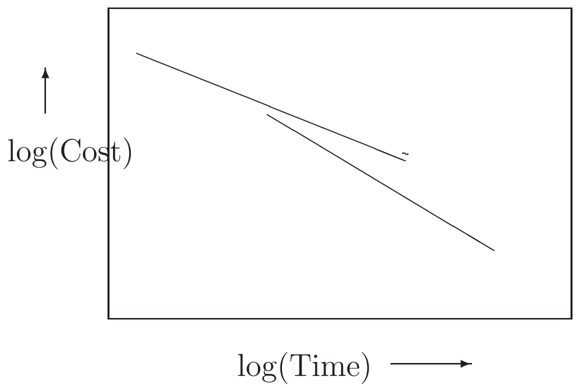

Figure 1.39: The cost per megabyte of storage keeps dropping (adapted from[7]).

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.

Collect representations about the world

Organize and summarize those results

Integrate with other information and beliefs

Apply them to making a decision

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.