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.

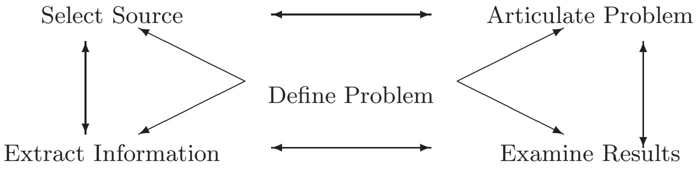


Figure 3.4: A task may also be viewed as problem analysis and information may be gathered and used as needed for the analyses[39].

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.

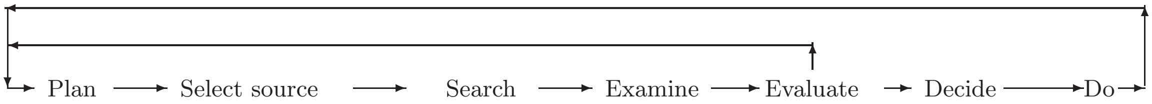


Figure 3.6: In this idealized schematic, the process of collecting information, that is the *Look* part of Look→Decide→Do, is itself a cycle (use IFLA: find, identify, select, obtain).

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.

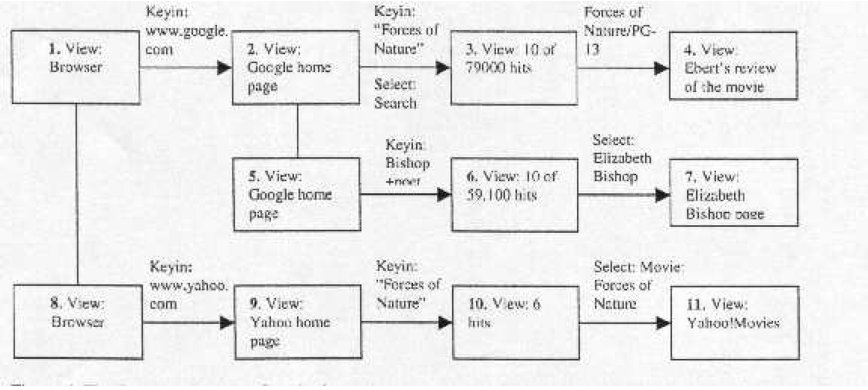


Figure 3.12: This problem-behavior graph trace of search behavior[15]. Actual searches are often non-linear. (redraw) (check permission)

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

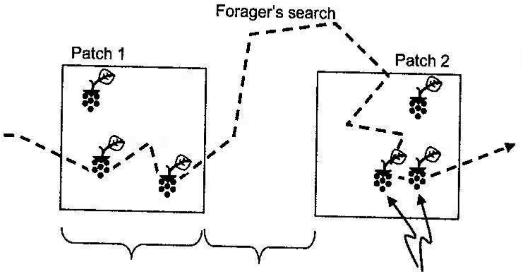


Figure 3.13: Information seeking can be thought of a type of foraging[41]. Thus foraging theory descri how information consumers will move from one information source to other information sources. (redraw)

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).

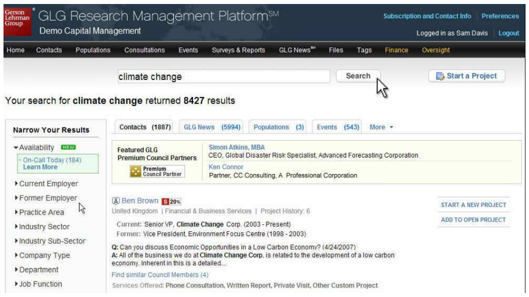
Fig ??.

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".



Your search for **climate change** returned **8427** results

Featured GLG Premium Council Partners

Simon Atkins, MBA
CEO, Global Disaster Risk Specialist, Advanced Forecasting Corporation

Ken Connor
Partner, CC Consulting, A Professional Corporation

Ben Brown
United Kingdom | Financial & Business Services | Project History: 6

Current: Senior VP, **Climate Change** Corp. (2003 - Present)
Former: Vice President, Environment Focus Centre (1998 - 2003)

Q: Can you discuss Economic Opportunities in a Low Carbon Economy? (4/24/2007)
A: All of the business we do at **Climate Change Corp.** is related to the development of a low carbon economy. Inherent in this is a detailed...

Find similar Council Members (4)

Services Offered: Phone Consultation, Written Report, Private Visit, Other Custom Project

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

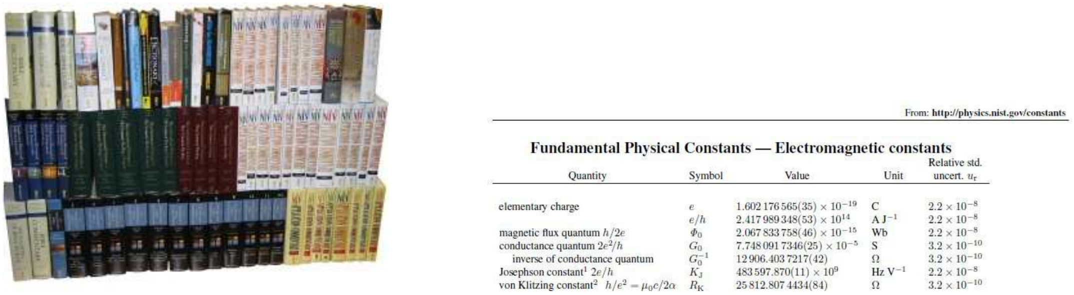
Reference services can be delivered remotely. by telephone, email, or chat. We can call these virtual reference services. The quality of the interaction (e.g., social presence) is affected by the richness of the medium [3]. This can also be a step toward automated question answering (5.6.5) since text 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

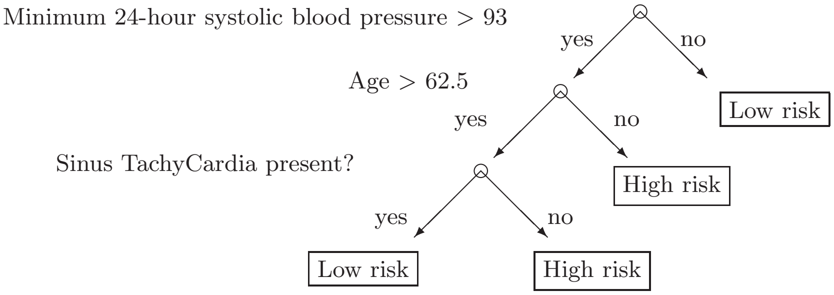


Figure 3.18: A decision tree for a hospital to use for determining a patient's the chance of a heart attack[16].

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).

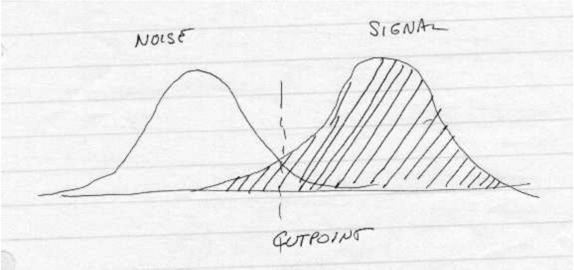


Figure 3.20: A decision may involve finding a signal in a noisy environment. Whether a noise you hear is really your doorbell. A decision cut-point is shown between the two distributions. In the middle, the two distributions overlap and it is not possible to tell the distributions apart. (to be rendered)

		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).

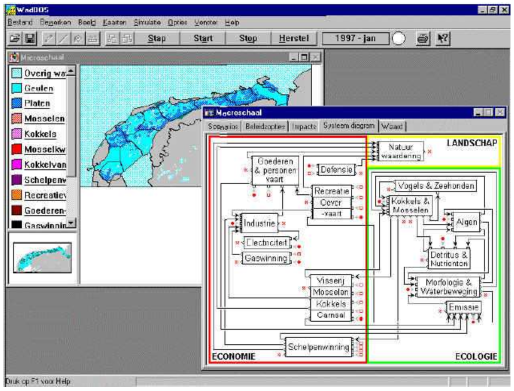


Figure 3.24: A decision support system which models the ecological dynamics of the Wadden Sea[7]. (check permission)

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.

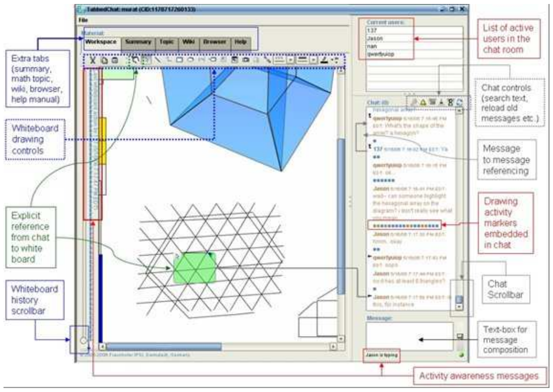


Figure 3.25: A whiteboard interface that allows users to share comments about displayed objects. In this case, it is used by virtual math teams[6].

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.

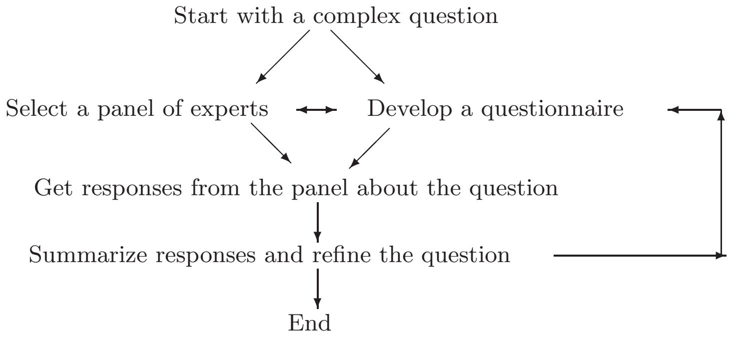


Figure 3.26: Schematic of the Delphi method for analyzing alternative paths in complex problems.

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

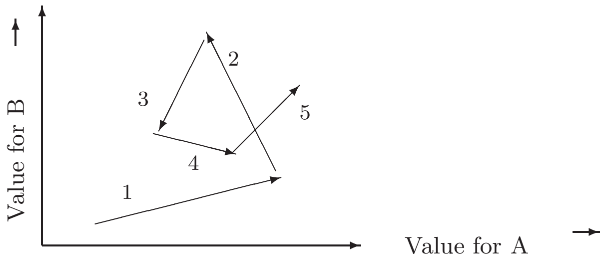


Figure 3.27: Negotiation can be thought of as finding the compromise between the two sides (A and B). In this example, five sets of tradeoffs between those factors are examined. Through negotiation two equalize values of the outcomes The lines indicate reservation values — minimum acceptable values for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

$$\begin{tikzcd}
 & x \arrow[dl, <->] \arrow[dr, <->] & \\
y \arrow[rr, <->] & & z
\end{tikzcd}$$

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).

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

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

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.

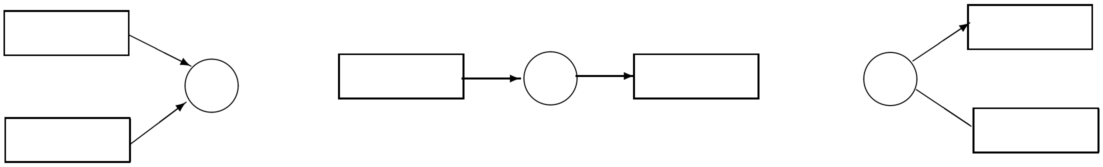


Figure 3.30: Three basic coordination structures (Fit, Flow, and Share) between activities (rectangles) and resources (circles) (adapted from[38]).

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).

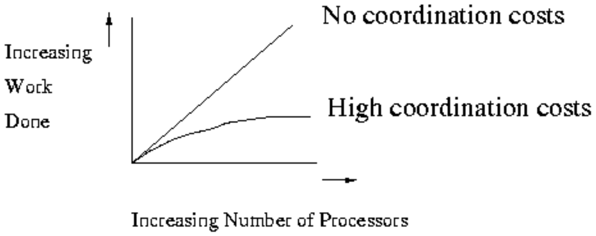


Figure 3.31: Coordination costs affect the amount of work that gets done by a group of processing units – whether people or computers.

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

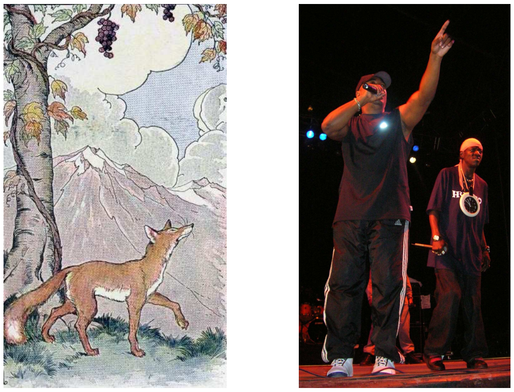


Figure 3.34: Left: The Fox and the Grapes from Aesop's Fables[8]. Right: the Hip-Hop artist Public Enemy. Entertainment can also provide information. (check permission)

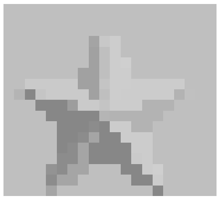


Figure 3.35: Cyber-drama.

(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.

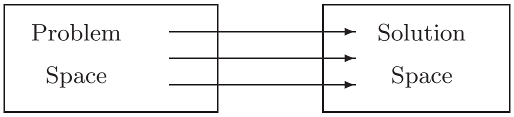


Figure 3.36: Problem solving tries to find a path from the definition of the problem, the problem space, to the range of possible answers, the solution space.

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.

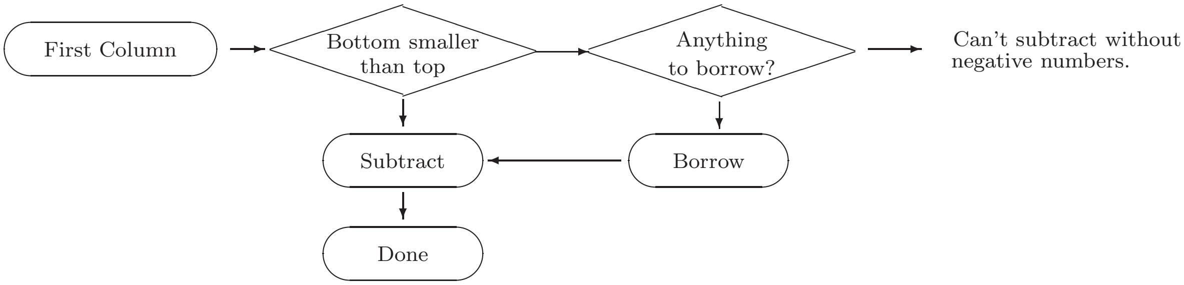


Figure 3.37: An activity diagram illustrating borrowing which is a simple algorithm to do subtraction.

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).

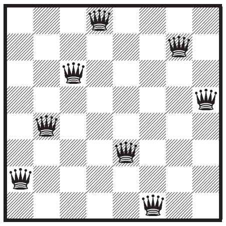


Figure 3.38: The 8-queens problem demonstrates the value of algorithms to solve problems that are very difficult to solver by trial-and-error. The queens need to be lined up so that no two are on the same vertical, horizontal or diagonal row.

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.

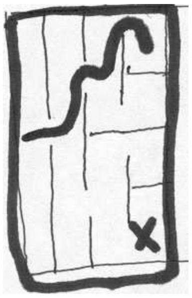


Figure 3.40: A person starting at S and trying to find a target (F) in a maze with a simple tree-like structure might apply a simple rule of always taking the left branch until reaching a dead-end. The person would then “backtrack” to the nearest choice point and try following that with a left-hand rule.

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).

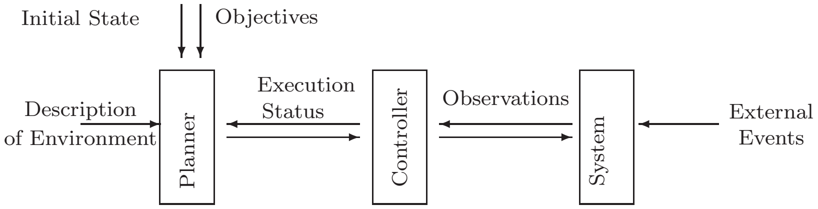


Figure 3.42: Schematic of a dynamic planning system. (check permission)

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.

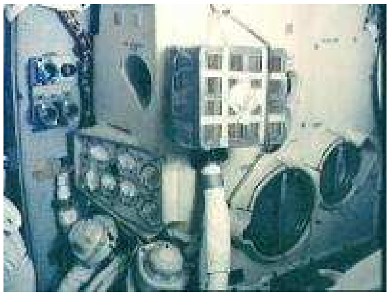


Figure 3.44: "Houston, We've Had a Problem". After the Apollo 13 accident, the oxygen supply for the crew was endangered. A canister was improvised to filter the air.

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.

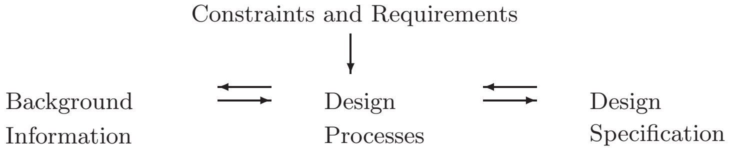


Figure 3.47: There is a tight interaction between the information use and the task activities.

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)

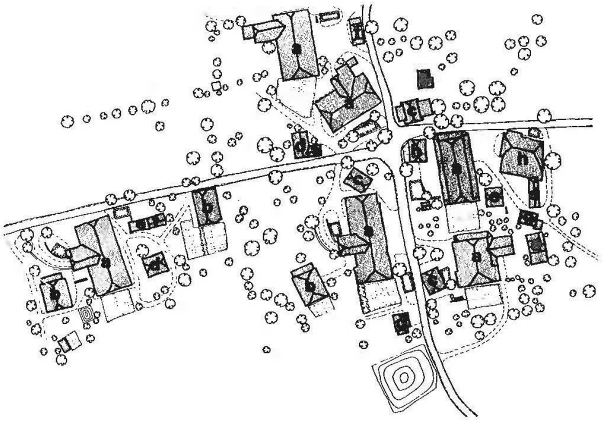


Figure 3.49: Patterns as generative grammars. Here, conventions describing the way traditions for designing homes result in an organic layout in a small village[10]. Organic growth versus over-controlled growth.

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]).

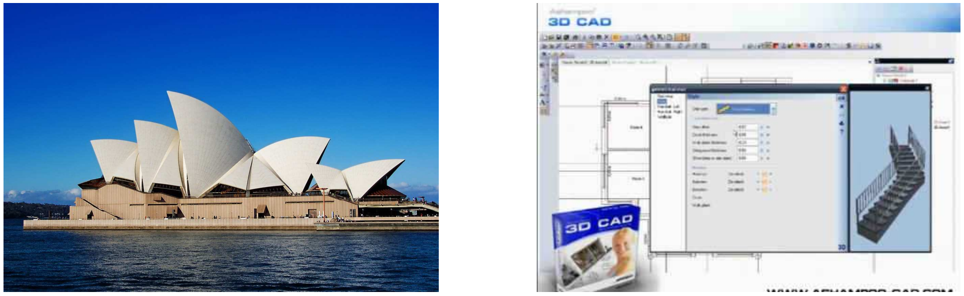


Figure 3.51: Architecture is a type of design. Modern architecture is often implemented with CAD systems. Though, of course, the overall design also needs consider costs and building codes. (check permission)

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.

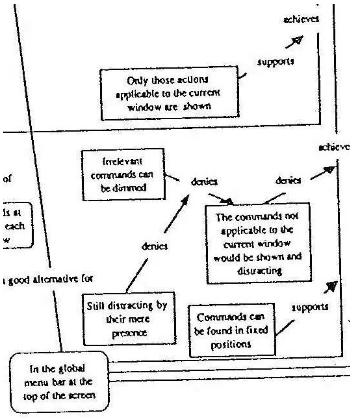


Figure 3.52: Detail of design rationale graphic[12]. (check permission) (redraw)

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.

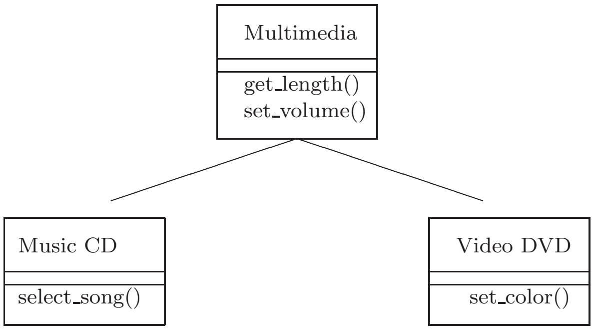


Figure 3.61: Methods may be inherited across a class hierarchy. For instance, controls for playing different types of multimedia objects may be inherited from a generic multimedia class to specific items. Setting the volume would be a property for both CDs and DVDs but setting color would be useful only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

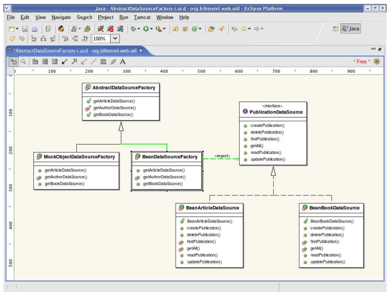


Figure 3.62: UML Class diagram. (check permission)

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.

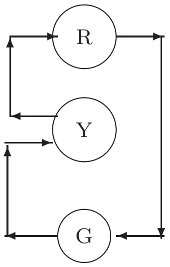


Figure 3.63: A traffic light as a simple state machine. The state transitions occur after a fixed amount of time. (redraw)

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

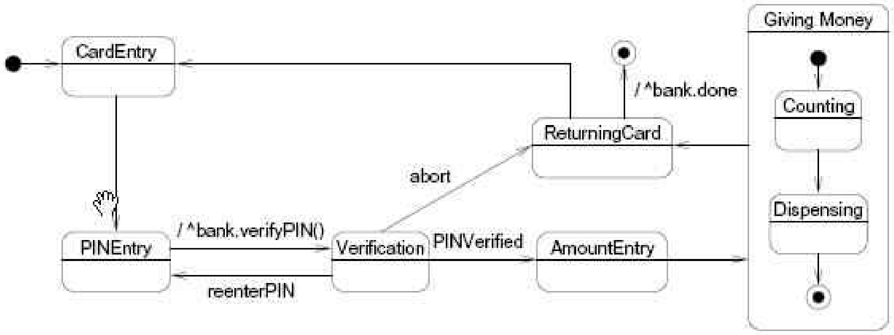


Figure 3.64: State chart for an ATM machine. Note that the start points are indicated with the bulls-eye. Also note that the “Giving Money” state is a hierarchical state with two nested sub-states. (redraw) (check permission)

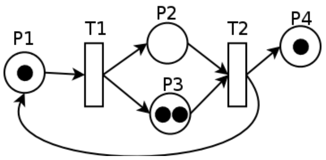


Figure 3.65: Example of a simple Petri Net. All the states preceding a gate must be occupied by tokens before the transition occurs. In this case, the P2 condition has not been met so that T2 is not triggered. These are used in workflow models and are an essential component of UML activity diagrams.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

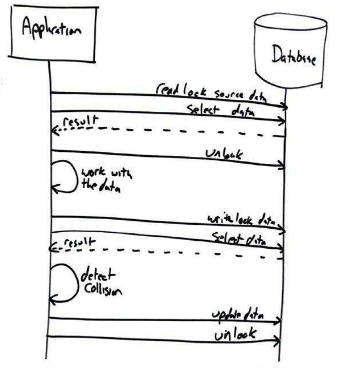


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Figure 3.66: Concurrent streams. (redraw)

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.

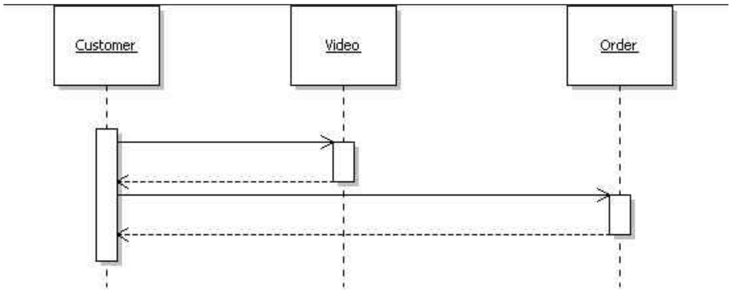


Figure 3.67: Sequence diagrams show how messages are passed among objects. The customer may explore the attributes of a video and how they would place an order. (redraw) (match to previous figure)

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

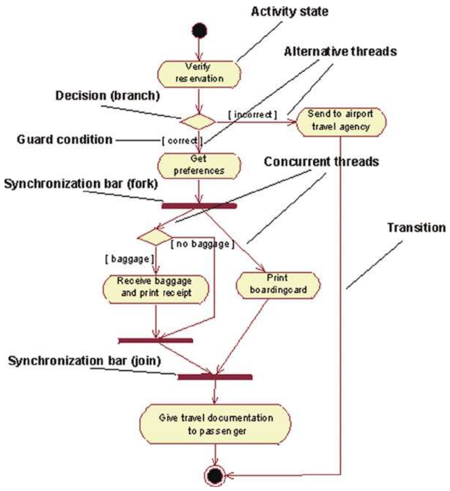


Figure 3.68: An activity diagram is similar to a flowchart, for the steps in a login and command execution (adapted from[28]). (redraw) (check permission)

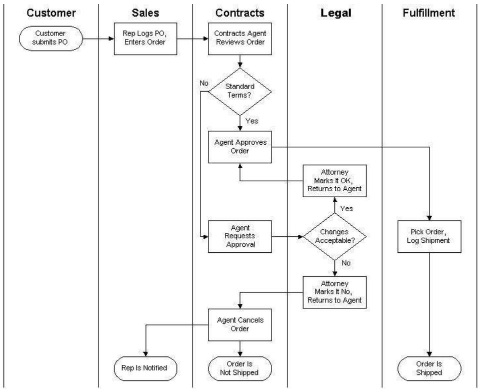


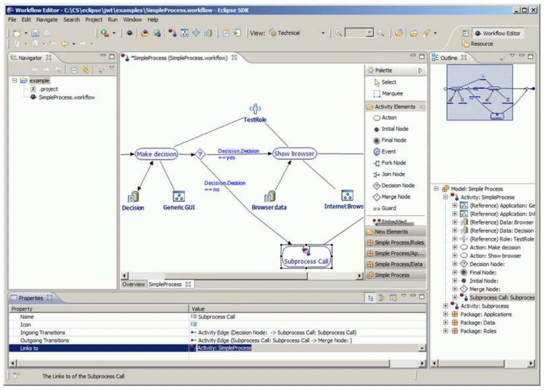
Figure 3.69: UML swimlanes show grouping of activities. (redraw) (check permission)

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)



Property	Value
Name	Subprocess Call
Icon	
Ingoing Transitions	Activity Edge (Decision Node: -> Subprocess Call: Subprocess Call)
Outgoing Transitions	Activity Edge (Subprocess Call: Subprocess Call -> Merge Node:)
Links to	Activity: SimpleProcess

The Links to of the Subprocess Call

Figure 3.70: Workflow editor. (check permission)

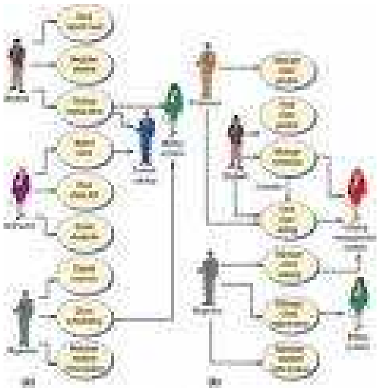


Figure 3.71: We expect that individuals fill specific roles when dealing with a complex system. These roles are known as use cases and they are illustrated with a use-case diagram. (redraw) (check permission)

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.
- Fisher, K.E., Erdelez, S., and McKechnie, L.E.F. Eds. *Theories of Information Behavior.* Information Today, Medford NJ, 2005.
- Ghallab, M., Nau, D., and Traverso, P. *Automated Planning: Theory and PracticesKn.* Morgan-Kaufmann, San Francisco, 2004.
- Gharajedaghi, J. *Systems Thinking: Managing Chaos and Complexity: A Platform for Designing Business Architecture.* Butterworth-Heinemann, Oxford UK, 1999.
- Kuhlthau, C.C. *Seeking Meaning: A Process Approach to Library and Information Services*, 2^{nd} ed., Libraries Unlimited, Westport CT, 2004.
- Jones, W. *Keeping Found Things Found: The Study and Practice of Personal Information Management* Morgan-Kaufmann, San Francisco, 2007.
- Petroski, H. *Invention by Design: How Engineers Get from Thought to Thing.* Harvard University Press, Cambridge MA, 1996.
- Plous, S. *The Psychology and Judgment of Decision Making.* McGraw Hill, New York, 1993.
- Schon, D.A. *Educating the Reflective Practitioner: Towards a New Design for Teaching and Learning in the Professions.* Wiley, New York, 1990.
- Sternberg, R. *The Psychology of Problem Solving.* MIT Press, Cambridge MA, 2002.
- Weick, K.E. *Making Sense of the Organization.* Blackwell Press, Oxford UK, 2001.