

# **THE CONCEPTUAL INDEXING OF CONVERSATIONAL HYPERTEXT**

**Richard E. Osgood**

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# The Conceptual Indexing of Conversational Hypertext

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The Conceptual Indexing of Conversational Hypertext

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# Abstract

## The Conceptual Indexing of Conversational Hypertext

Richard E. Osgood

Linear text limits an author's ability to satisfy the variety of knowledge needs and diverse interests of readers. To solve this problem, hypertext presents text in a non-linear arrangement linked by key phrases in the text so that readers can more easily find passages suited to their needs and interests. However, non-linear reading via hypertext creates two additional problems well-known to researchers in information science. Chief among them is the loss of coherence in reading hypertext linked passages. Also typical hypertext indexing methods are overly syntactic and atheoretical.

To address the coherence problem, this dissertation presents conversational reading and its ASK Michael implementation as a new way to structure hypertext. It describes how text questions can replace imbedded text phrases to better label links between passages and how the categories of a model of conversational coherence can better group these questions for easy reader selection.

To address the unprincipled indexing problem of hypertext, this dissertation describes a step-by-step method for conceptual indexing of hypertext. The question-based method employs a working representation of anticipated reader questions raised by a passage and questions for which the passage supplies answers. Links are generated by a computer assisted, manual matching process of questions raised with questions answered. The 2,000 indices of ASK Michael were generated by the question-based method. In situations where question matching might be impractical, a second conceptual indexing approach is proposed. Based on the AI techniques of frame representation, classification models, and simple inference procedures, a semi-automated indexing tool was developed and tested in several application environments.

This research demonstrates the utility of combining the non-linear design of hypertext with a conversational model and principled conceptual indexing methods to create workable solutions to the problems of structuring and accessing large bodies of information.

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## Chapter 1

# Making Reading Like Conversation

### Introduction

Reading requires a great deal of background knowledge. When the reader does not have the knowledge assumed by the author, comprehension can be difficult. For example, consider the background knowledge required to understand a passage from "The Competitive Advantage of Nations" (CAN), a recent book by Michael Porter (1990):

Heidelberger Druckmaschinen (Heidelberg) was founded in 1850 by the brother of Andreas Hamm. Heidelberg concentrated on sheet-fed presses, introducing a web-fed press considerably later than its competitors. The company rose to prominence when it introduced a significantly improved sheet-fed press in 1914, known as the Heidelberg Tiegel. The press, the first with fully automated paper handling, achieved an output of 2,600 sheets per hour. Printing quality was also improved by the use of a device that allowed higher printing pressure. The superior quality and performance of the Tiegel, Heidelberg's pioneering of assembly line production of printing presses (in 1926), and the early establishment of a worldwide marketing and service network led to success unparalleled in the industry. It sold more than 165,000 units by the time the model was discontinued in 1985; one Tiegel was even worshipped in the Sennshu-den shrine in the city of Kobe.

By the late 1800s, these and other German firms had emerged as world leaders. A gradual process of consolidation began during the world economic

downturn following World War I. ... (CAN, pp. 184-186)

The average adult reader understands most of this passage because he or she possesses knowledge the author presumes his readers have. Among other things, the author assumes the reader knows a great deal of terminology like what a printing press is and how large 2,600 is. He also assumes knowledge of more complex economic motivations like why a company would want to market its product.

When a reader has too little knowledge, comprehension declines, and questions arise in the mind of the reader. Those unanswered by the text slow the reader down. Eventually, he or she can be overloaded, and comprehension can break down completely (van Dijk and Kintsch 1983). For example, suppose a young reader has no grasp of the purpose of a printing press or the business of its manufacture. Most of the Tiegel printing press story will not be understood because the author assumes this knowledge. The reader cannot appreciate the importance of the improvement in paper handling or print pressure. The reader may even miss the overall point of the passage which is the value of innovation and risk-taking in the success of a company.

To anticipate a reader's questions, an author generally tries to include the prerequisite knowledge a reader will need. However, the linearity of the text limits the extent to which an author can do this. Not surprisingly, the author of the book from which the Tiegel press story was taken does not explain the purpose of a printing press at the level a young reader might need. This would be an unwanted digression for the majority of adult readers.

In conversations, unlike reading, the background knowledge problem is mitigated by the participants' ability to ask questions of one another. The answers received provide knowledge at the moment when it is needed. A text can respond more directly to the specific knowledge needs of a reader if interacting with it can be made more like a question-and-answer dialog. Given the static nature of text, however, readers' likely questions would have to be anticipated and answers pre-stored. A reader could choose to read the answers to questions he or she has without having to read answers to other questions he or she does not have. Reading would become non-linear. Somehow, the continuity of the segments of text the reader actually does read would have to be maintained (Kintsch 1974), but if that problem can be solved, non-linear reading could be made as responsive as conversation.

The goal of supporting reading in this way is one of the motivations behind the concept of hypertext (see, for example, Nelson 1967; Conklin 1987; Marchionini and Shneiderman 1988). A basic hypertext system links other passages to phrases in a text that might need explaining. A reader can select the phrase when the explanation is needed. Otherwise, he or she reads on without interruption.

The hypertext answer to the background knowledge problem takes one step toward a solution, but does not go far enough. Its indices are tied too closely to the phrases in the text, and the methods of producing them are atheoretical

(Spiro and Jehng 1990). For example, suppose a passage of CAN uses the term "competitive advantage". Available in other passages of the book are a variety of definitions for the term, a proposed theory of competitive advantage, and applications of this theory to a variety of industries. A phrase-based hypertext link cannot distinguish these options for the reader. As a result, each passage must be inspected to determine its relevance. To be useful to a reader, a hypertext link needs a label that describes enough about the answer for the reader to determine its relevance.

Hypertext needs a theoretically grounded and practical method for producing conceptual links. *Ad hoc* indexing in hypertext is typically accomplished by simply highlighting the key phrases of the text and matching another passage which elaborates the phrase in some way. For example, *ad hoc* indexing of the term "competitive advantage" involves locating another passage that elaborates it. This search should be guided by specific goals to satisfy the likely knowledge needs of readers concerning "competitive advantage", and to be practical, some efficient way to conduct this search must be found. Typically, no explicit model of reader knowledge needs is employed in hypertext indexing (Spiro and Jehng 1990). Should a model be applied, the limited semantics of a hypertext phrase-based link make it impossible to properly label generated links with their intended use. Typical methods for simplifying the search are dependent on the existence of syntactically equivalent phrases in the text. No practical method for determining semantic equivalence is available (See Chapter 2).

The central issue is to develop a conceptual model of the required indexing. Indices should link ideas, concepts, and the implications of the text, not simply its words. Such a conceptual model would help designers of hypertexts to make the connections in the text that readers are likely to need when they have questions. In this dissertation, I present a model of indexing built on Schank's Conversational Association Categories (Schank 1977; Schank 1989; Ferguson, et al. 1992), that solves the indexing problem in hypertext. I show how questions organized by the categories of this model can serve as a useful working representation for manual conceptual indexing and as natural labels for other relevant passages useful to readers engaged in non-linear reading. I also define a useful set of inference procedures based on these categories which can partially automate the conceptual indexing of text. As evidence for the utility of these methods, I describe a prototype system and a corresponding indexing tool for each approach to conceptual indexing.

In this chapter, I present a model of reading comprehension that explains how questions arise in reading and can be left unanswered by linear text. From this problem statement, I show how hypertext with a conceptual model of indexing can solve the knowledge problem in reading by answering many of these questions. I conclude by briefly describing a system, ASK Michael, that implements this model of indexing. I outline the methods used to build the system and propose an alternative indexing approach that may solve the problem a manual indexer has with the magnitude of the indexing task. The



remainder of this dissertation presents a detailed discussion of the ASK Michael prototype, the theory and practice of the manual indexing, the automated indexing approach and its applications, and two types of alternative approaches.

### A Model of Reading Comprehension

Applying prior knowledge and raising questions are the basis of a simple model of reading adapted from the understanding cycle proposed by Schank (1989) and Ram (1989). A person reads in the context of expectations originating from prior knowledge. When a reader's expectations fail, he or she generally draws enough information from the material being read and his or her prior knowledge to infer a satisfactory explanation, one that keeps the comprehension process going smoothly and automatically (Rieger 1975; Schank and Abelson 1977; Wilensky 1978).<sup>1</sup>

Sometimes a reader does not know enough to infer these explanations. When a plausible inference cannot be made, he or she forms a goal to acquire the missing knowledge (Ram 1989; Hunter 1989). This strategic goal manifests itself as a conscious awareness of an unanswered question (*cf.* strategic processes, McNamara, Miller, and Bransford 1991). A question results from the reader's failed retrieval from memory of the knowledge needed for inference. For example, suppose that a reader of the Tiegel press story did not understand the worship of a printing press. Because there is no answer in the text, a reader might form the question:

- (1) *Why would someone worship a printing press?*

In an attempt to explain the worship of the Tiegel press, the reader might consciously try to recall something about Japan or printing presses and infer an answer. If successful, the reader could continue reading with little disruption. Should the reader find no plausible explanation, the unsatisfied knowledge goal might cause a more obvious interruption of the cycle. Assuming it mattered, the reader may puzzle over the unanswered question and suspend reading to search for a plausible explanation. The reader might look back through the passage just read, skim ahead, look in other books or ask people (Belkin and Cool 1993). If successful, the reader would return to the normal cycle of reading. If not, the question would remain unanswered in the reader's memory.

What happens to these unanswered questions? On the surface it appears that a reader forgets many of them. For example, when I first read the Tiegel press story, printing press worship piqued my curiosity. I quickly glanced around the page for an explanation. Finding none, I continued reading, since it did not matter much. A few weeks later, while rereading a section of text about

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<sup>1</sup> See also, psychology research on automaticity (Shiffrin and Schneider 1977; Ratcliff and McKoon 1981) and on automatic processes in reading (Ferreira and Clifton 1986; Greenspan 1986).

why Japan was late getting into the printing press industry, I spontaneously recalled the question and found a plausible explanation for printing press worship. Japanese written language, Kanji, consists of literally thousands of characters and cannot be typeset. The Tiegel is apparently an offset press which does not use typesetting. The Japanese probably worship the Tiegel because it helped them disseminate their culture in print.

Zeigarnik (1927) presents empirical evidence that people do not forget their questions. The evidence from her experiments, which were reported in Hilgard (1956), demonstrate that unfinished tasks are more memorable than completed ones. Birnbaum (1986) uses these findings to support his contention that increased memorability of pending goals is related to noticing opportunities for satisfying those goals. This suggests that as a pending knowledge goal, an unanswered question is saved in memory and actively seeks its own answer.

### The Problem of Unanswered Questions in Reading

Unanswered questions may become a barrier to comprehension (*cf.* prior knowledge in Spillich, et al. 1979). When these comprehension questions are peripheral to understanding the main point of the text, they can be ignored. However, when questions critical to understanding are left hanging, they can accumulate; a text can become incomprehensible, possibly due to the cumulative impact of failed inferences during reading (Stanovich 1986).

Unanswered questions do not always mean the reader is headed for a breakdown of comprehension. Some may also be opportunities to explore issues that may interest the reader (*cf.* interestingness, Schank 1979; Anderson, et al. 1986). A reader may bring prior interests to the text, or the text itself may inspire an interest. These interests may be expressed as questions. When a reader's interest is low, an interest-based question can be ignored. When it is high, a question cannot be left hanging indefinitely by a text without frustrating the reader. For example, suppose a reader was very interested in the printing press as a device. After reading the Tiegel press story, he or she might have some questions:

- (2) *What is a web-fed press?*
- (3) *How does a sheet-fed press differ from a web-fed one?*
- (4) *How was paper handling fully automated?*
- (5) *What method was used to allow higher print pressure?*
- (6) *Who were Heidelberg Druckmaschinen's competitors?*

The reader might be very interested in answers to Questions 2, 3, 4 and 5 and less interested in Question 6. The reader will not suffer a comprehension problem, but may be frustrated or bored, if the author fails to answer, at least, some of them.

An author has a responsibility to answer comprehension questions and interest-based questions in the same text and, therefore, tries to provide background information as well as interesting content to readers. Yet, linear text

seriously limits an author's ability to do so, because an author can address only one question at a time and cannot address the needs of a diverse group of readers.

## Solving the Problem of Linear Text

Linear text limits what an author can do to anticipate and respond to potential questions from the reader. An author may write a passage to answer each question the anticipated reading audience may ask. He or she may even write different versions of an answer to accommodate readers with different backgrounds or interests. However eventually, he or she must settle on a single linear arrangement of these passages, which will be more suitable for some readers but less suitable for others. The author can offer basically only two options to a reader—to read on, or search for something else to read, often with little help from the text.

If the author could lay out passages in an arrangement natural to their function, this problem of lack of choice could be avoided. Some passages function as alternatives and should be arranged in parallel; others are best read in sequence. Sometimes the order in which they are read ought to be left to the reader who often knows best what would be most relevant. Linear text is naturally suited only to sequential arrangements and limits the choices provided to readers.

On the other hand, departing from a linear arrangement requires very careful and informative labeling of the reading alternatives, or it can make matters worse for readers. For example, given a non-linear text, such as hypertext, the reader must decide what to read next based on the minimal information in a hypertext link. After a series of these decisions, a reader may have a sense of being "lost" in the complexity of interconnected passages, because many passages turn out to be irrelevant (Conklin 1987).

The design of a non-linear reading system must avoid this problem, while still addressing the need for choice. Participants in a conversation are able to pursue digressions and questions when these are helpful, without becoming frustrated or "lost". Imagine that when a reader opened a book, the author joined the dialog as a guide to its content. This might improve a reading experience in at least four ways:

1. Supports Question-and-Answer-Based Dialog - As a person reads, he or she may require some background knowledge about something in the text. He or she can turn to the author, ask a question and receive an answer. Assuming an answer exists, a question can be pursued for as long as it takes the reader to gain a good understanding. Reading is not limited to the author's original agenda but becomes *question-and-answer-based*.
2. Maintains Coherence in Non-linear Reading - No matter what the

direction of the conversation, the author can help the reader maintain a coherent understanding of the text. If the reader is unable to understand the connection between an assertion in the text and its supporting detail, the author could give a helpful example or other background knowledge that could bridge the gap in the reader's knowledge left open by the text. Reading this way makes sense, because it would maintain the normal and necessary *coherence* of reading within the non-linear arrangement of the text.

3. Generates Interest in the Content - Occasionally, the author might also point out some interesting sidelights the reader may have missed. Of course, the text itself does some of this, but the author can give more suggestions because he or she is not limited by a linear format. This would help *generate interest* in the content.
4. Satisfies the Interests of Diverse Readers - Finally, with the exception of personal communication, all text is intended for a readership. The author may have knowledge that applies to diverse readers and can include many *interest-satisfying* choices for particular readers.

Many of these benefits can be achieved in a hypertext without the direct involvement of the author. Assuming the author has had the foresight to provide answers to questions the reader is likely to raise, somewhere in his or her text, clever indexing can point the reader to the right passage to answer a question or to satisfy an interest.

### **An Example of a Conversational Reading Interaction**

Here is an example that illustrates these improvements. Suppose that a computer program could answer any question posed by the reader of "The Competitive Advantage of Nations" (Porter 1990). The reader might be reading about the history of the ceramic tile industry:

Italy's ceramic tile production was concentrated in the Emilia-Romagna region, in and around the small town of Sassuolo. In the Sassuolo area, literally hundreds of firms were involved in the ceramic tile industry. (CAN, p. 210)

The reader might immediately think of a couple of questions for the system:

- (7) *Why did the ceramic tile industry develop there?*
- (8) *Why were there so many firms in the same area?*

He or she could ask Question 7 and the system might respond as follows:

Sassuolo was in a relatively prosperous area of the country with many well-to-do farmers and well-paid workers from the machinery industries located

nearby. Many local citizens were able to put together the modest amount of capital and organizational skills required to operate a tile company at the time. A running joke was, "With four people you can play cards. With three you can start a tile company." (CAN pp. 211-212)

The reader receives what is needed to understand the tile story by simply asking a question.

At this point the reader could follow-up with Question 8, or if another follow-up question has come to mind, the reader could ask that. For example, the previous answer might raise the question:

- (9) *What machinery industries were located nearby?*

The system might then answer:

The tile industry benefited from a pool of mechanically trained workers. Emilia-Romagna, and Modena in particular, was home to Ferrari, Maserati, Lamborghini, and other firms with a long tradition of technical sophistication. Many engineers and others gravitated to the tile industry as established firms prospered and demand grew. The president of Assopiastrelle in 1986, for example, started as a technician with Ferrari. In 1959, as the ceramic tile sector was booming, he formed a company to supply machinery to tile manufacturers. Not long after, he managed to purchase a tile company and began manufacturing tiles. (CAN, p. 212)

Finally, the system might suggest some additional questions which might interest the reader. For example:

- (10) *How successful internationally were these tile firms?*  
 (11) *What is so difficult about tile manufacturing that technical sophistication in tile manufacturing equipment confers a competitive advantage?*

This example illustrates how reading might be improved by making it more like conversation in four ways: making it question-and-answer based, coherence-maintaining, interest-generating, and interest-satisfying for diverse readers. Each affects the reader's ability to attend to and learn from a text. Correspondingly, each affects the indexing of a system that implements the approach.

### **Improvement 1: Question-and-Answer-Based Reading**

Traditional reading is largely one-way communication. It can be hard for a reader to pay attention when he or she cannot interact with the author, because text cannot respond personally to a reader.

A linear text does not always address an individual reader's questions as they arise. The author's flow of thought, expressed in a text, controls the flow of thought in a reader. For example, in reading an engaging novel, a reader "enters" the story and is carried along in it. By identifying with a character or visualizing

a scene, the world of the text seems real and interesting. However, a reader can never be completely satisfied because eventually he or she will want to know something the text does not supply. It may be a loose end in the plot that an author never returns to, a missing reminder about some seemingly insignificant event that happened earlier, or an overlooked explanation of a fact mentioned earlier.

A reader remains essentially passive while following the flow of the author's thought. This passivity can inhibit the reader's ability to learn from a linear text. Educational researchers have found ways of making reading more active by coupling it with discussion (Brown and Palincsar 1989), with strong visual support (Bransford, et al. 1992) and with questions and answers (Raphael and Pearson 1985; Paris, Wasik, and Turner 1991).

A *question-and-answer-based* reading system can create an environment in which active learning can occur. Because of its question and answer format, a reader can better guide the system to provide relevant information. Such compliant question and answer systems have been implemented and have been shown to be effective (Graesser, Langston, and Lang 1992; Bareiss and Osgood 1993; Bareiss and Beckwith 1993).

In order to construct such a system, text must be indexed in a new way that will enable a reader to navigate directly via questions. It will be the job of an indexer to decide what the reader is likely to need to know, where the need will arise and where in the text to go to get an answer.

## **Improvement 2: Maintaining Coherence in Reading**

A reader's ability to pay attention depends on the coherence of what he or she is reading. The same is true of conversation. Conversations have a topic and they are coherent as long as participants stay within limits set by the topic and the rules of conversation (Schank 1977). If someone drones on incoherently, other participants in the conversation grow restless and inattentive. Similarly, a reader will become impatient with an author who does not supply what the reader needs or wants to know.

Two key issues are the relevance of the material to the reader and its coherence (*cf.* readability, Weaver and Kintsch 1991). The goal of making reading more relevant for more readers was behind the decision to make text non-linear; but this goal can also adversely affect the coherence of a text. An author maintains coherence by careful attention to the connectivity from sentence to sentence and paragraph to paragraph in the text. But in non-linear reading, a reader may enter a particular passage from a variety of other reading contexts. Because the particular passage cannot be written to connect smoothly to every context that may precede it, continuity and coherence may be lost.

A method is needed to compensate for this potential loss. Normally, the reader maintains coherence by asking and receiving answers to questions that naturally arise in the context of the author's original linear text. That process is usually subtle, automatic, and driven by the coherence implicit in the content.

But where an author feels a difficult transition warrants it, questions to be answered may be explicitly stated in the text. Explicit questions or other explicit descriptions of the author's intent in the text enhance its coherence, because a reader is told exactly what he or she should expect from reading a particular piece of text.

To restore lost coherence in non-linear reading, questions could be explicitly stated in the reading interface, as an author might do in linear text. However, unlike linear text, a reader will have many more of them to sort through in order to find the most relevant one. The questions must be organized to facilitate this search.

Questions could be organized by their relevance to a topic or by some scheme derived from the ways authors have of making text coherent. Topical schemes will not work because they are open-ended and incomplete. However, researchers on the rhetorical structure of language agree that, at least at an abstract level, the kinds of coherent transitions that can occur in text are relatively small (Schank 1977; Kintsch 1982; Murray 1988). These so-called "categories of coherence" (for example, specifics, causes, or results) can be used to organize questions for the reader.<sup>2</sup>

Constructing a *coherence-maintaining* reading system from a linear book is the job of the indexer of the system. He or she must first analyze the content of the text to determine where explicit questions might be raised by readers. The indexer must then classify these questions according to their categories of coherence, so that the reader can find relevant questions and still maintain coherence in his or her interaction with the system. The indexer completes the job by locating places in the text where these questions are answered and by making the connection between them. This provides coherent connectivity from passage to passage for the non-linear reader.

### Improvement 3: Interest-Generating Reading

To attract the interest of a casual or disinterested reader, a text has to tell a reader something unexpected or otherwise get him or her engaged in thinking about something he or she cares about.

A question the reader has not thought to ask can be interesting if it is anomalous in some way. For example, here is an intrinsically interesting question:

(12) *When might it be necessary to fire all your employees to succeed in business?*

This question violates a central premise of a reader's model of how a business functions. A reader can be engaged by a system that shows him or her some

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<sup>2</sup>These categories are a reformulation of Schank's conversational associational categories (Schank 1977; Schank 1989). I present them in detail in Chapter 4.

fascinating questions to ask.<sup>3</sup>

The text can give the reader an unexpected answer to his or her question. For example, suppose the reader has just read about Coca-Cola's dominance of the world's soft drink market in CAN. He or she might raise a question about how it happened and be directed to read a surprising story about how the company became internationally successful almost by accident:

Some companies became established internationally through the war effort. Coca-Cola, for example, set up bottling operations around the world to supply American troops, in response to a request by General Eisenhower designed to boost morale. (CAN p. 305)

An *interest-generating* reading system should offer a reader access to the most interesting parts of the text by posing interesting questions. It should show a reader good questions to ask to motivate an engaging experience of reading. To build a system that can do this, the indexer of the system should mark certain passages of content as intrinsically interesting and label them with interest-provoking questions, so disinterested readers can find them easily.

#### **Improvement 4: Interest-Satisfying Reading**

No book can hold every reader's attention. It cannot be relevant, coherent, and interest-generating for everyone. A linear text is a shared resource and cannot be tailored to any single individual. As a result, to be satisfied with a reading experience, a reader chooses what to attend to in a linear text.<sup>4</sup> When selecting something relevant to read, a reader uses strategic reading skills to break away from the linearity of the text. These skills include skimming for main points, searching for a previously read reference, inferring the text structure, searching indices and headings, reflecting on and synthesizing the elements of content, forming questions and expectations, and making predictions (Brown and Palincsar 1989; Pearson and Fielding 1991; Paris, Wasik, and Turner 1991). These practices all circumvent, to some extent, the linearity of the text. For example, suppose a reader has an interest in understanding the Japanese domination of the consumer electronics industry. He or she might search the book's index or skim sections of text in CAN for relevant material. The reader's interest should maintain the relevance of reading across discontinuous segments of text.

Clearly, one way to improve reading would be to support these reading strategies that a reader commonly uses to pursue a specific interest. Therefore, an *interest-satisfying* reading system should facilitate interest-based, non-linear access to text.

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<sup>3</sup>See Chapter 4 for more information on anomalous questions.

<sup>4</sup>Some interesting attempts have been made to make narrative reading more flexible by giving a reader some options. Among them are the "Choose Your Own Adventure" book series available from Bantam Books. For instance, there are 21 possible paths through "The Deadly Shadow" by Richard Brightfield, Bantam Books, New York, NY. 1985.



Such a non-linear system requires indexing that serves a reader's information gathering strategies. When converting an existing text into a conceptually indexed hypertext system, the indexer is limited to the content available. The indexer must add a great deal of structuring, summarizing, and labeling to the text to enable a reader to pursue a personal interest. As a result, the indexer must endeavor to provide the best support of strategic reader activities that the content will support, including topic lists for locating and skimming the main points, dynamically constructed lists of previously read passages for backward reference, overviews of text structure, as well as conceptual links for questioning.

This dissertation describes a computer program called *ASK Michael*, that implements these four improvements to reading text, and with it, a method called *question-based indexing*, that produces the conceptual indices needed by the system. I have also produced a more automated alternative to the question-based method called *dynamic indexing*, that can index much larger amounts of text. The following sections briefly describe each of these research contributions.

## The ASK Michael Conversational Reading System

ASK Michael is a hypertext based on the text of Michael Porter's "The Competitive Advantage of Nations." It is designed to meet the four requirements for improving a reader's understanding of text. Its central feature for doing so is the conceptual indexing embodied in its links between passages.

ASK Michael's indices are *question-and-answer-based*. Through them, the system engages a reader in a question-and-answer dialog.

To initiate the dialog, ASK Michael presents the reader with several arrangements of topical labels. The reader selects an introduction to or a summary for one of these topics that is of interest and the system displays a relevant passage. These interfaces are called *topical zoomers* and are not designed to answer a specific question; instead, they provide the reader a passage that will orient him or her to the topic. ASK Michael depends on the interaction of the reader with the content of this first passage to create a context for answering reader questions.

To sustain the dialog, ASK Michael presents passages in a reading interface called the *browser*. Through the interface, the reader asks a question relevant to the passage he or she is reading. The system responds by displaying another passage that contains the answer. The reader views the answer and may elect to pursue a follow-up question relevant to the newly displayed passage or to return to the original passage .

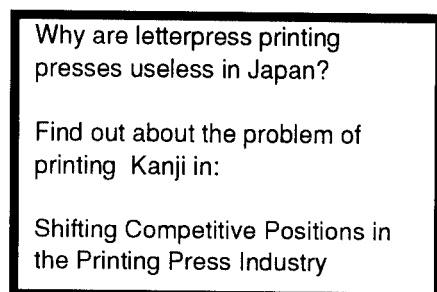
The design of ASK Michael purposefully limits the questions a reader can ask to those that apply to the specific passage displayed for which other passages can supply answers. Because the number of questions that meet these two criteria is small, a free text question-asking capability is unnecessary in ASK Michael.

Instead, the system displays the actual text of questions as a menu of relevant items a reader can elect to ask. Figure 1-1 shows one menu item that applies to a passage in ASK Michael about the different types of printing.

ASK Michael employs explicit questions organized by a classification scheme introduced earlier to *maintain coherence* in the question-and-answer dialog. A reader sees explicit questions in the ASK Michael reading interface as the labels for links to answers (Figure 1-1). These questions give a reader the information required to judge which answers will best maintain coherence of a reading experience.

Sometimes, the text of a question is insufficient to give coherence to nonlinear reading. As discontinuous passages of CAN are read in succession in ASK Michael, a reader may need help with the coherence of the transition between them, because they were not written by the author to fit together. ASK Michael includes with its display of an explicit question raised the main point of the answer passage and some additional bridging text that introduces the text of the answer. Figure 1-1 exemplifies the three components of a question-based link that give coherence to reading across discontinuous passages.

To make locating the questions easier, ASK Michael groups them according to four basic purposes a reader has in asking for information. A question may request: an elaboration of a topic; a causal account of an event, action or state of affairs; a comparison between situations or objects; or some advice about how to apply knowledge. Each purpose can be achieved in two basic ways which are represented in the ASK Michael interface by opposing



Causes

Figure 1-1: An ASK Michael Link

categories. A question about a topic may be elaborated in either more general or more specific ways. A causal account question may concern prior cause or subsequent results. For example, the question in Figure 1-1 is displayed in the "Causes" category of the interface, where most "Why" questions reside. A comparison question may request something similar or dissimilar. An advice question may concern what should or should not be done in a situation. A reader with a specific question selects one of the question

categories and searches the contained questions for the one he or she wishes to ask.

ASK Michael is designed to *generate interest* in its content through its question-based indices. A reader views passages from CAN in the context of the written questions he or she might raise. This menu of displayed questions may suggest interesting questions to a reader that he or she might not think to ask and may lead the reader to some intrinsically interesting text that a reader might otherwise have missed. For example, Figure 1-1 shows an interesting question about a language that cannot be printed by a common type of printing press.

Similarly, when perusing possible reading material before beginning to

read, a reader may not have a specific interest. For example, the question contained in Figure 1-1 can be displayed outside the context of a particular passage in ASK Michael to give potentially interested readers a chance to see what is available that might be worthwhile to read. In addition to the topical zoomers introduced above, ASK Michael has a zoomer that displays intrinsically interesting questions. These questions act as invitations or advertisements to the potentially interested reader.

ASK Michael tries to *satisfy interests* readers have. Readers use their strategic skills to maintain a topical interest in traditional linear reading. ASK Michael functions to explicitly amplify these skills by giving a reader a clear means of following a specific interest from passage to passage. A reader starts to follow a specific interest initially through ASK Michael's topical zoomers, then, through the questions of the browsing interface, and finally, through the backtracking mechanisms of the system. Three zoomers give readers an outline of ASK Michael's topical content. One of these zoomers displays the main points of the content in the original order of CAN. A reader who would otherwise skim the text for main points can browse this list instead. The other two zoomers shows the topics of the system at an abstract level. They provide access to introductory and summary material on the topic and organize the main points of the content of CAN for a reader who wants a more detailed table of contents than is typically provided in a book.

The browsing interface of the system contains links like the one depicted in Figure 1-1. This collection of links includes some with general and others with specific questions related to the content of an immediate passage being read. Questions covering a wide variety of interests can be included assuming content is available to answer them. Because they relate only to the immediate passage, they are limited in number, are easily searched by a reader, and have a clear meaning. As a result, a reader can maintain an interest across passages in ASK Michael by locating and pursuing topically relevant questions.

ASK Michael maintains a record of the names of passages read by a reader to support possible backtracking. The reader may browse this list of names and return to a passage at any time. However, one goal of ASK Michael is to populate its reading interface with enough link alternatives to reduce a reader's need to backtrack. In many instances, a reader can continue with an interrupted passage by asking the next logical question—moving conceptually forward directly from a current passage to the physically prior passage.

All of these improvements to reading implemented in ASK Michael depend on its conceptual indexing with questions.

## **Question-based Indexing of ASK Michael**

To index ASK Michael the indexer self-consciously simulates the activity of a potential reader. In concept pre-reading a text for every possible path through its passages is the desired result. However, this is an impractical approach to its

indexing. Instead, a method was devised for the indexer of ASK Michael to avoid explicitly creating a complex non-linear arrangement directly from an analysis of the source material .

Central to the method is its use of questions as a concise representation of textual material. The role of an indexer is to connect passages using questions alone without reference to the source text. To do this, an indexer first analyzes source material for the major points it makes. The result is the division of a linear text into distinct passages each of which can stand alone as an answer to one main question. These individual passages are classified by general topic and named by the main point of the passage. Each passage is analyzed for the subordinate questions it answers. Together, these *questions answered* represent the potential primary and secondary uses of a passage. Each passage is also analyzed for the questions it leaves unanswered. These *questions raised* represent the potential spots where a reader may want to ask a question. An indexer forms a link by matching a question raised in one passage with a similar question answered in another passage.

The matching of thousands of questions recorded for CAN material was made practical by organizing these questions into groups by topic (for example, about Germany) and by interrogative purpose (for example, requests for explanations). Within each grouping (for example, explanations concerning Germany), an indexer could more easily match questions-raised with questions-answered.

This question-based indexing method was designed to produce a system that would make the four improvements in reading outlined above.

1. Support Question-and-Answer-Based Dialog - Not surprisingly, ASK Michael indexing is itself question-and-answer-based. By analyzing the source material of CAN and recording the questions it raises and answers, an indexer constructs a system that is naturally predisposed to question-and-answer dialog. The question representations the indexer uses become the labels the reader sees in the reading interface. The question raised is typically shown as the first component of a link (Figure 1-1). Any differences between the question raised and the question answered are used to formulate the bridge that occurs in the center of the link. The name the indexer has given to the text segment that answers the question becomes the third component of a link.
2. Maintains the Coherence of Non-linear Reading- An indexer of the system uses the same criteria to assess the coherence of potential connections as the reader uses during reading. Consequently, the categories of coherence which organize the reading interface also organize the matching process of question-based indexing. However, indexing differs from reading in its use of topical categories. In reading, the topical grouping of questions is unnecessary because the content of a passage forms the topical context in which coherence is maintained. In the question-matching part of indexing,

no passage is available to set the topical context. Because ASK Michael indexing relies on question representations alone, it employs topical categories and the categories of coherence to organize matching.

3. Generates Interest in the Content - When an indexer discovers a passage containing intrinsically interesting material, the question answered by the passage is given a special designation. The zoomer that offers this material to the reader is constructed of these questions. Similarly, the indexer includes such questions in the browsing interface when a question match is found for them during the normal matching process.
4. Satisfies the Interests of Diverse Readers - The interests of a readership envisioned by an author are reflected in the topical classification and naming of passages and their question representations produced by an indexer during the analysis of an existing text. Menus formed from the topics and names of passages become the zoomers of the system. Menus of links created by question-matching fill the reading interface with relevant reading options. These zooming and browsing menus satisfy readers with interests as diverse as the content will support.

Question-based indexing represents one practical solution to the indexing problem for an existing text. It is distinguished from other potential approaches by its use of informal representations (questions) for both the incoming and the outgoing parts of a link. However, as the size of a database of passages grows, the process of identifying links via the question-based method becomes progressively more complex. More automation is desirable to keep the process practical. Yet, the informality of questions limits the role of automation in the linking process to searching and sorting by their assigned categories. This drawback was one motivating factor for developing another way to index large quantities of text.

## Dynamic Indexing

As a database of passages grows beyond a certain size (depending upon the degree of interrelatedness), the process of identifying relevant links between passages becomes prohibitively difficult for indexers, who are the content analysts for the system (Bareiss and Osgood 1993). Their job is to generate the questions and produce the links using the question-based method, described above. With so much content to analyze, an indexer experiences a saturation problem. He or she cannot maintain consistency in the composition of questions; and with thousands of questions to manage, an indexer can no longer easily locate matches within the question groupings of the method (Osgood and Bareiss 1993; see also the cognitive overhead problem, Conklin 1987).

The dynamic indexing approach provides automated assistance for

indexers to expand the number of passages they can effectively index before the saturation problem is encountered. An indexer represents a passage in a form that is processable by a computer-based tool. By comparing its representations to that of other passages, the tool infers links between the newly represented passage and other passages. An indexer reviews and approves each link, because the inferred links are not guaranteed correct. The tool that implements dynamic indexing has specific inference procedures for each of the eight kinds of links found in the ASK Michael reading interface.

In this application of dynamic indexing, an indexer is protected from the ever increasing complexity of searching for links as the text base grows. Instead of spending time composing and matching questions in the question-based method, the cost to the indexer is time spent representing a passage and reviewing proposed links.

Automated dynamic indexing was tested in two contexts: a computer supported collaborative writing environment (Schank and Osgood 1993) and a large-scale hypermedia system designed to support military transportation planning (Bareiss and Osgood 1993). In the collaborative application, a reader writes a new passage in response to reading a passage in the system. The new passage is linked only to the passage that inspired its writing. A reader has no practical way of linking his or her new passage to other existing passages. As a result, a pattern of *sparse indexing* emerges in the system, for which dynamic indexing is one solution. In the transportation planning application, the very large size of the story base causes the *indexer saturation* problem described earlier, which makes it a candidate for dynamic indexing.

Dynamic indexing as a solution to the indexer saturation and sparse indexing problems is work-in-progress. Preliminary results are discussed later in this dissertation.

## Summary and Dissertation Overview

A reader's understanding of a text can be improved by providing him or her with access to relevant information at the points in the process where questions arise. Some arise as part of a reader's attempt to understand the text; others arise out of the reader's own interests. Because it is a shared resource for groups of readers, a linear text cannot address the variety of questions an individual may have as they arise.

Hypertext is a technology for organizing non-linear text. It partially solves the problem by introducing links between passages which a reader can use to get answers to more questions. The reader can skip around in the text via these links and is no longer bound to the author's original sequence. Hypertext is not the complete solution, however, because its links are ambiguous and formed by *ad hoc* methods.

The solution proposed in this dissertation is to replace the syntactic model of indexing in hypertext with a conceptual model. Four basic issues are

confronted in the conceptual approach used in ASK Michael:

1. *How can a reader gain access to the knowledge he or she needs to understand a text, given the variability in reader background and the limitations of linear text?*  
By restructuring a reader's interaction with text as a question-and-answer dialog with a non-linear reading system, he or she can gain access to the knowledge needed when questions arise by locating his or her question in the reading interface of the system. Once located, the system responds with a new text passage that answers the question.
2. *Given the number of potential questions a large body of text can answer, how can the options be presented to a reader to keep interaction with the system coherent and minimize the effort required to locate a relevant question?*  
In ASK Michael, an explicit model of the kinds of questions that can arise while reading a specific passage is used to both restrict and organize the questions a reader sees at any one time. Only questions related to a currently displayed passage is presented in the reading interface, where they are organized by a system of categories drawn from a theory of human conversation. A reader selects his or her question from one of these categories and reads a passage that contains its answer.
3. *How will the system engage a reader who has no prior interest in the content of the text database?*  
ASK Michael selects from among the passages of its database ones that are intrinsically interesting. It labels them with questions that are engaging, informative and surprising which are organized in a selection interface by a model of the ways questions can be interesting. A reader can select a question he or she finds interesting from one of these categories and can read an engaging passage.
4. *How will the system satisfy the interests of diverse readers?*  
ASK Michael has been indexed to provide broad coverage of basic topics available in the source text from which it was taken. The system assumes the reader will use his or her strategic reading skills to locate an initial passage of interest through the topical zooming interfaces of the system which are based on these topics. A reader can continue to pursue a topical interest to the extent the content of the system will support such a search through the linkages between passages available in the system's browsing interface.

The research presented in this dissertation contributes to an understanding of the conversation-like function of questions in non-linear reading and in the conceptual indexing of non-linear reading systems, like hypertext. This understanding consists of a theory of questions from which I derive a practical method of manually indexing text, which was used to index ASK Michael, a

hypertext prototype built around the text of an existing book. I have also developed an alternative, semi-automated indexing method, which may prove to be more practical for indexing much larger bodies of text than that of the research prototype.

The remainder of this dissertation develops the idea of conversational reading. In the next chapter, I critique two current computer-based alternatives for improving reading. In Chapter 3, I present an example session with ASK Michael, a non-linear reading system that demonstrates how reading can be made more responsive. In Chapter 4, I propose a theory for the use of questions as indices for non-linear reading. In Chapter 5, I present a methodology for question-based indexing and show how it was used to index ASK Michael. In Chapter 6, I introduce the dynamic indexing approach which solves the scale-up problem of the question-based method. Finally, in Chapter 7, I summarize the contributions of this research and suggest some future directions.

By way of comparison to the ASK Michael approach, many information science researchers are engaged in developing indexing methods to access information and have used them to produce systems that function very differently. In the next chapter, I discuss several of these systems and their underlying models of indexing as they relate to the work presented in this dissertation.



## Chapter 2

# Related Work on Hypertext and Information Retrieval

### Introduction

ASK Michael is designed to improve a reading experience by organizing a reader's search for information using a model of conceptual indexing. Two alternative approaches, previously developed by researchers in information science, share this same goal but are based on different models. In hypertext, a reader navigates through the text by selecting words which have been linked to other passages. In information retrieval (IR), the reader enters key words into the system which then retrieves passages that contain them. To structure reading, each of these alternatives locates relevant relationships between passages based on the words of the text, not its meaning.

As a result of this difference, ASK Michael can address the problems of linear reading described in Chapter 1, in ways these alternatives cannot. However, to build such a system requires that four issues be addressed:

- How to make reading question-and-answer-based.
- How to restore the coherence lost in breaking up a linear text.
- How to generate interest in non-linear text.

- How to satisfy readers with diverse interests.

In this chapter, I discuss the ability of hypertext and information retrieval to address these issues and contrast each alternative with the approach used in ASK Michael. These comparisons will establish a context for understanding the research presented in this dissertation.

Faced with high relative labor costs, for example, American consumer electronics firms moved to locate labor-intensive activities in Taiwan and other Asian countries, leaving the product and production process essentially the same. This response led only to labor cost parity, instead of upgrading the sources of competitive advantage. **Japanese rivals**, facing intense domestic rivalry and a mature home market, set out to eliminate labor through automation. Doing so involved reducing the number of components which further lowered cost and improved quality. Japanese firms were soon building assembly plants in the United States, the place American firms sought to avoid. (CAN: p. 85)

Figure 2-1: A Basic Hypertext Link

## Hypertext and Conversational Reading

Hypertext originated from a simple observation about written language (Bush 1945; Nelson 1967; Conklin 1987; Marchionini and Shneiderman 1988). Written language contains many explicit or implied cross-references. For example, one passage may provide necessary background for understanding another. An indexer of a hypertext simply makes this connectivity explicit in the phrase-based links he or she marks in the text. A hypertext assists with navigation between passages by displaying these links as *embedded phrases* highlighted in the text. By selecting one of them the reader signals the system to reposition him or her for reading another passage associated with that particular phrase.

For example, suppose a person reads the passage in Figure 2-1 in a hypertext system. The bold embedded phrase "Japanese rivals" labels a link to another passage. From the label and the context, the reader knows that the related passage is about the Japanese rivals of American consumer electronics firms. Should a reader wonder about "rivals", he or she need only select the bold phrase, and the system will display a passage related to that topic.

An indexer of a hypertext creates many of these embedded phrase links in an attempt to capture the natural network of content relationships that exist among passages. The indexer's purpose is to give a reader as much control over what he or she reads as possible and at the same time, to make as much potentially relevant content available as possible.

In the first part of this section I review the ability of basic hypertext to meet the four requirements for conversational reading. At the conclusion of this section, I discuss the Point and Query interface (Langston and Graesser 1992;

Graesser, Langston, and Lang 1992), which improves hypertext indexing in a way similar to ASK Michael but uses questions differently.

### Question-and-Answer-Based Reading in Hypertext

The semantics of links in basic hypertext are too impoverished to support a question-and-answer dialog with a reader. First, the hypertext indexer's purpose in labeling text for the reader conflicts with the author's purpose in writing text. The author composes linear text primarily to carry a structured message (for example, a reasoned argument) to the reader (Figure 2-1). In contrast, the indexer wants to circumvent the author's organization by introducing non-linearity in the arrangement of passages. However, phrases that occur naturally in the text are too ambiguous and too limited to label related passages (Thomas and Norman 1990) and do not provide enough information in a link to make navigation sufficiently unambiguous.

Second, embedded text labels make poor cues for reader questions. An indexer knows a reader will have questions and hopes to mark phrases in a text that the reader can recognize as similar to the question he or she has in mind. For example, in Figure 2-1 the indexer marked the phrase "Japanese rivals" to support a reader's question. Here are some possible questions associated with the embedded phrase:

- (1) *Who are these Japanese rivals?*
- (2) *How is it that these Japanese companies became rivals?*
- (3) *Why is there rivalry between U.S. and Japanese firms?*
- (4) *How does this rivalry compare to rivalry in other industries?*
- (5) *What's an example of the use of automation at a Japanese rival?*
- (6) *What else did Japanese rivals do to achieve a competitive advantage?*

Given the ambiguous phrase label, an indexer cannot tell the reader which question the related passage will answer. The reader must actually inspect the indexed text to see which is answered, which diminishes the utility of indexing.

Finally, many implicit relationships between passages cannot be represented by embedded phrases. Implicit relationships among passages occur when ideas and concepts are not concisely expressed in the words of the text but still are implied by it. Such relationships are as important as the explicit ones in the reader's search for information. When an indexer tries to represent an implicit link, he or she frequently cannot find a good phrase to use as a label and must leave it out. For example, after reading the text of Figure 2-1, a reader might have the question:

- (7) *Why didn't American companies automate?*

This question arises from the main point of the passage in Figure 2-1, but there is no obvious phrase in the passage that can serve as a label for it.

ASK Michael solves the semantic problem of hypertext links by including

disambiguating information within the link. An ASK Michael link includes a question that will be answered in the related passage, an informative name for the related passage, and, if necessary, some bridging text to help explain how the related passage answers the question.

### Maintaining Coherence in Reading Hypertext

Freeing the reader from the linear structure imposed by an author can create problems of coherence in reading. Hypertext lacks the kind of principled and well-organized approach to indexing that can compensate for this lost coherence (Conklin 1987; Nielsen and Lyngbæk 1990; Simpson and McKnight 1990; Spiro and Jehng 1990). Embedded hypertext links lack structure (Figure 2-2 and Figure 2-3). They can have no structure independent of their position in the passages in which they occur. The problem this causes for navigating in hypertext is well-documented (Marshall and Shipman 1993) and affects three kinds of reader navigation decisions: recalling past navigation decisions, making current ones, and planning future ones.

First, a reader will have a problem returning to a previously read passage, given the high level of extraneous search for relevant passages that is generally required in a basic hypertext. As a result, a reader has difficulty inferring the implicit organization of the content from navigating within it (Marshall and Shipman 1993). For example, after reading part of the text of Figure 2-2, suppose the reader selects "Japan's economic success", reads the text of Figure 2-3, and begins exploring related passages via some of its links. During this exploration, the reader will see some marginally relevant passages and many irrelevant passages, because of the ambiguity of link labels (Marchionini and Shneiderman 1988). Eventually, the reader will be unable to continue reading the rest of the text of Figure 2-2, because its location has been obscured by the complexity of his

THE RISE OF JAPAN

Japan, the other large defeated nation in World War II, was not far behind Germany in becoming a world economic power. The achievement is all the more remarkable because Japan started behind even Germany in terms of natural resources. It also lacked **Germany's historical positions** in such important sectors as **chemicals** and **machinery**.

The story of **Japan's economic success** has been told many times in recent years. It is a story that usually assigns a starring role to **government** and emphasizes **Japanese management practice**. My own view of Japan's success is somewhat different. Like all nations, Japan has achieved national **competitive advantage** in some industries but has failed in many others. Whatever is happening in Japan clearly does not work equally well in all industries. Management practice alone cannot explain all it has been credited with.... (CAN: p. 384)

Figure 2-2: A Text with Embedded Phrase Links

The Japanese success story is built on **dynamism**. Japanese firms have been pressured into rapid and continual innovation that has often anticipated world market needs. Companies have relentlessly upgraded their **competitive advantages** rather than resting on them. The **Japanese economy** has formed **competitive clusters** and upgraded its **mix of industries**.

The high rate of **capital investment**, rapid productivity growth, and rapidly rising income per capita (shown in **Table 7-1**) are some of the many overall indicators that the process of upgrading is occurring. Equally striking evidence is found in the pattern of export share gains and losses between 1978 and 1985 in competitive Japanese industries, summarized in **Figure 8-3**. Japan had **world export share** gains of 15 percent or greater in more than twice as many industries as losses. The plurality of gains over losses is particularly striking in advanced industries such as **semiconductors / computers, transportation, office products, entertainment and leisure products, and household appliances** (including air conditioning)... (CAN: pp. 417-418)

Figure 2-3: A Second Text with Embedded Phrase Links

or her path through the text. As a result, a reader is unable to backtrack to an alternative path once he or she has chosen an initial path. Instead, a reader must start over from an initial passage (Conklin 1987).<sup>5</sup>

Second, the reader will have difficulty making well-founded navigation decisions, given the inconsistency of link labels in hypertexts (Simpson and McKnight 1990; Spiro and Jehng 1990). In basic hypertext, a reader cannot use an embedded phrase link for navigation effectively when he or she cannot establish a stable meaning for it. For example, Figure 2-3 contains the phrase "competitive advantages". In that context, it may point to a passage that defines the economic concept. Figure 2-2 has the term "competitive advantage" also. There is no guarantee that it points to the same definition or even to a definition at all.

Conversely, the proliferation of synonymous labels makes interpreting them all the harder for a reader. For example, the terms "Japanese economy" (Figure 2-3) and "Japan's economic success" (Figure 2-2) could mean the same thing and refer to the same passage. If they do, a reader might eventually recognize them as synonymous. If they do not, he or she must see them as distinct. When they are synonymous sometimes and distinct at others, a reader simply cannot infer what they point to at all. Because of these label problems, the reader must discover the purpose of a link by reading the related passage.

Third, a reader's sequence of navigation decisions is likely to be an impediment to understanding the text, because embedded phrase labels used in navigating do not inform the reader which related passages are of primary

<sup>5</sup>Many hypertext systems offer a "book mark" or "paper clip" function to allow readers to mark places they may want to reference again. While the function may solve the problem of marking interesting content, it does not solve the backtracking problem. Backtracking to alternative paths requires the reader to decide to identify and mark alternatives before he or she actually has an interest in pursuing them.

importance for comprehension and which passages are secondary. For example, in Figure 2-2, Michael Porter uses the term “competitive advantage” which is arguably the most important term in the book. Without a basic grasp of Porter’s theory of competitive advantage, the reader will not understand the story of Japan’s rise to world economic dominance. Yet, the term is mentioned last in the text. It should be the first navigational choice offered and should be marked as important background, but the embedded phrase index does not permit this.

To summarize, hypertext indices are insufficient to maintain the continuity and coherence of reading, because they are too ambiguous and unstructured. A reader cannot easily find previously read stories, navigate unambiguously to new ones, or rationally order his or her path through a hypertext system’s passages.

ASK Michael solves many of the coherence problems of hypertext. First, its links have less ambiguous semantics and are organized by a categorical model of the kinds of coherence readers expect in reading linear text. Second, its backtracking facilities, which avoid irrelevant navigation decisions, enable a reader to continue reading in a passage interrupted by a side exploration. The less ambiguous labeling of links gives readers a much better idea of the content of a related passage. Finally, the stability of the question categories on each browsing screen of the system assists a reader in finding the most relevant link and provides the cues the reader needs to order his or her exploration of a topic.

### **Interest-Generating Reading in Hypertext**

A reading system should engage a disinterested reader. Basic hypertext has no specific facilities for doing this. It provides its normal linking procedure to the indexer, who can include interesting stories in the content, assuming they exist. However, embedded phrase labels of basic hypertext may be inadequate to explicitly denote the interesting characteristics of an indexed passage. As a result, disinterested readers will find nothing in the system beyond its basic text content to attract their attention.

ASK Michael offers intrinsically interesting questions in both the context of reading and as a means of locating an engaging place to start reading. These questions are found respectively in its browsing interface and in the “Interesting Themes” zoomer designed to present *a priori* interesting topics.

### **Interest-Satisfying Reading in Hypertext**

A reading system should offer material that is of interest to a range of readers. The most obvious solution is to offer a variety of links that are specifically constructed by an indexer to apply to the interests of specific readers. However, a basic hypertext system associates only one link with each embedded phrase (Figure 2-1). No overloading of the index labels for alternative classes of readers is possible. As a result, an indexer has difficulty providing the many alternatives a diverse reading community may need.

Hypertext designers have developed a number of solutions to the problem short of abandoning embedded phrase links. A typical hypertext is loaded with every conceivable linkage between passages to appeal to many reader interests. While no overloading of individual terms is allowed, designers hope that readers will be satisfied with the many choices available to them. Systems constructed in this way become cluttered with too many alternatives, making meaningful choice impossible. Conklin (1987) illustrates his point with a graphical map of nodes in an English literature hypertext implemented in Intermedia. A graphical representation of the Intermedia system is "black" with hundreds of interconnections among passages.<sup>6</sup> While his discussion does not address the issue explicitly, the richness of interconnection is presumably an attempt to accommodate the interests of many readers.

An alternative approach in some hypertext systems is using webs or layers within a single system to reflect reader interests. A web is a set of links for a specific class of users (Garrett, Smith, and Meyrowitz 1986). An indexer constructs a web for each kind of interest envisioned in the reading community. A reader can freely switch between or combine webs to customize a reading environment for his or her specific interests. However, variability among readers does not always cut neatly into distinct classes along the abstract topical lines typically represented by webs. Therefore, a system with this design will often require a reader who defies neat categorization to do substantial amounts of switching between webs to navigate to relevant passages.

ASK Michael breaks with the embedded phrase approach of basic hypertext. As a result, it can represent whatever interest an indexer wishes to include in the system. The indexer may overload one area of text with as many links as necessary to represent the questions that need attention. Even with such overloading, manual browsing of the system's links for reading alternatives is practical for a reader, because the system limits and categorizes its links. ASK Michael displays only links that are relevant to the passage currently shown in its reading interface. It further limits links to those for which related passages are available. It displays its links in eight distinct categories to enable a reader to more quickly locate the most relevant one.

In summary, ambiguous link labels and lack of link structure make hypertext unsuitable for true question-and-answer dialog. Basic hypertext systems do not effectively solve the coherence problem introduced by non-linear reading, and they do little to provide interest-generating or interest-satisfying options for a reader. However, the basic idea of contextualizing links in text is sound. It is fundamental to increased flexibility in reading, but it must be coupled with principled conceptual indexing to succeed.

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<sup>6</sup>Intermedia is a hypermedia browsing and authoring environment developed at Brown University. Its user-defined linking facilities give it the capability of interconnecting text (or other media) as richly as the indexer desires (Yankelovich, et al. 1988).

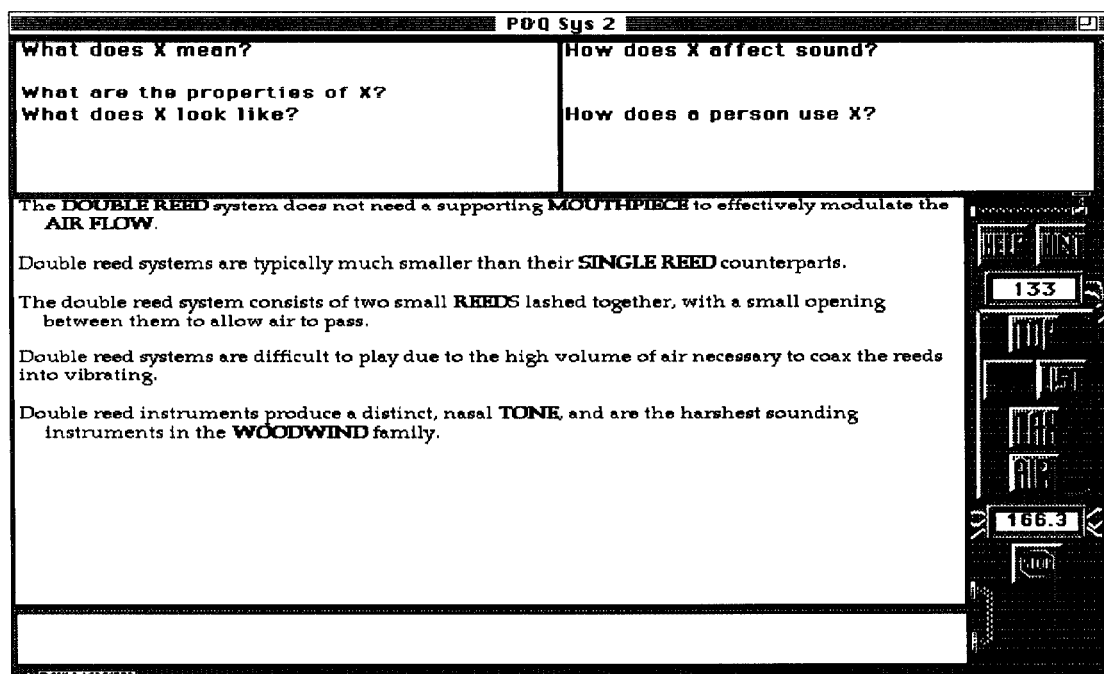


Figure 2-4: The Point and Query Interface

### An Alternative to Basic Hypertext

Hypertext is not a single paradigm. Variations in indexing structure and presentation abound (Conklin 1987; Marshall and Shipman 1993). Basic hypertexts display links as embedded phrases in the text only. Other hypertext systems augment embedded phrases with explicit link semantics. Langston and Graesser's (1992) Point and Query interface (P&Q) displays embedded phrases in one window of text and semantic interpretations of the link associated with each phrase in adjacent windows (Figure 2-4). The P&Q system describes woodwind instruments. By selecting a term in the lower window, a reader signals the system to display relevant general types of questions in the upper windows. The reader then selects one of the questions to traverse a link.

P&Q solves some of the problems with hypertext link semantics by attaching a set of general questions to each embedded phrase. The combination of a phrase and its questions defines a set of unambiguous meanings for the link. In Figure 2-4, the reader may apply any displayed question to a previously identified embedded phrase and receive a concise answer. For example, a reader selects the embedded phrase, "Reeds". The system displays the applicable questions (See Figure 2-4). The reader selects a question to apply, "What does X mean?" The system displays a new text segment that answers the question, "What does 'Reeds' mean?"

The advantage of this approach, in contrast to basic hypertext, is that link semantics are less ambiguous. In most cases, the reader need not browse the related passage to determine its relevance as is typical in basic hypertext. This makes P&Q's browsing facility stronger than a basic hypertext's facility and



reduces its dependence on a powerful zooming facility for navigation. As a result, P&Q provides only a taxonomy of basic concepts (the TAX button in Figure 2-4), a list of key concepts (the LIST button) and an abstract air flow model of a woodwind instrument (the AIR button) for zooming.

However, the P&Q approach does not completely solve the problems of hypertext links. The general questions are limited in number (19 in all) and apply only to the potentially ambiguous noun phrases embedded in the text. There are two primary shortcomings. First, the possible topics and interrogative purposes for questions form a very large set of potential questions. Some questions are too complex to be expressed as templates, for example, "How does the effect of the length of the air column on the tone of a reed-based woodwind like a clarinet compare with its effect in a non-reed-based woodwind like a flute?" or "How do orchestrations balance the tone qualities of the various woodwinds to achieve particular effects?"

Second, the limitations and ambiguity of embedded phrase referents in P&Q transfers to the general question. P&Q cannot represent links between passages where the basis of the link is the implicit content of the passage. P&Q users may have difficulty with ambiguous terms. For example, had the term "key" been used, the general question could not clear up the confusion between "key" on a woodwind instrument and the "key" of a piece of music. The P&Q user relies on the designer of the system to include modifiers in the text to clear up ambiguities—an approach ill-suited to the conversion of an existing text (CAN) to non-linear reading (ASK Michael).

## Information Retrieval and Conversational Reading

Information retrieval (IR) systems differ fundamentally from hypertexts in how a text database is explored. Hypertext is based on a strong distinction between initiating an exploration and sustaining one, while IR systems assume that users can combine several independently initiated queries to produce the effect of an exploration. This distinction is important to the balance among the roles of indexer, reader and system. The IR systems claim is that most search and retrieval of text can be automated with little or no *a priori* conceptual indexing.<sup>7</sup>

Information retrieval technology grew out of the automated text retrieval community associated with the advent of office information systems. The whole impetus for the technology was specific document retrieval, not exploration of text. As large on-line archives of text began to accumulate, office workers required more sophisticated retrieval techniques which led to two basic commitments.

First, designers of IR systems strive for comprehensiveness in recall. Recall measures the percentage of relevant articles in the database that actually appear

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<sup>7</sup>Some IR systems employ indexers to classify articles according to a standard thesaurus of keywords for a domain. These keywords provide a limited set of conceptual indices.

	DATE	TITLE:	AUTHOR:
1	1992	World roundtable: land of falling semicond	Robertson, Jack
2	1992	Rocky road to unity. (coordinated European	Gosch, John
3	1991	Can the U.S. get back in? After losing the	McLeod, Jonah
4	1991	The US wins one in high-tech tv. (high def	Kupfer, Andrew
5	1990	The new, improved color computer.(Comput	Tanzer, Andrew
6	1990	Why NEC has U.S. companies 'shaking in the	Neff, Robert
7	1990	Bigger, wider, flatter, brighter: the key	Carey, John
8	1989	Silicon Valley is watching its worst night	Hof, Robert
9	1989	U.S. gropes for unity on HDTV. (high-defin	Iversen, Wesley R
10	1989	TV or not TV? That's Brannon's question	Shandle, Jack
11	1989	High-definition TV is rallying a digital r	Port, Otis

Figure 2-5: EXAC Query Results List

in the list of results. A very large system may search hundreds of thousands of abstracts (or sometimes the full texts of articles). A goal of IR systems designers is to give users the sense that the system has performed an exhaustive search on their behalf of a whole class of literature and has given them the complete list of articles (or other text units) that are of interest to them.

Second, designers of IR systems strive for precision in retrievals. Precision measures the percentage of what has been recalled that is judged relevant by a user. Within the limits of its database, an IR system can quickly and accurately retrieve any article given an author name, periodical name, title or any other unique feature. With non-unique keyword features precision is lower (Blair and Maron 1985).

Here is an example interaction with a real system, the EXAC Periodical Index, that illustrates the basic functionality of IR systems. EXAC is typical of many information retrieval systems in use in libraries, legal and medical establishments and businesses. Like most IR systems, the EXAC system accepts Boolean queries of the form *keyword Boolean operator keyword ...* where "keyword" can be any word or phrase that occurs in the database and "Boolean operator" can be either **AND**, **OR**, or **NOT**.

Suppose a reader comes to the system with the question:

- (8) *Why do the Japanese dominate the consumer electronics industry?*

EXAC requires a reader to formulate a query in order to explore this question. Through a sequence of sub-optimal retrievals, the reader refines the query until it produces a manageable number of citations and represents the basic topics of the question. The results of such refinement might be the query:

**Japan and Competition and Consumer Electronics**

EXAC returns the entries listed in Figure 2-5, ordered by the date they first appeared in print. After inspecting the abstract for each entry, 10 of the 11 articles listed turn out to be irrelevant. The remaining abstract, shown in Figure 2-6 from article number six of Figure 2-5 is only marginally relevant. While applicable to

Author(s):	Neff, Robert
Title:	Why NEC has U.S. companies shaking in their boots.
Publ. type:	company profile
Source:	Business Week March 26 1990, n3151, p90(3)
ISSN:	0007-7135
Abstract:	<i>Japan's</i> NEC Corp, co-founded by Western Electric Co in 1899, is gearing itself to compete and surpass IBM and AT & T as the world's biggest electronics company by the early 21st century. NEC has grown to become the world's largest chip manufacturer, fourth in computers and fifth in communications. Observers view NEC as a formidable company, the most serious threat to US firms from Japan. However, NEC needs to deal with some problems, such as strife at its highest corporate levels and weakness in mass marketing strategies. NEC is also establishing powerful information networks, dubbed 'C&C,' or computing and communications. In 1990 NEC will spend about \$1.7 billion, or 7 percent of revenues, on research and development. NEC is strong in the area of integrated services digital networks (ISDN) and <i>consumer electronics</i> and is concentrating on updating the company image to match its marketing strategies.
Illustrations:	Despite steady sales gains ... profit growth is slowing. (graph)
Subjects:	NEC Corp.--Management
Abstract:	Consumer electronics--Marketing Electronics industry--Japan Japan
Identifiers:	Electronic Industry; Japanese <i>Competition</i> ; Marketing Strategy; Image; ISDN; Industry-Sponsored Research; Company Profile; Outlook
SIC:	3600

Figure 2-6: Entry Six from the EXAC Query Results List

the topic of the ascendancy of the Japanese industry, the abstract contains no explanation of it.

The reader could continue the search for relevant articles by varying the keywords and Boolean operators. For example, he or she could replace terms like "competition" by semantically equivalent phrases like "competitive advantage".<sup>8</sup>

EXAC is an example of an IR system in its most basic form. Within the IR paradigm, variations in query approach and index representation abound. Some retrieval algorithms use exact matching of terms (the EXAC system). Others use partial matching (Belkin and Croft 1987).<sup>9</sup> To improve precision, some systems give the user the ability to provide information about the relevance of retrievals. When passages are loaded into the system's database, each is assigned a vector of weights that represents the profile of terms used in the passage. During retrieval, the user selects a passage from those the system has retrieved that has high relevance. The assigned vector for this passage serves as a refined retrieval cue to the database. This relevance feedback method is an example of the basic commitment of IR to using automated processing of the words of a text to

<sup>8</sup>This dialog was taken from the Expanded Academic Index (EXAC), an information retrieval system for articles from periodicals available to students and faculty at Northwestern University.

<sup>9</sup>Belkin and Croft (1987) contains a good overview of the diversity of IR approaches.

approximate conceptual indices (Salton and Buckley 1990).

With this background, let's look at IR systems, as exemplified in the EXAC system, in terms of the four requirements for conversational reading.

### **Question-and-Answer-based Reading in Information Retrieval Systems**

IR systems are not designed to engage a reader in a meaningful question-and-answer dialog. System performance is not adequate to sustain the level of relevance a reader requires. The problem appears in the recall and precision of retrievals. These performance measures of IR systems are inversely related (Blair and Maron 1985). As the user attempts to improve the precision of a query, recall is adversely affected and vice versa. For example, in a large-scale database, an incompletely specified query will produce results with high recall and low precision. A user will find it impractical to search manually among the largely irrelevant results for the few relevant items. More narrowly defined queries have lower recall but possibly higher precision. A user may not have access to many relevant entries, which have erroneously been excluded from the results. As a result, a user's question-and-answer dialog with the system quickly becomes tedious, as he or she tinkers with the terms of the probe into which his or her question has been translated to optimize recall and precision.

Another problem is that IR query terms cannot directly represent reader questions. Instead, a reader must guess clever ways of getting the system to give an equivalent result to real questioning. Questions cannot be translated into features for use in Boolean queries without a significant loss of meaning. For example, the query given to EXAC about why the Japanese dominate the consumer electronics industry is a syntactic expression. It does not represent the full semantics of a reader's question.

One especially important aspect of question semantics cannot be represented. Typical IR system query languages cannot express the interrogative function of a question, because all of the words that indicate purpose are excluded from the lexicons of systems. The purpose of the EXAC example question was to retrieve an explanation. Words like "why", "because", "how", "explains", "causes", and "reasons" which indicate explanation cannot be combined with the topical terms of the query. In the event that these terms could be included in a query, there is still no practical method for representing their semantic relationship to the other terms of the query that can capture the meaning of the example question above.

ASK Michael carefully separates the activities of zooming into a topical area and precise browsing to a relevant passage. The system places less demand than an IR system does on its topic retrieval capability and relatively more on explicit question-asking, for which an IR system has very poor support. ASK Michael directly states the question to which the reader will receive an answer in the context of a passage that gives the question relevance. As a result, retrievals are very precise in the system and relevance is assured.

## Maintaining Coherence in Reading via Information Retrieval Systems

IR systems do not address the loss of coherence that accompanies the reading of non-linearly arranged text passages. In fact, information retrieval is not primarily directed at reading, but rather at the more preliminary process of selecting a document to read. If coherence could be assessed in an IR system, it would be a property of the reading pattern across selected entries from the database after a query and across the results of queries. Coherence, of course, should come from reading discontinuous passages related conceptually in the same ways that linear text passages are. Yet, within a list of query result entries, IR systems can support only one kind of relationship. The system extracts only similar articles (sharing identical keyword or full-text phrase indices); no other relationship is possible. Similarly, across queries, a user can only compose follow-up queries that further narrow the initial query. Non-similarity-based relationships of the kind represented by the conversational categories of ASK Michael are inexpressible in IR systems. For example, suppose a user reads an article about Japanese success in the consumer electronics industry. Should a user want a contrasting view of Japanese industry, he or she must form a completely new query using, for example, "Japan's weakest industries". It selects articles unrelated to those selected in the Japanese consumer electronics industry query.

Recently, advocates of IR systems have begun to claim that automated excerpt level linking can be added to IR systems, so a reader can navigate hypertext-style (Salton and Allen 1993). However, the excerpt approach uses the same basic syntactic, automated approach to indexing as previous systems and suffers from the same problems.

ASK Michael has a very different approach to establishing coherence in what it displays to a reader. It retrieves passages for a reader only as they are selected for reading, because there is little need to inspect a passage for its relevance as there is in IR system retrievals. Also, unlike IR systems, the indexer of ASK Michael contextualizes the presentation of questions in the passages that raise them. Relationships between passages are not limited to similarity as in IR systems. Instead, passages can be related by any of the eight categories of coherence presented in ASK Michael's links.

## Interest-Generating Reading in Information Retrieval Systems

IR systems have no special ability to generate interest in a disinterested reader, because of the IR system commitment to automated means for index generation. Generating interest implies indexing that offers the reader something anomalous that he or she does not know to look for (Schank and Osgood 1991). Anomalies cannot be extracted from text by automated means without solving the natural language problem (Birnbaum 1986) and the common sense knowledge problem (see, for example, Lenat, et al. 1990).

The EXAC retrieval interaction is ill-suited to generating interest, because a user has no way to distinguish an interesting anomaly from an irrelevant

retrieval in the list of selected entries. Suppose the intrinsically interesting passage about Japanese worship of a printing press was placed into an IR system. A user interested in Japanese religious practice might query the system with "Japanese **and** worship". Among the hundreds of retrieved articles would be one associated with printing press technology. In its abstracted form a user would not infer that printing presses are worshipped, but that an irrelevant article just happened to contain both query terms. It would probably be skipped as one of the many irrelevant entries that IR system queries return.

As described earlier, ASK Michael offers anomaly-based questions for generating reader interest via manual conceptual indexing. The clear semantics of these links and their direct display in the reading interface give a disinterested reader a way of finding them that a user-initiated query facility like that of an IR system cannot provide.

### **Interest-Satisfying Reading in Information Retrieval Systems**

The query-based extraction of entries from a database of articles cannot satisfy the diversity of reader interests for follow-up or take full advantage of strategic reading skills. Coverage of a class of literature is the presumed strength of an IR system database, where articles to satisfy diverse users will probably be available. Yet, the problems of IR query formation and follow-up questioning outlined above make it virtually impossible to actually pursue a specific interest in an IR system. It is not enough to have the material stored in a database; a reader must have ready access to it which requires conceptual indexing. IR indices derived by automated methods can reflect only the text-based surface features of the material. Articles relevant to a reader's deep or complex interests, as reflected in his or her questions, can be retrieved only by guessing possibly related surface features. These features will retrieve many irrelevant articles.

Thesaurus efforts in various research communities are an attempt to get around this problem. By enumerating all of the key concepts of a domain, and using them to index textual material manually, an IR system can do deep (semantic) feature retrieval using basic syntactic methods. The question is not whether this solves the problem or not, but whether manual indexer time might be better spent on another form of indexing—one that anticipates a reader's likely needs and interests in a particular context.

ASK Michael's conceptual indices support a reader's strategic reading skills. By using its browsing capabilities to reduce the need for precision in zooming, the system can provide a few abstract topic categories in menu form. The menu approach fully discloses the content of the system to the reader making it possible for the reader to better select an area to explore. Using the highly precise direct questions of the browsing interface, a reader can clearly recognize and pursue an interest in a way not possible in an IR system.

In conclusion, IR systems like EXAC do not meet any of the requirements of conversational reading. Question-and-answer-based navigation is impossible

because queries cannot be entered that adequately reflect a reader's questions. The answers received are either imprecise or incomplete. Whether searching the entries resulting from a single query or composing related queries, a user cannot maintain the coherence of multiple related interactions with an IR system, because the semantics of queries are purely similarity-based. IR systems have no special ability to generate new reader interests. Finally, pursuing interests in IR systems is difficult because a reader's interests are poorly represented by surface feature indexing.

## Conclusion

Hypertext and IR systems provide readers with non-linear access to text databases, but have very different means of dealing with the problems created when these databases become large. Basic hypertext uses the passage a reader is viewing to contextualize non-linear reading. The system limits the complexity of options open to a reader by displaying only reading alternatives that have relevance to what the reader has just read. On the other hand, a basic IR system attempts to hide the complexity of reading possibilities by showing a user only those passages that meet his or her selection criteria. In their attempt to provide users access to large text databases, both basic hypertext and IR systems fail essentially for the same reason. *Each ties its indexing to the words of the text.*

Each has its means of attempting to map the words of the text to their meanings to users. However, neither succeeds at extracting the required conceptual information from the text. Hypertext does not extract conceptual information at all. Links are constructed manually from the words of the text. Any semantic interpretation produced by the indexer is lost. Some IR system implementations attempt to map differing word senses to common terms or to use statistical techniques to resolve textual ambiguities. Ultimately, they fail because these methods do not address the key problems of natural language understanding.

Conceptual indexing is the alternative approach presented in this dissertation. The task of determining the meaning of the text extends the role of the indexer over that of basic hypertext or IR systems, but provides the reader with a much better product—one that meets the requirements of conversational reading.

These comparisons with alternative delivery and indexing approaches provide the necessary background for understanding the significance of the ASK Michael approach. To better appreciate this approach, I present an example session with a system that implements it in the next chapter.

## Chapter 3

# ASK Michael: A Conversational Reading System

### Introduction

In Chapter 1, I outlined the problems of linear reading and proposed a non-linear reading solution which depends on a theory of conceptual indexing of text. I have constructed a computer-based reading system called ASK Michael which tests this theory using the text of a published book.

ASK Michael is a computer program that engages a reader in a conversation-like question-and-answer dialog with a text. In Ask Michael, the reader is not tied to an author's linear organization of material, but can instead pursue questions of personal interest as they arise, taking an idiosyncratic path through the material.

Michael Porter's "The Competitive Advantage of Nations" is an excellent choice as a subject for a non-linear reading program, since it contains a wealth of interesting material but is generally considered difficult to read. Karen Pennar, Business Week's economics editor, who reviewed it in 1990, said, "It was a



massive undertaking for Porter and those who helped him—and it's a huge undertaking for anyone who sets out to read it because of its organization." She observed that a reader might get more out of the book by reading those parts of it relating to some specific point he or she was curious about, such as "...why two regions in Italy—Valenza and Arezzo—account for a \$2 billion trade surplus in precious-metal jewelry and nearly half of total world jewelry exports" (Pennar 1990). Michael Porter himself writes in his Preface that individuals in particular jobs will want to read specific parts. For example, "business executives will want to read Chapter 11, which is about the implications of my theory for company strategy" (Porter 1990).

ASK Michael's database contains approximately one quarter of the book's text and figures. This represents over 175 pages of written text—more than enough to demonstrate the effectiveness of conversational reading. Within the database, the text is divided into just under 200 passages, called *stories*,<sup>10</sup> each of which makes a single main point.

ASK Michael is designed to make it easy to find the sections of CAN that are most relevant to a reader through its system of conceptual indices to stories. ASK Michael's indices correspond to questions that the reader can ask for which the system has answers. A reader need only select a question of interest via a graphical human interface to instruct the system to display another passage which answers it.

The stories in ASK Michael's database are linked by the indices into a network of related information. A question raised in one story links it to another story which contains an answer. Each story both raises and answers a number of questions. The cumulative result is a richly interconnected body of textual material well-suited for non-linear reading.

ASK Michael is designed to initiate and sustain a dialog through its human interface. The *zooming* interface in ASK Michael displays options for the reader to choose to begin reading. After the reader has located an initial passage of interest, the *browsing* interface shows the reader which relevant follow-up questions ASK Michael can answer from its database.

ASK Michael conducts its dialog with the reader using a model of human conversation (Schank 1977; Ferguson, et al. 1992; Bareiss and Osgood 1993). The model consists of a taxonomy of the sorts of general "follow-up" questions a participant in the conversation is likely to have at any point. Each of the categories comprising the taxonomy is assigned to a location in the browsing interface. Specific questions that the reader can ask about the current story are organized under each category. The reader asks a question by identifying a question category of interest, then selecting one of the specific questions displayed in that category. The system responds by displaying a new passage that answers the question. New questions relevant to this new passage are

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<sup>10</sup>The term "story" has come into use among researchers at the Institute for the Learning Sciences to describe a unit of media that has coherence and makes a point. It is not limited to narrative, but includes most genres of information.

displayed in the categories of the browsing interface, and the dialog continues.

The taxonomy consists of eight question categories, organized in pairs:

- **Topic Elaboration Questions:** The reader can “zoom in” towards more specific aspects of the topics such as descriptions of objects or examples of situations (the *specifics* category), or “zoom out” to explore the broader context in which a situation occurs (the *context* category).
- **Explanation Questions:** The reader can move back in time or causality to the reasons behind a state of affairs (the *causes* category) or can move ahead to the consequences of a situation (the *results* category).
- **Comparison Questions:** The reader can look for analogies (the *analogies* category) to or alternatives (the *alternatives* category) to the situation described or an opinion expressed in the currently displayed passage.
- **Application Questions:** The reader can receive a warning about what not to do (the *warnings* category) or advice about how to seize an opportunity suggested in a passage (the *opportunities* category).

In this chapter, I discuss two aspects of interacting with ASK Michael. This two part presentation reflects a strong commitment to the different roles of zooming and browsing in the system. I present the browsing interface first, because it illustrates most of the important contributions of this research. I follow-up with a discussion of each of several zooming interfaces provided by the system. I conclude with a description of additional system features.

## Browsing the ASK Michael System

Interaction with ASK Michael begins with the zooming system, which enables the reader to locate an initial story. Once the reader has located this story, ASK Michael presents the reader with the *browsing interface* shown in Figure 3-1.

The browsing interface displays the current story at the center of the screen and provides a reader direct access to other passages that answer questions he or she is likely to have during the reading of the passage. When the reader selects a question, the system shifts the focus to the passage that answers that question, displaying it at the center of the screen. Questions relating to this new passage are displayed around the outside of the screen.

There may be any number of specific questions organized under a given question category, which are displayed as a card stack. Back question cards may be brought forward by clicking on them. Top question cards may be expanded for better viewing and scrolling by clicking on them. When more questions exist than will fit in the stack, scrolling arrows appear which provide the reader access to the undisplayed questions.

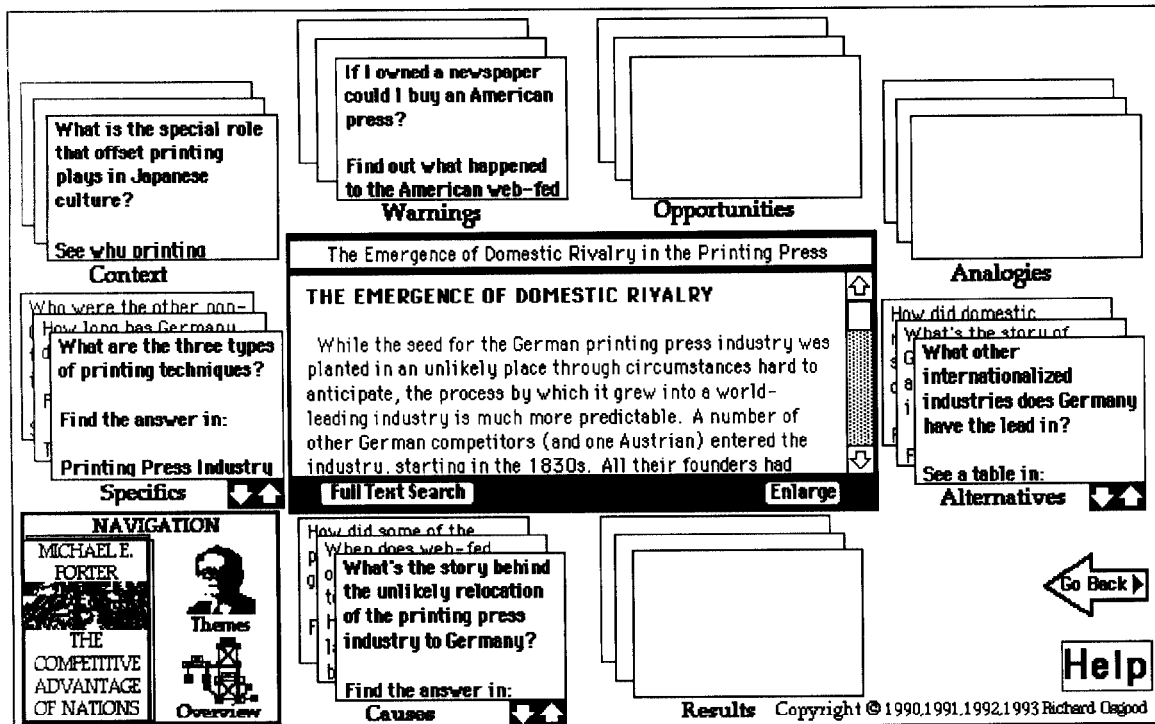


Figure 3-1: The Browsing Interface in ASK Michael

ASK Michael's browsing screen incorporates other features that help the reader to navigate to other content. The reader can view a new passage by double-clicking on a question card containing a question of interest. The Navigation pad in the lower left of the screen provides direct access to the zooming functions of the system, which are described in a later section of this chapter. The "Full Text Search" button provides a keyword/phrase search function across the entire text database. When a match is found, the system replaces the current browsing screen with a browsing screen for the first passage in which the term occurs.<sup>11</sup>

To see how these features enable conversational reading, I now present a scenario of a reader's interaction with the browsing interface of the system. The scenario itself is presented in italics.

### The Browsing Scenario

Browsing begins with reading a passage. As a question arises, a reader looks for an answer among the questions displayed by the browser. A reader may or may not find his or her question there.

*While reading about the development of the printing press industry in Germany (Figure 3-1), the reader becomes interested in knowing why the industry developed in Germany. Since this is a question about causes, the reader searches the "Causes"*

<sup>11</sup>The reader can press the "return" key to step through subsequent occurrences.

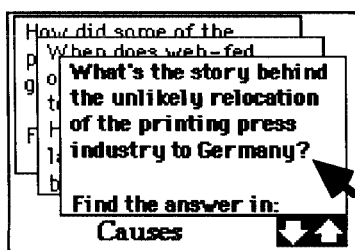


Figure 3-2: A Question Card

category for a question similar to his own question. He locates and double clicks on the question in Figure 3-2 and receives a new passage to read, pressing "Enlarge" to view more of the text (Figure 3-3).

This is a typical example of a basic interaction in ASK Michael. A question that arises in the course of reading a passage is asked and answered with another passage.

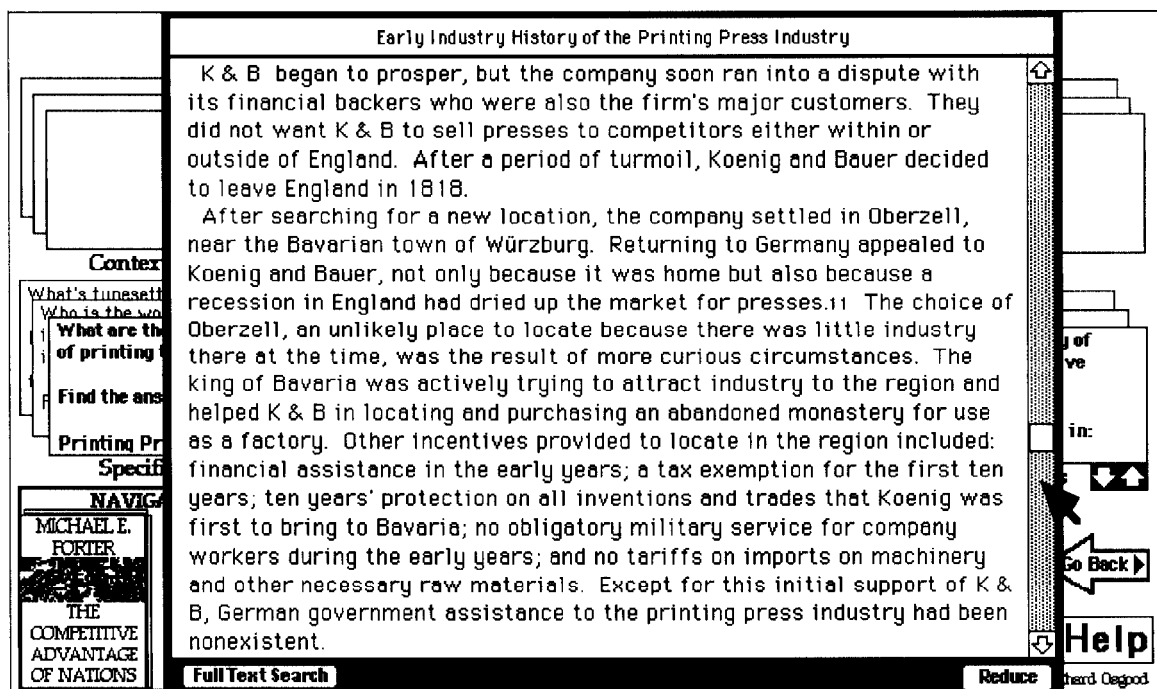


Figure 3-3: The Enlarged Reading Window

*Having read the answer to the raised question, the reader returns to the original passage (Figure 3-1) by pressing "Reduce" followed by "Go Back". Reading on, the reader encounters the passage in Figure 3-4 and wonders why the Tiegel printing press was worshipped in Kobe, Japan. Since this question is also a causes question, the reader again locates the "Causes" stack of questions in the interface (Figure 3-2), and clicks repeatedly on the link scrolling arrows to browse through them. This time, however, the specific question he is interested in asking is not present.*

As this interaction illustrates, it is not always possible for a reader to find his or her question listed among those of the browsing interface. While it is reasonably certain that the system does not contain a passage that directly answers the question, the system may nonetheless contain enough relevant information for the reader to infer an answer.

The categories of the system suggest a strategy the reader can use for

Heidelberger Druckmaschinen (Heidelberg) was founded in 1850 by the brother of Andreas Hamm. Heidelberg concentrated on sheet-fed presses, introducing a web-fed press considerably later than its competitors. The company rose to prominence when it introduced a significantly improved sheet-fed press in 1914, known as the Heidelberg Tiegel. The press, the first with fully automated paper handling, achieved an output of 2,600 sheets per hour. Printing quality was also improved by the use of a device that allowed higher printing pressure. The superior quality and performance of the Tiegel, Heidelberg's pioneering of assembly line production of printing presses (in 1926), and the early establishment of a worldwide marketing and service network led to success unparalleled in the industry. It sold more than 165,000 units by the time the model was discontinued in 1985; one Tiegel was even worshipped in the Sennshu-den shrine in the city of Kobe.

Figure 3-4: The Continuation of the Passage in Figure 3-1

continuing the search for his or her question. A reader with a specific problem to solve will first look for advice (the categories at the top of the screen). Should that fail, he or she will look for a similar situation from which advice may be borrowed (the categories at the right side of the screen). Should that fail, the reader then looks to the causality categories (the categories at the bottom of the screen) to see if sufficient knowledge exists to extract advice from existing explanatory material. Finally, if all else fails, the reader looks to the specific details and the context (the categories at the left side of the screen) of the situation in an attempt to build up enough knowledge to construct plausible advice.

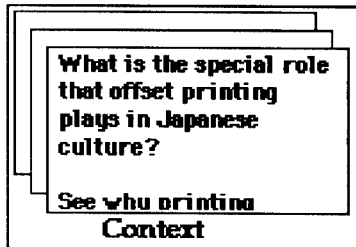


Figure 3-5: Potentially Relevant Question

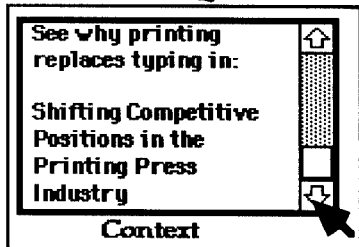


Figure 3-6: Expand and Scroll a Link

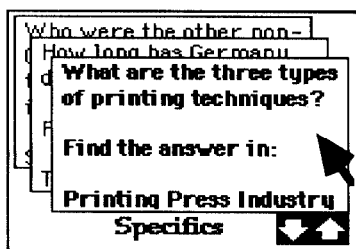


Figure 3-7: A Digression Question

Having failed to find an explanation in the "causes" category, the reader looks to the "context" and "specifics" categories for the information from which an explanation might be constructed. In the "Context" category the reader notices the question shown in Figure 3-5, clicks on it once to expand it, clicks the scrolling down arrow to view the rest of the link (Figure 3-6) and concludes it may have some relevance.

However, the question mentions a kind of printing, "offset printing", which the reader has a question about. Since this is a specifics question, the reader looks in the "Specifics" category and clicks on the question depicted in Figure 3-7. The system responds with the passage shown in Figure 3-8.

After reading this digression about offset printing press technology, the reader has two options: to "go back" or to keep browsing for a relevant question that will lead him or her to the same information via a slightly different path.

The screenshot displays the ASK Michael indexing interface. At the center is a window titled "THE PRINTING PRESS INDUSTRY" containing text about three principal printing techniques: letterpress, gravure, and offset. Surrounding this central window are several floating question cards and navigation elements:

- Context:** A stack of empty boxes.
- Warnings:** A card asking "Why are letterpress printing presses useless in Japan?" with a sub-question "Find out about the problem of printing".
- Opportunities:** A card asking "What's the most successful press ever built?" with a sub-question "See why the Tiegel press built in 1914 was still".
- Analogies:** A card asking "Is there any relationship between printing presses and other sorts of presses, like wine presses, for example?".
- Specifics:** A card asking "Who is the world leader in the printing press industry?" with a sub-question "Find the answer in:". Below it is a "NAVIGATION" section with a portrait of Michael E. Porter and the text "THE COMPETITIVE ADVANTAGE OF NATIONS".
- Alternatives:** A card asking "What kinds of technology are used in the robotics industry?" with a sub-question "Find the answer in:". Below it is a "Go Back" button and a "Help" button.
- Other cards:** "How did early printing?", "How is ink made for a web-fed press made?", and "See what press speeds top-quality paper can withstand in:". Below these is a "Cause" label and a "Full Text Search" button.
- Results:** A "Results" label and a copyright notice: "Copyright © 1990,1991,1992,1993 Richard Osgood".

Figure 3-8: The Answer to a *Specifics* Question

One of the features of ASK Michael indexing is its rich cross-linking of passages, which provides a reader multiple ways of navigating to the same information. Often, a reader may discover a way of continuing with a question interrupted by a search for background information without backtracking, because the background passage raises a similar question.

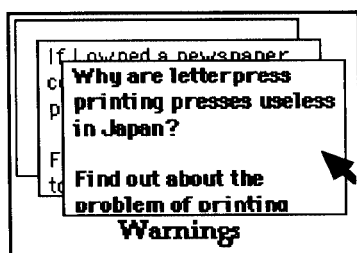


Figure 3-9: Continuing an Interrupted Question

While browsing, the reader notices a "Warnings" question about printing the Japanese language (Figure 3-9). (This question is in "Warnings" because it describes a problem.) From his reading, the reader realizes that there is something significant about press type for the Japanese. The reader double clicks on the question and the system displays its answer (Figure 3-10).

The reader eventually discovers the answer to the question in the text displayed in Figure 3-10. The Kanji language cannot be typeset because it consists of many thousands of characters. The Japanese probably venerate the offset press because it does not require typesetting and was instrumental in the dissemination of their culture in print.

This example illustrates the many avenues open to a reader looking to explore a text via non-linear reading.

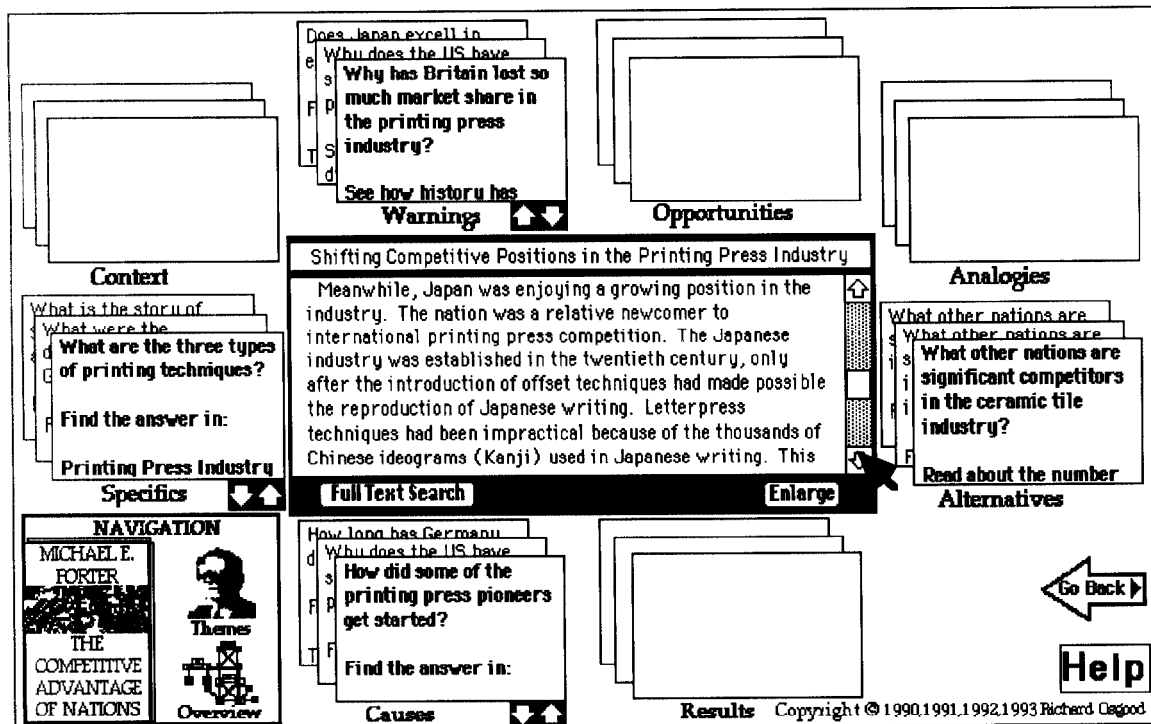


Figure 3-10: The Answer to the Continuation Question

## Zooming in ASK Michael

In this section, I present the ASK Michael *zooming interface*. A reader begins the session with ASK Michael by locating a passage of interest via *zooming*. ASK Michael has four separate zoomers depicted in Figure 3-11. Each zoomer addresses a reader's needs in a somewhat different way. The *View Story Sets* zoomer shows a reader the abstract topical categories which he or she may explore in the system. The *Story Titles* zoomer provides a reader a way of getting directly to a passage of specific interest. It is especially appropriate for a reader who has past experience with the system or more sophisticated knowledge of its content. The *Overview* zoomer provides a reader with a means of exploring the connections between the abstract topical categories of the system. Finally, the *Interesting Themes* zoomer is designed to engage a reader who begins to use the system without a specific pre-existing interest.

A zoomer is not designed to get a reader to the exact passage that necessarily answers a specific question. Rather its task is to get the reader into a region of the database within which likely initial questions and others derived from them will be answered via the more precise process of browsing.

I now present four scenarios that illustrate the function of each of the zoomers.

**Story Titles**

1. Four Studies in National Competitive Advantage
2. The German Printing Press Industry
3. Printing Press Industry Technology
4. Considerations in Buying a Printing Press
5. Chronology of Technological Developments Since World War II
6. Early Industry History of the Printing Press Industry
7. The Emergence of Domestic Rivalry in the Printing Press Ind...
8. The Strategies of German Printing Press Competitors
9. Specialized Factor Creation for Printing Presses
10. Sophisticated Home Demand for Printing Presses
11. The German Printing Cluster
12. Shifting Competitive Positions in the Printing Press Industry
13. Flexographic Printing Technology
14. Danger Signals in the Printing Industry
15. Summary of the German Printing Press Industry
16. The American Patient Monitoring Equipment Industry
17. Patient Monitors
18. The Patient Monitor Market
19. Patient Monitoring Industry History
20. Anticipatory U.S. Demand for Patient Monitors
21. Maturing Demand for Patient Monitors
22. Contrasts in the US and World Demand for Patient Monitors
23. Recent Technological Improvements in Patient Monitors
24. Internationalization of Patient Monitor Technology
25. Development of the U.S. Patient Monitoring Industry
26. The Emergence of European Competitors in the Patient Monit...
27. The Emergence of Japanese Competitors in the Patient Monit...

**ASK MICHAEL PORTER**  
about the  
**COMPETITIVE ADVANTAGE OF NATIONS**

**Manufacturing**

- Printing Press Ceramic Tile
- Patient Monitor
- Robotics

**Services**

- Engr & Const
- Auctioneering

**Postwar Nations**

- Postwar US Switzerland
- Sweden
- Germany

**Interesting Themes**

**Overview**      **View Story Sets**      **Help**

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Figure 3-11: The ASK Michael Main Zooming Interface

### The View Story Sets Zooming Scenario

One way to access a hypertext initially is by *topic*. ASK Michael provides a reader with a limited selection of very general topics in its "View Story Sets" zoomer. Once an initial topical selection has been made from the icons of the zoomer, the system provides three options to the reader via a pop-up menu (Figure 3-12): to view an introduction to the topic area, to receive a summary of available topic content, or to select from a menu of subordinate topics. The "Introduction" option presents a basic background passage to a reader with a vague interest in a topic. The system's browsing interface displays this passage and also shows the reader some good questions to ask. The "Summary" option provides the reader seeking to locate a specific question with a passage in which he or she can preview most of the sub-topics in a topic area. The browser presents many specific questions on the topic that may match the reader's question. With the "Names" option, the reader can navigate directly to a specific passage via a menu of the names of passages within that topic area. (See the discussion of the "Story Titles" zoomer for more detail.)

*The reader wonders whether the U.S. has a printing press manufacturing industry. The reader presses "Printing Press" in the "View Story Sets" zoomer, releasing the mouse button with the cursor over "Summary" as shown in Figure 3-12. The system responds with the browsing screen depicted in Figure 3-13.<sup>12</sup> The reader reads and*

<sup>12</sup>The screen shown in Figure 3-13 is ASK Michael's browsing interface described earlier in this



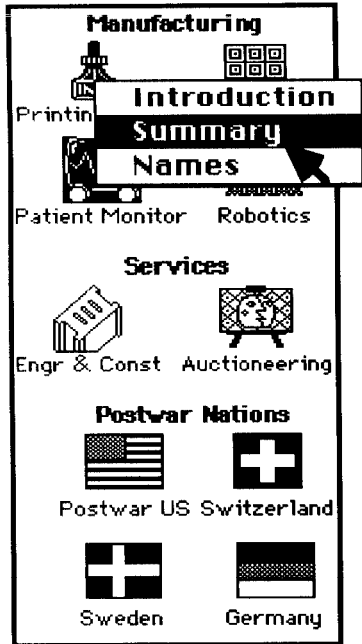


Figure 3-12: View Story Sets

scrolls the text (center of Figure 3-13) until encountering the portion shown in Figure 3-14. The reader notes the problems in the U.S. printing press industry introduced in the passage.

Wanting to know more, the reader examines the questions displayed in the browsing interface (Figure 3-13), notices the question in Figure 3-15 and double clicks on it. The system displays the passage in Figure 3-16.

Zooming and browsing often combine to help a reader locate an answer to a specific question. The browsing interface in which an introduction or summary appears organizes a menu of follow-up questions a reader might raise. Because of the topic elaboration function of an introduction or a summary passage, the questions it raises can provide more precise entry into the content. The reader selects a text question similar to his or her question from the browsing interface, and the system provides an answer by displaying a more directly relevant passage.

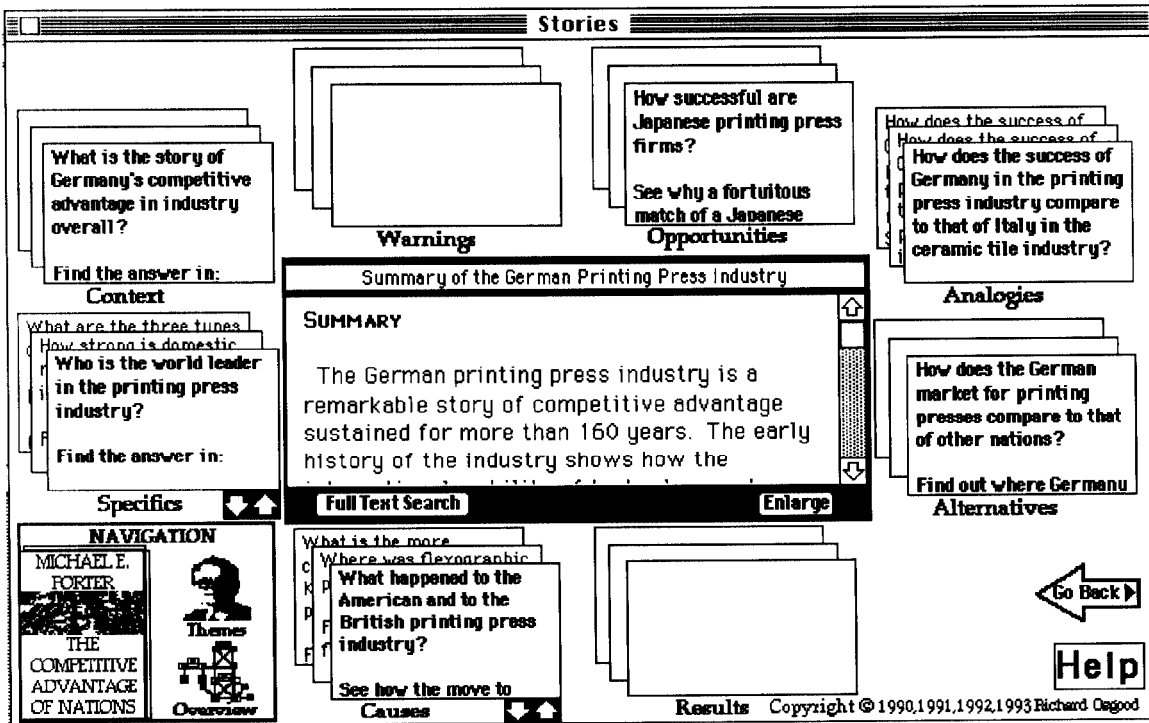


Figure 3-13: An Industry Summary

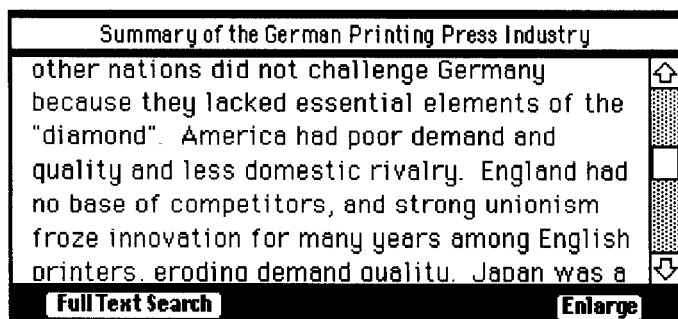


Figure 3-14: The Scrolled Summary

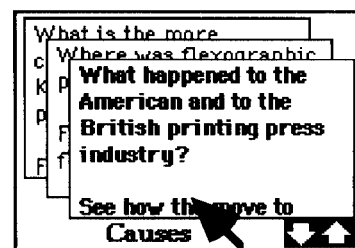


Figure 3-15: A Question to Refine a Zoom

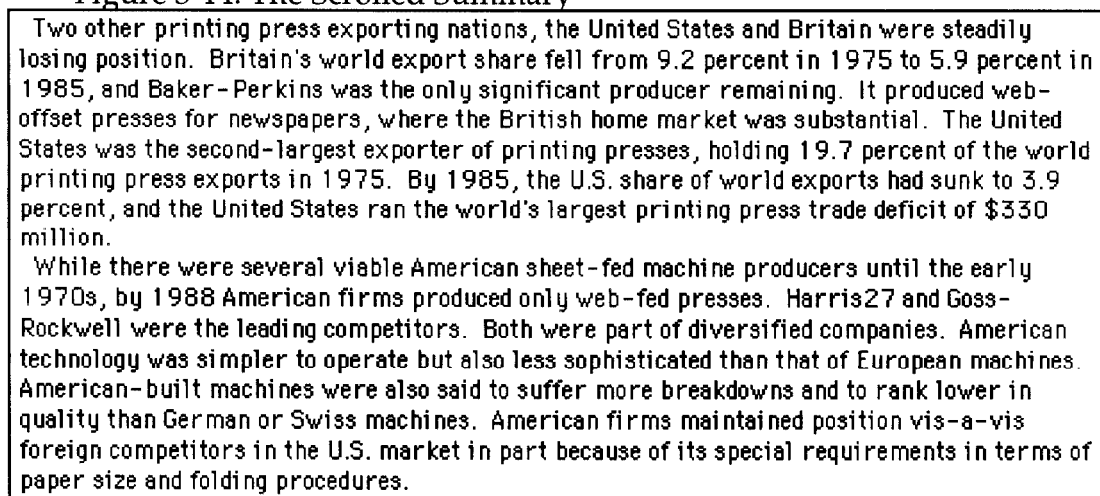


Figure 3-16: The Result of a Refined Zoom

### The Overview Zooming Scenario

The overall structure of the information provided in CAN is only partially reflected in the hierarchy of topics contained in the "Story Sets" zoomer. Relationships also exist across parts of the topical hierarchy. For example, the section on the printing press industry is connected to the other three industries with which it is compared in Chapter 5 of CAN and, secondarily, with the story of German competitive advantage (Chapter 7 of CAN), the nation which is the author's focus in the press industry section.

The "Overview" zoomer is designed to show the reader primary and secondary *topic relationships* inherent in the content of CAN.

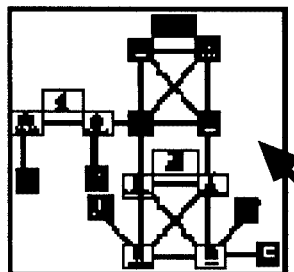


Figure 3-17: Overview

*The reader is interested in the broader context surrounding the printing press industry. Beginning again with the main zooming interface of Figure 3-11, the reader selects the "Overview" zoomer by pressing "Overview" (Figure 3-17). The system responds with the zooming screen depicted in Figure 3-18.*

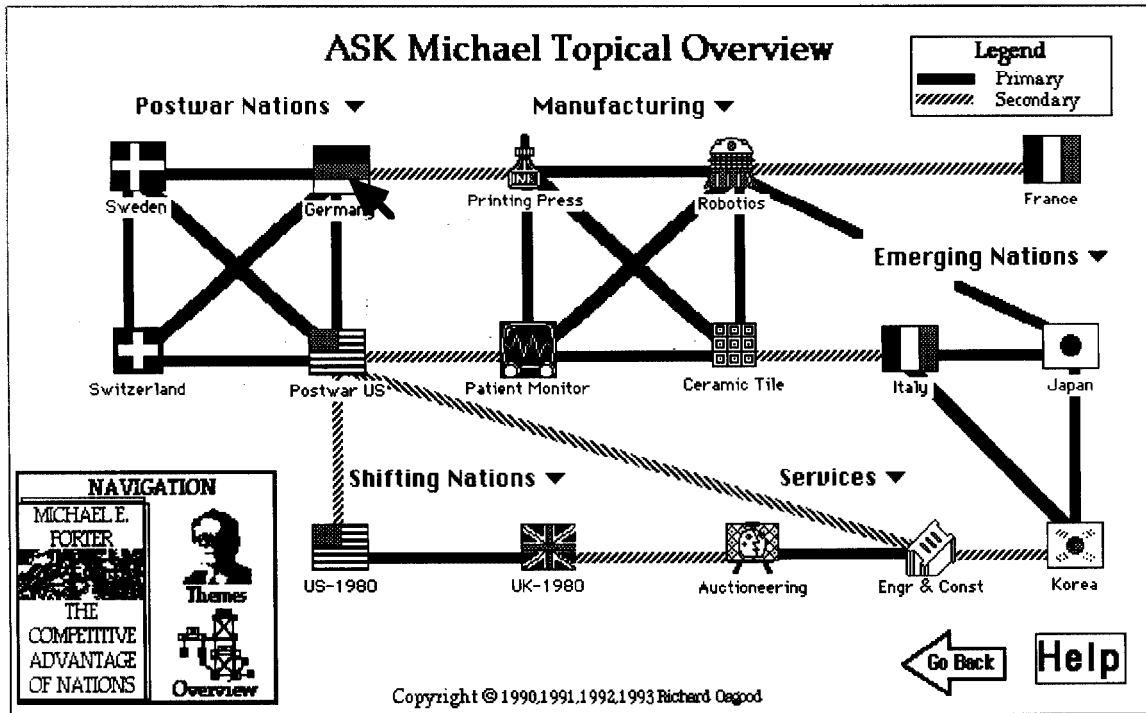


Figure 3-18: The Topical Overview Zoomer

The interface in Figure 3-18 represents the entire content of ASK Michael at an abstract level. The links shown in the diagram depict the explicit and implicit relationships of the content. The primary relationships in the diagram depict the strong connectivity and explicit structure of the CAN text as written by Michael Porter. The secondary relationships show the reader the implicit connections in the content as determined by indexers during construction of the system. At each node of the diagram, the menu of options shown in Figure 3-19 is available to guide the reader's descent into the passages of ASK Michael.

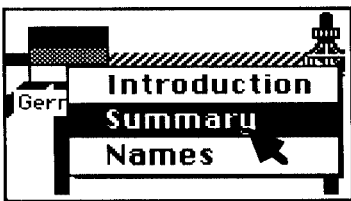


Figure 3-19: National Summary

*The reader selects "Summary" from the menu that appears after clicking on "Germany" (Figure 3-19), because of its link to the printing press industry. The reader presses "Enlarge" and reads the passage depicted in Figure 3-20 to broaden his understanding of German competitive advantage beyond that of the printing press industry. From here, the reader may pursue his particular interests by browsing.*

### The Story Titles Zooming Scenario

The "Story Titles Zoomer" provides a zooming function for a reader who wishes to refer back to a passage by name, or who prefers to scan the individual passage titles contained in the system. The story titles, each of which was assigned by the indexer during the construction of the system to reflect the main point of a passage, offer a greater level of *topic detail* to the reader than the typical table of

Germany in Perspective

**GERMANY IN PERSPECTIVE**

Germany has had unusual advantages in all the determinants of national competitive advantage, covering a range of industries that draw on technological ability in chemistry, mechanical engineering and physics. The economy is built on early mover advantages, mostly growing out of science a technology. Many German competitive positions were created by the turn of the century. What is particularly notable about Germany is the ability to sustain positions in these fields over long periods of time.

The unique strength of the German economy has been its capacity to upgrade its advantage by raising the quality of human and technical resources and improving product and process technology. In accomplishing this, German firms have moved into more and more sophisticated segments. The mutual reinforcement of the "diamond" has allowed German firms to sustain these positions as well as to extend clusters into a remarkably wide range of related industries. Decades of prosperity, like in Switzerland, are taking their toll.

Germany achieved premier industrial status around the turn of the century. The deep, systemic advantages it has long enjoyed allowed Germany to recover from two devastating wars. The wars may well have provided the setbacks, the hardships and the pressures that have

What is the all these con in German i  
Find the ans  
Context  
Specific  
NAVIG  
MICHAEL E. PORTER  
THE COMPETITIVE ADVANTAGE OF NATIONS  
Full Text Search  
Reduce  
Go Back  
Help  
hard Cagood

Figure 3-20: Summary of German Competitive Advantage

contents.

*The reader wants to revisit a passage read about problems in the German printing press industry. The story titles act as cues to the content of the system's passages.*

1. Four Studies in National Competitive Advantage
2. The German Printing Press Industry
3. Printing Press Industry Technology
4. Considerations in Buying a Printing Press
5. Chronology of Technological Developments Since World War II
6. Early Industry History of the Printing Press Industry
7. The Emergence of Domestic Rivalry in the Printing Press Ind...
8. The Strategies of German Printing Press Competitors
9. Specialized Factor Creation for Printing Presses
10. Sophisticated Home Demand for Printing Presses
11. The German Printing Cluster
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23. Recent Technological Improvements in Patient Monitors
24. Internationalization of Patient Monitor Technology
25. Development of the U.S. Patient Monitoring Industry
26. The Emergence of European Competitors in the Patient Monit...
27. The Emergence of Japanese Competitors in the Patient Monit...

Figure 3-21: The Story Titles Zoomer

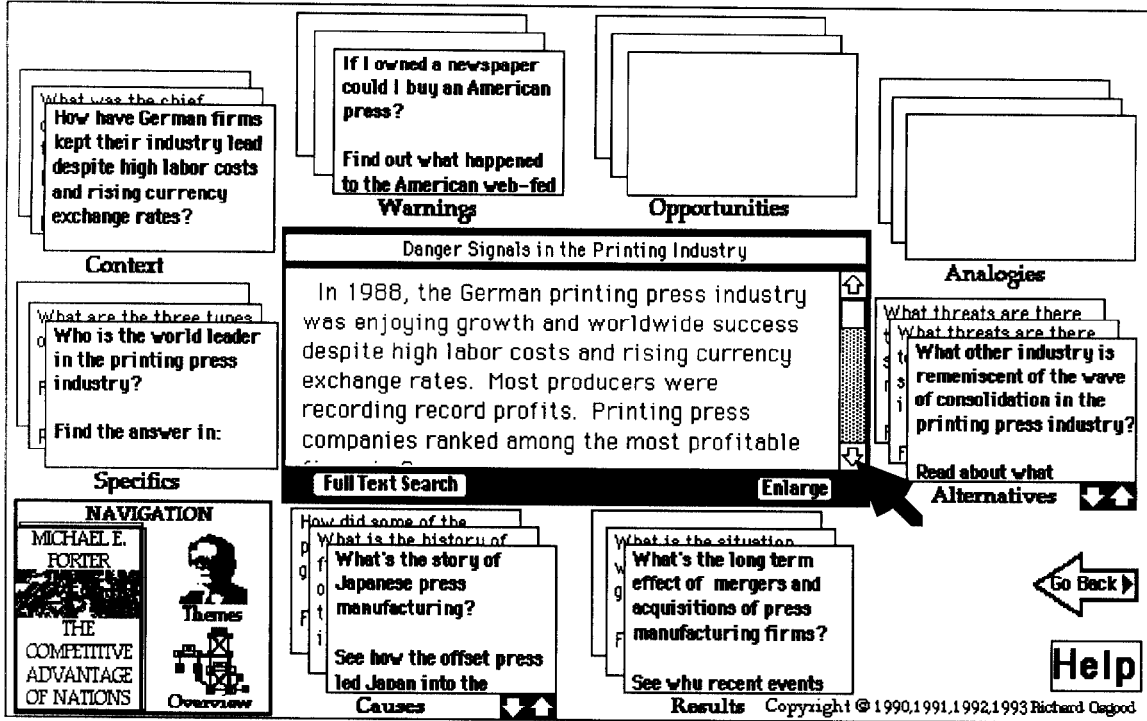


Figure 3-22: Browsing the Problems in the Printing Press Industry

Beginning again with the main zooming interface of Figure 3-11, the reader selects the highlighted name depicted in Figure 3-21, and system responds with the screen depicted in Figure 3-22.

### The Interesting Themes Zooming Scenario

The “Interesting Themes” zoomer presents the reader with a completely different way to begin reading. It can engage a reader with *no specific topic* interest via questions that imply that some surprising or unexpected information is available.



Figure 3-23: Themes Button

A casual reader with no particular interest in the material is exploring ASK Michael. Beginning again with the main zooming interface of Figure 3-11, the reader presses the “Interesting Themes” button shown in Figure 3-23. The system displays the screen in Figure 3-24.

This interface functions like the browsing screen described earlier in this chapter. It presents questions in eight basic categories using the same viewing and navigating features as browsing. Individual links can be expanded and scrolled to view their complete contents. A specific link can be brought to the top of the stack. When more than three links exist in a category, the stack of question links can also be scrolled.

Links are organized into groups by the type of interesting question they contain. ASK Michael’s categories are based on Schank’s work on interestingness

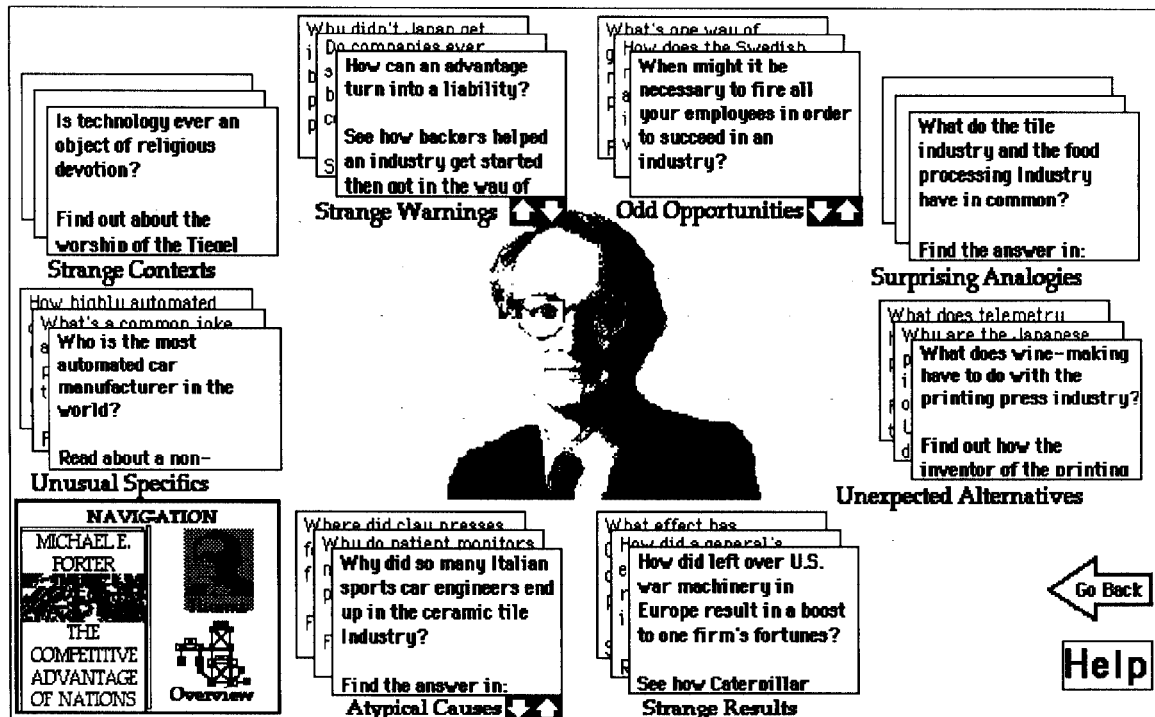


Figure 3-24: The Interesting Themes Zoomer

(Schank 1979) and the categories of the browsing interface. They include “Strange Warnings”, “Odd Opportunities”, “Surprising Analogies”, “Unexpected Alternatives”, “Strange Results”, “Atypical Causes”, “Unusual Specifics” and “Strange Contexts”. In the following chapter, I present a more complete account of ASK Michael’s model of interestingness upon which these categories are based.

*While examining the questions in this interface, the reader notices the “Strange Contexts” category and decides the idea of religious devotion to technology is interesting. By double clicking on the top question, as shown in Figure 3-24, he can see the passage that begins the browsing scenario presented earlier (Figure 3-1). Thus engaged, the reader’s interaction might then continue with that scenario.*

## Other Reader Aids in ASK Michael

ASK Michael has several other features, some of which are available from its main system menu (Figure 3-25). The “Navigate” feature shows the reader the

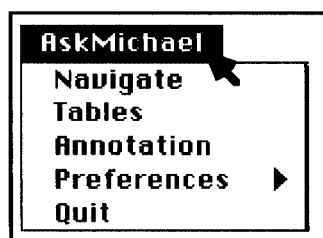


Figure 3-25: Main Menu

passages of CAN in the order in which Porter presented them. When the reader selects this feature from the menu, the system displays a navigation palette of buttons next to each passage displayed by the system. The reader can select the next passage as depicted in Figure 3-26 or any of a number of other landmarks, such as the introduction or summary to the chapter from which the passage was taken. This

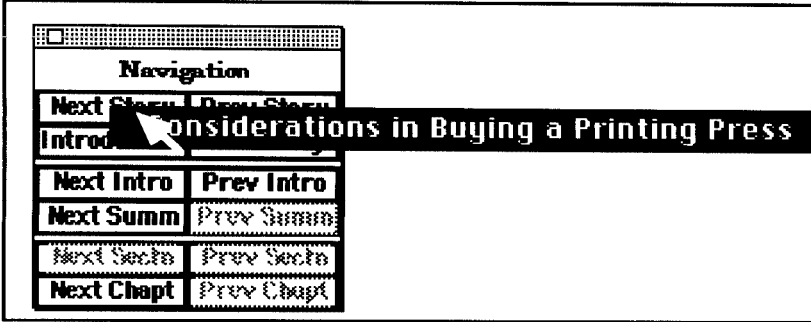


Figure 3-26: The Navigation Aid

palette enables a reader to use some of his or her strategic reading skills to locate a relevant passage when options available from zooming and browsing are

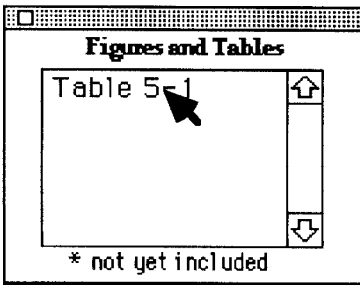


Figure 3-27: Graphics

TABLE 5-1 Estimated World Printing Press Sales by Press Technology, 1985 (in billions of DM)	
Offset	9.5
sheet-fed	5.0
web-fed	4.5
Non-Offset	2.5
(roto-gravure, silk-screen, and letterpress)	
Total	12.0

Figure 3-28: A Table from CAN

exhausted.

The "Tables" feature displays graphical or pictorial information associated with a passage. When a table is available a "T" appears next to the "Full Text Search" button of the browsing screen. A reader may use this feature via the system menu to display a list of figures or tables associated with the displayed passage (Figure 3-27). Clicking on one item in the list displays the graphic (Figure 3-28).

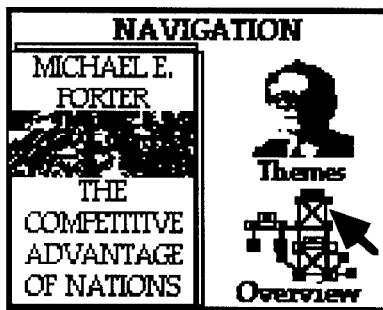


Figure 3-29: Zoomer Access

The "Annotation" feature (not shown) gives a reader a place to take notes during reading. Should the reader select this item, a window opens as a companion to the reading and navigating activity. In this window, the reader can read or modify old notes or record new notes which are permanently associated with the passage displayed in the center text area of the browsing interface. When an annotation is available, an "A" appears next to the "Full Text Search" button of the browsing interface.<sup>13</sup>

A navigation pad (Figure 3-29) provides

<sup>13</sup>The annotation facility proved to be very useful in refining the indexing of the system. In actual trials of ASK Michael, readers used this facility to record additional questions that should have been included in the indexing of the system. Periodically, I reviewed these questions and, as answers were found, new links were added to the system.

readers with direct access to any of the system's zoomers. It is available in the lower left corner of the browsing screen (Figure 3-1) and the "Overview" (Figure 3-18) and "Interesting Themes" (Figure 3-24) zooming screens.

## Conclusion

ASK Michael is an example of a new kind to non-linear text based on the metaphor of a conversation. Restructuring a book such as "The Competitive Advantage of Nations" as a question-based hypertext can improve text understanding in the four ways outlined in Chapter 1:

- A reader can engage in a question-and-answer dialog with the system via its browsing interface. The reader interacts with the system by alternately selecting questions from the interface and reading a new passage that contains an answer. Questions related to the new passage are then presented to the reader to sustain the dialog.
- Selecting clearly stated questions from the fixed categories of the browsing interface helps maintain the coherence of an interaction with the system. A reader's options for selecting a new passage are always related to what he or she has been reading. As a result, the reader can sustain an exploration of a topic through many passages without a loss of coherence.
- Readers with diverse interests can find answers to their questions. A reader can identify and follow the references he or she finds interesting or important, because the links in ASK Michael contain more information than typical citations or cross-references in a book. Also, the system's topical zoomers provide the reader with a variety of methods for satisfying his or her interests.
- A reader who might not have bothered with the linear book can often find an interesting passage in ASK Michael's "Interesting Themes" zoomer. The system's model of interestingness helps a reader to locate an interesting question to pursue.

The interleaving of zooming, browsing and reading is fundamental to how the reader and the system achieve a conversation-like interaction in ASK Michael. Using his or her comprehension and strategic reading skills in conjunction with the facilities of ASK Michael, a reader can engage in an interest-satisfying, coherent question-and-answer dialog with a non-linearly arranged text.

ASK Michael is an experiment in using questions to index an existing book. In the next chapter, I present the theory of questions which underlies the indexing of the system.



## Chapter 4

# A Theory of Questions

### Introduction

ASK Michael is intended to give the user a non-linear reading experience that is coherent, interesting, and question-and-answer-based. Its utility to fulfill these goals rests upon its indexing structure, which in turn is based upon an underlying theory of questions. In this chapter, I describe that theory.

To understand why a theory of questions is relevant, one must understand the problems to be confronted in the design and construction of a non-linear system such as ASK Michael. The system must facilitate non-linear reading by creating a natural environment in which a reader can ask and obtain answers to his or her questions from a text. The design of this environment must be based on an understanding of what would motivate someone to stop reading one passage to pursue another. In general, the reason is that something in the first passage has raised a question in the reader's mind, which the second passage can answer. Suppose a person unfamiliar with Japanese religious practice reads the text:

...one Tiegel (printing press) was even worshipped in the Sennshu-den shrine in the city of Kobe.

By the late 1800s, these and other German firms had emerged as world leaders....(Porter 1990)

Finding press worship surprising, the reader might form a mental question:

- (1) *Why would anyone worship a printing press?*

This question calls for an explanation which can be found in another passage:

...The Japanese industry was established in the twentieth century, only after the introduction of offset techniques had made possible the reproduction of Japanese writing. Letterpress techniques had been impractical because of the thousands of Chinese ideograms (Kanji) used in Japanese writing....(Porter 1990)

By following an ASK Michael explanation link between these two passages, the average reader can infer an answer, assuming a small amount of prior knowledge about printing and its importance in disseminating culture.

This simple example illustrates four problems to be confronted in the design and construction of a non-linear reading system. First and most difficult to address is the problem of restoring the coherence lost in breaking up text into segments. When a reader asks and receives an answer to a question such as Question 1 from a non-linear reading system, the normal coherence of reading linear text may be interrupted because the answer passage may not continue the point being made in the passage which inspired the question. Similarly, the answer passage may be taken from the middle of an author's presentation of another point. Thus, an important requirement of a non-linear reading system such as ASK Michael is to establish coherence between passages. How ASK Michael meets this requirement to maintain coherence during a question-and-answer dialog will be the major focus of this chapter.

Second and also difficult to address, is the problem of creating the many linkages between passages like those depicted in the above example that are necessary to the conduct of an effective question-and-answer dialog. In an ideal non-linear reading system, a reader will follow a dynamic pattern of questioning and reading which depends only on his or her specific knowledge needs and interests at the moment. To approximate this ideal, linking must be conducted from two perspectives. A linear text must be restructured such that the best answer the text provides is made available at the point where the corresponding question may arise. Conversely, to approach ideal linking among passages, likely reader questions must be anticipated and answers found. How ASK Michael meets this requirement to optimally link passages for the reader is introduced in this chapter and is the purpose of the next chapter.

Third is the problem of how to combine these solutions in an interactive question-and-answer-based interface that operates as effortlessly as asking and obtaining an answer to Question 1 in the above example. When the reader has a well-formed question to ask in response to a current passage, he or she must be able to communicate that question to the system to obtain an answer. How ASK Michael manages this question-based interaction with its readers is described in this chapter.

Fourth is the problem of addressing the complementary situation of the reader whose questions are too vague or ill-formed to communicate to the system. When a reader is not quite sure what to ask, the system should provide suggestions. How these suggestions are provided will depend on whether or not the reader is already engaged in reading. When already engaged, the system should offer contextually relevant suggestions. Otherwise, the system must make

suggestions independent of reading context. How ASK Michael handles situations in which readers may not know what to ask is also described in this chapter.

The remainder of this chapter presents four models which address each of these four problems respectively. They are:

- **The Model of Conversational Coherence:** The problem of sustaining the coherence of reading non-linear text in ASK Michael is addressed by a model of conversational coherence inspired by Schank's (1977) "Conversational Associational Categories". The categories of this model are an abstract characterization of the interrogative function of questions. Thus, likely reader questions can be assigned to them so that within a given category of interest, a reader can more easily find the specific question that would help maintain coherence in non-linear reading. Similarly, a more specialized version of the categories can improve the precision of the indexing of the system by facilitating the matching of likely reader questions with questions answered by the text.
- **The Model of Question-Answering:** The problem of locating answers to questions is addressed by a model of question-answering in which answers are pre-stored and linked to questions. (The implementation of this relative indexing solution is the subject of the next chapter.)
- **The Model of Question-Based Interaction:** The next problem to be addressed is how to provide an interface that supports a question-and-answer dialog which is also consistent with the solutions to the coherence and question-answering problems. A simple recognition model of question-based interaction is presented which underlies ASK Michael's non-linear reading interface.
- **The Model of Interestingness:** The problem of providing question-based interaction to a reader also occurs when a reader has no specific question. Within the context of a specific passage, the ASK Michael interface can display intrinsically interesting questions to attempt to inspire a reader interest. Outside of the context of a specific passage, ASK Michael can display intrinsically interesting questions using a version of the conversational categories modified by Schank's (1979) idea of interestingness. The model specifies how interesting questions can be defined and arranged for readers who might need suggestions.

Together these models that underlie ASK Michael are its functional theory of questions. Questions play a role in each model. The interrogative functions of questions comprise the categories of the model of conversational coherence. Anticipated reader questions raised by a passage and questions that a passage can answer function as the working representations of an indexing method for

the system. Questions function as the selectable items in the ASK Michael menu-based question-asking approach. Finally, intrinsically interesting questions function as the interest-inviting representations for the reader.

In what follows, I discuss each of these models in detail.

## **A Model of Conversational Coherence in ASK Michael**

ASK Michael is a non-linear reading system whose entire content came from "The Competitive Advantage of Nations". As the reader navigates the system, he or she will often choose to deviate from the original linear arrangement of passages in order to get an answer to a question.

Non-linear reading breaks up the coherence of passages written to be read together, which can make it difficult for a reader to follow an author's sequence of points. Reading a relevant and descriptive question before each passage provides the reader with information that can improve the overall coherence of a sequence of non-linear reading choices and thus, can improve understanding. Assuming the indexer of the system has anticipated the reader's question and linked it to an appropriate answer (see the question-answering model in the next section), a reader can raise a question to the system by simple selection (see the model of question-based interaction later in this chapter). Alternatively, a reader without a specific question can scan the questions of the interface looking for one that seems interesting (see the model of interestingness later in this chapter). Either way, using questions eases the reader's transition from passage to passage in non-linear reading.

In this section, I discuss a model of coherence used in ASK Michael that is based on two functions of questions. A question specifies both a reader's prior knowledge to be elaborated in an answer (Ram 1989) and the type of elaboration to be provided by the answer (Lehnert 1978; Murray 1988). The prior knowledge expressed in a reader's question is its *topic*. The request portion of a question, its *interrogative function*, specifies the knowledge need of the questioner (Dehn 1989). For example, in Question 1 above, "worship a printing press" is the prior knowledge to be elaborated, and the "Why" portion, which signifies explanation, specifies the type of elaboration requested.

Each of these functions can be broken down into a system of categories which can organize both a reader's interactions with ASK Michael and the indexing of the system. In the next two sections, I introduce the specific ASK Michael taxonomies and describe their application.

### **The Interrogative Function of a Question**

The browsing interface of ASK Michael is explicitly organized around a taxonomy of the interrogative functions of questions. A reader can ask and ASK Michael can answer literally hundreds of questions on many topics, each serving a specific interrogative function. By classifying and displaying predicted reader

questions by interrogative function, a reader can search the appropriate category for a text question similar to his or her mental question.

The taxonomy was derived from a model of connectivity in human conversation. Inspired by Schank's (1977) "Conversational Association Categories", Ferguson, et al. (1992) proposed eight conversational categories for labeling connections between stories in the ASK Tom system: Context, Examples, Background, Results, Alternatives, Indicators, Warnings and Opportunities.

In contrast to the original ASK Tom approach which classified *answers* to questions (stories), the ASK Michael approach arose from the observation that the *questions* themselves, not answers, are what ought to be classified in a reading interface. A reader browsing the navigation alternatives will know only the question he or she wishes to ask, and can have little advance knowledge of the specific content of an unread story indexed in the reading interface. In other words, to be of value, the interface categories must classify the reader's questions, not the answers.

The same taxonomy can work for questions as well as for their answers. The interrogative function of a question specifies what knowledge goal will be met. When the answer is found, it will satisfy that goal. Therefore, a natural correspondence exists between an interrogative function of a question and its answer.

<u>ASK Tom</u>	<u>ASK Michael</u>
Warnings	Warnings
Opportunities	Opportunities
Alternatives <sup>14</sup>	Alternatives
	Analogies
Results	Results
Background	Causes
Indicators	Specifics
Examples	Specifics
Context	Context

Figure 4-1: ASK Tom's Taxonomy

When applied to questions in ASK Michael, the eight original ASK Tom categories were modified slightly to achieve symmetry. Figure 4-1 shows the mapping of ASK Tom categories to ASK Michael. The categories represent the most abstract questions a reader can ask. More specific questions likely to be asked by readers can be found within one of these abstract types. For example, the *causes* category represents the question: "What is the cause of this

state of affairs?" Within that category can be found questions such as Question 1 above, "Why would anyone worship a printing press?"

The symmetry of the ASK Michael categories suggests a useful interpretation which can be helpful to readers. The *context* and *specifics* categories can classify questions whose answers constitute a shift or **elaboration** of the topic of a passage toward the more general (*context*) or the more specific (*specifics*) respectively. Its *causes* and *results* categories can classify a question about antecedents or consequences, respectively, along the causal chain of **explanation** associated with the content of a passage. Its *alternatives* and *analogies* categories can classify a question that invites a **comparison** of similar or dissimilar content

<sup>14</sup>The ASK Tom Alternatives category was split between *analogies* and *alternatives* in ASK Michael and other subsequently created ASK systems such as Trans-ASK.

<p><b>Elaboration:</b> Adjustments to the specificity of a topic under consideration and slight digressions like clarifying the meanings of terms or describing situations in which the topic arises.  <i>context:</i> the big picture within which a piece of information fits.  <i>specifics:</i> an example of a general principle or details of a situation.</p> <p><b>Explanation:</b> Explaining or giving background and describing outcomes as a means of gaining understanding. (Temporal order and the causal chain are grouped because people typically collapse the distinction.)  <i>causes (or earlier events):</i> how a situation developed.  <i>results (or later events):</i> the outcome of a situation.</p> <p><b>Comparison:</b> Making comparisons with other situations at the same level of abstraction as the current information as a second means of gaining understanding.  <i>analogies:</i> similar situations from other contexts.  <i>alternatives:</i> different approaches to take in a situation.</p> <p><b>Application:</b> The application of knowledge or carrying away a lesson, either negative or positive, for use in the reader's situation.  <i>opportunities:</i> advice about things to capitalize on in a situation.  <i>warnings:</i> advice about things that can go wrong.</p>
--

Figure 4-2: ASK Michael's Conversational Categories (Interrogative Functions)

items introduced within a passage. The *warnings* and *opportunities* categories can classify a question about a possible **application** of knowledge gained in reading a passage. Application questions help a reader find uses for the knowledge gained in the reader's situation. When a relevant application question is not available, comparison and explanation questions help a reader construct an understanding of the topic from which an application might be inferred (see, the understanding cycle in Schank 1989). Elaboration questions help a reader understand the conceptual content of the domain from which an indexer might also infer an application. See Figure 4-2.

This interpretation of the conversational categories can be viewed as a new strategic skill for non-linear reading. A reader begins by asking for advice directly applicable to his or her situation. In the absence of a suitable question, he or she next explores the comparison categories hoping to construct useful advice by analogy. Again in the absence of an applicable question, a reader can turn to the explanation categories in an effort to retrieve a useful causal explanation which he or she can apply. Failing that, the reader may at least gain an understanding of basic domain concepts from which a causal understanding might be constructed.

Similarly, this interpretation proved useful for indexing the system. An indexer can use the four basic types of categories to suggest likely reader questions. (See the next chapter for a discussion of this use.)

The eight categories of the basic taxonomy organize a reader's question-and-answer dialog with the system. In principle, an even more detailed breakdown could have been produced; however, it is difficult for a reader accustomed to linear text to choose among many categories especially if he or she does not have a well-formed question. Also, from an implementation standpoint, the screen space available in the human interface limits the number of link categories displayed to about eight. (Given the arrangement of categories in the

browsing interface of ASK Michael, pop-up menus or other approaches for displaying questions in categories were possible.)

However, it was useful to expand the taxonomy to a more detailed level for indexing during system construction. During question-based indexing, described in the next chapter, an indexer generates the links between passages needed for non-linear reading by representing each passage of text by the questions it raises and answers. These questions are input to a computer-assisted process in which questions raised are matched with questions answered to form links. The tractability of this process depends crucially on making as many reliable distinctions as possible among interrogative functions of questions. A fine-grained taxonomy is useful in indexing because it separates questions into smaller groupings, making the indexer's search for matches easier.

ASK Michael's detailed taxonomy of interrogative functions was developed by analyzing 2,100 questions produced by the content analysis of CAN. The phrases in questions that express their interrogative function were reduced to 37 basic categories organized within the eight symmetric categories described above. This detailed taxonomy organized questions from which ASK Michael links were generated (see Chapter 5). It was expanded only to the degree necessary to classify the questions that ASK Michael contains; therefore, many plausible categories have been omitted simply because questions requiring them did not occur. For example, the *uses* category occurs under **applications**; but *misuses* questions were not encountered and the category was not generated.

In the following four sections, I present the taxonomy of questions employed in ASK Michael. Each section presents the purpose of one of the four branches of the taxonomy, a brief example, a short sub-category description, and the method of deriving the terms of the branch. Bold type in Figure 4-3 to Figure 4-6 signifies actual categories used for CAN indexing.

### Elaboration Questions

A reader expresses an interest in reading about a new topic closely related to the topic of a passage currently being read by asking a topic elaboration question. In the course of reading, a reader may develop an interest in the details or the context of the topic of a passage. The elaboration categories organize these topic shifting questions. For example, after reading about the impact of World War II on Europe, a reader may want to narrow the focus to the impact on France, a *details* question which can be found in the "Specifics" category of the ASK Michael interface. Similarly, while reading a passage, a reader may fail to understand some of its basic concepts. For example, while reading about the ceramic tile industry, the reader may encounter an unfamiliar term such as "dynamism". The reader may benefit from a *definition* of that term, which again may be found in the "Specifics" category of the interface.

Figure 4-3 depicts the set of elaboration subcategories used in ASK Michael indexing. The knowledge goals of a novice often involve understanding the structure and concepts of a domain. These concerns may give rise to

<p><u>Context</u></p> <ol style="list-style-type: none"> <li>1. <b>Context</b> - In what situations does the German education system give them a competitive advantage?</li> <li>2. <b>Attitudes</b> - What is the Swedish attitude toward advertising and the media ?</li> </ol> <p><u>Specifics</u></p> <ol style="list-style-type: none"> <li>1. Explicit Details <ol style="list-style-type: none"> <li>a. <b>Amount</b> - How large are the engineering and construction industries?</li> <li>b. <b>Parts</b> - What are the four points of the diamond model in Porter's book?</li> <li>c. <b>Kinds</b> - What are the characteristics of demand conditions in Switzerland?</li> <li>d. Facts or <b>Details</b> - Where is Sassuolo Italy?</li> </ol> </li> <li>2. Implicit Details or <b>Examples</b> - What's an example of German excellence?</li> <li>3. Concept <b>Definitions</b> - What is meant by the term "competitive advantage"?</li> <li>4. General <b>Descriptions</b> - What's important to know about German competitive advantage?</li> </ol>
--

Figure 4-3: Elaboration—Minor Topic Shifts and Global / Local Shifts

questions about the context in which something occurs or the specific details and definitions of a domain. The first two elaboration subcategories classify questions about the environment in which a given state of affairs arises, which may be either impersonal situations (*Context*) or personal opinions (*Attitudes*).

The remaining subcategories represent questions about more specific aspects of a state of affairs, which meet the needs of novices engaged in learning the basic concepts and definitions of a domain. They can also be useful to a more knowledgeable reader who needs specific details to analyze some aspect of a domain. Explicit requests for specialization include qualitative or quantitative measures (*Amount*), the decomposition of assemblies into sub-components (*Parts*), the breakdown of categories (*Kinds*) and the specification of attributes or properties such as location (*Details*). More often, detailed information is best communicated by example (*Examples*), and sometimes, terminology needs *Definition*. Other ambiguous requests for clarification are classified in the catch-all category *Descriptions*.

The elaboration hierarchy was generated from an analysis of the key concepts in questions that specify either the larger picture or more detail. "Big picture" concepts were recognized from expressions of aggregation such as "context", "situation", and "environment". Detail-specifying concepts were generated from terms expressing decomposition such as "example of", "parts of", "characteristics of". Other concepts occurring in questions involving domain specific specialization (for example, Europe to France) generated a specialization sub-category.

### Explanation Questions

A reader of ASK Michael is likely to have many causal questions, because explanation is so central to understanding. A reader may want explanations in terms of causes and results, or historical antecedents and consequences when temporal events are involved. For example, to understand the impact of World War II on Europe, a reader may find it helpful to know what happened during



<p><u>Causes</u></p> <ol style="list-style-type: none"> <li>1. Causality             <ol style="list-style-type: none"> <li>a. History                 <ol style="list-style-type: none"> <li>1). <b>Origins</b> - What are the origins of the ceramic tile industry in Italy?</li> <li>2). <b>History</b> - What is the history of the US patient monitor industry?</li> </ol> </li> <li>b. Causation                 <ol style="list-style-type: none"> <li>1). <b>Explicit (or theorized) Causes</b> - What causes governments to overregulate?</li> <li>2). <b>Impersonal Mechanisms</b> - How does a printing press work?</li> <li>3). <b>Personal Means</b> - How did the Japanese achieve dominance in the robotics industry?</li> </ol> </li> </ol> </li> <li>2. Enablements/Impediments             <ol style="list-style-type: none"> <li>a. <b>Reasons</b>- Why did the English dominate the auctioneering industry?</li> <li>b. <b>Object Resources</b> - What is needed to start a printing firm?</li> <li>c. <b>Personal Roles</b> - What role did the German demand for quality play in German industry's success story?</li> </ol> </li> </ol> <p><u>Results</u></p> <ol style="list-style-type: none"> <li>1. <b>Agent Actions</b> - What did German industry do to respond to increasing competition at home?</li> <li>2. <b>Temporal Events</b> - What happened in the chocolate industry after the invention of "consing"?</li> <li>3. <b>Future Predictions</b> - What will be the impact of German re-unification on German economic strength?</li> <li>4. <b>Actual Results</b> - What has been the impact of the German apprenticeship system on German industry?</li> </ol>
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Figure 4-4: Explanation—Causal and Temporal Relationships

and before the war.

Figure 4-4 depicts explanation-related question categories. Causal questions include those about direct events or agent cause and those concerning indirect influences on events and actions. In response to an expectation failure in reading, a reader will attempt to locate or construct an explanation. When a reader needs a thorough understanding, he or she will ask questions about means or direct causality, but when the requirements are less rigorous a simple temporal explanation will suffice. The direct causality questions concern inclusive (*History*) and initial temporal dependencies (*Origins*), general causal antecedents (*Causes*), and both impersonal (*Mechanisms*) and personal means (*Means*).

A reader may be concerned with more indirect influences and may raise questions about what enables or impedes a situation. *Reasons* questions call for an answer that states the specific goal or major causative factor that motivated an agent's actions in a situation. *Roles* questions and *Resources* questions concern the pools of people and objects that enable the causal chain.

When a reader's expectation failure concerns outcomes, he or she will raise a results question. *Agent Actions* questions identify a specific agent response to a state of affairs. *Temporal Events* questions request the next occurrence in a temporal sequence and may also imply a causal connection. *Future* prediction questions concern the possible, but as yet, unrealized impacts

of a state of affairs. Actual *Results* questions request a specific direct consequence of a causal factor.

Explanation-related categories were generated from question references to the causal chain or temporal sequence, for example, words such as “why”, “cause of”, “history of”, and “happened before”. The question, “What causes governments to overregulate?” clearly refers to factors having direct causal bearing on a government practice. Other causal relations were less direct and were generated from terms of enablement or impediment, such as “enable”, “reasons”, and “block”. Results categories were generated from references to consequence concepts, such as “impact”, “affect”, and “happened”.

### Comparison Questions

As a normal part of comprehending a text (described in Chapter 1), a reader may attempt to generalize what he or she is learning by comparing what he or she reads with what he or she knows. Comparisons are particularly useful for understanding the extent to which knowledge applies. Analogy broadens a reader’s understanding; a counter example or negative analogy limits it. To obtain this benefit, a reader forms comparison questions. For example, one way to understand the impact of World War II on Europe is by way of contrast with the impact of World War I.

Figure 4-5 presents the comparison question categories. Requests for a similarity assessment are divided between simple featural assessment and complex multifaceted assessments. Simple questions request an identification of most/least in comparison to all others (*Superlatives*), a comparative measure such as more or less than (*Comparatives*), or a comparison of simple features (*Comparables*).

Sometimes a simple comparison is not possible, for example, when comparing many complex aspects of the success of two nations in an industry. For more complex comparisons, a *Patterns* question requests a multi-dimensional similarity assessment; a *Relationships* question is a catch-all category for requests to perform unspecified assessments of the relationship of entities.

<u>Analogies</u>	
1. Simple	<ul style="list-style-type: none"> <li>a. <b>Superlatives/diminutives</b>- What nation has the highest per capita income?</li> <li>b. <b>Comparatives</b> - Is Germany’s GDP greater than Japan’s GDP?</li> <li>c. <b>Comparables</b> - How are the German and Swiss economies alike?</li> </ul>
2. Complex	<ul style="list-style-type: none"> <li>a. <b>Patterns</b> - What are the major clusters of Japanese industry?</li> <li>b. <b>Relationships</b> - What’s the relationship of European and Japanese markets for robots?</li> </ul>
<u>Alternatives</u>	
1. <b>Contrasts</b>	- How do the German and Swiss economies differ?
2. <b>Parallel Related Topics</b>	- What are the top 50 industries in the US? (in the context of those for Germany)

Figure 4-5: Comparison—Exploring Relative Position

Most requests for difference assessments are classified as *Contrasts*. However, *Related Topics* classifies one specific type of alternatives question that links parallel passages together. For example, often a CAN chapter is dedicated to the contrast of four industries or nations. Related topics questions cross-link the parallel threads together at the specific points where contrasts are implied, for instance, contrasts in the origins of competitive advantage in each of four industries. A reader forms a question regarding a difference when he or she already knows of a difference but does not know the extent to which it will affect his or her ability to generalize.

Comparison categories were generated from references in questions to multiple parallel entities. Similarity relationships were recognized by comparative terms, such as, "greater", "less", "compare", "similar", and "relationship". For example, the question, "Is Germany's GDP greater than Japan's GDP?" places Germany and Japan in an explicit parallel relationship. Dissimilarity relationships were recognized by terms of contrast, for example, "differ", "contrast", and "not". The *Superlatives* and *Related Topics* categories were generated from questions that reference implicit comparisons of parallel entries. For example, the superlative "most" implies compared to all others. In the context of the parallel sections of CAN Chapter 7, "German early industry history" implies comparison to the early histories related topic for the other three nations presented in the chapter.

### Application Questions

An application question is indicative of the reader's intent to apply the knowledge gained through reading. A reader may form many of his or her questions for the immediate purpose of elaborating the topic, getting an explanation, or making a comparison. However, this immediate purpose is typically subordinate to the reader's overall goal to apply what he or she has read in his or her own situation. For example, the reader wants an explanation because he or she is engaged in problem-solving, or some other task where an explanation will be relevant. Therefore, a reader may want answers to questions concerning the best application of the knowledge gained through reading.

ASK Michael's application questions have an analogical purpose. The system cannot tailor its advice to the specific situation of a reader, but it can show how others have applied the knowledge a text provides. For example, a reader who understands the impact of World War II on Europe might also want some help applying that knowledge in a current situation. In this case, ASK Michael points the reader to the story of how U.S. heavy equipment companies did in fact apply their knowledge of the nature and extent of the destruction of the war to gain a competitive advantage during the reconstruction of Europe. The reader must then adapt the advice for his or her own use.

<p><u>Opportunities</u></p> <ol style="list-style-type: none"> <li>1. Abstract Advice             <ol style="list-style-type: none"> <li>a. Inferred                 <ol style="list-style-type: none"> <li>1). Personal <b>Purposes</b> - What is Michael Porter's purpose in writing "The Competitive Advantage of Nations?"</li> <li>2). Object <b>Uses</b> - What is a letter press used for?</li> <li>3). Process <b>Functions</b> - What is the function of typesetting in printing?</li> </ol> </li> <li>b. Actual <b>Lessons</b> - What lessons does the Japanese success story in robotics teach?</li> </ol> </li> <li>2. Specific <b>Opportunities</b> - What opportunities did the Swedish transportation industry capitalize on to gain an advantage?</li> <li>3. Hypothetical Advice             <ol style="list-style-type: none"> <li>a. <b>Hypothetical Lessons</b> - Normally, what does it mean when a nation does not continue to establish new business in an industry?</li> <li>b. <b>Advantages</b> - What are the advantages of relocating an industry?</li> </ol> </li> </ol> <p><u>Warnings</u></p> <ol style="list-style-type: none"> <li>1. <b>Warnings</b> - Why was it a bad idea for the German printing industry to consolidate in recent years?</li> <li>2. <b>Problems</b> - What kinds of problems does government regulation create?</li> </ol>
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Figure 4-6: Application—Advice and Pedagogy

The application categories presented in Figure 4-6 were divided between positive and negative advice. A reader will want positive advice and negative advice to guide his or her process of forming new goals, plans, and actions in his or her specific situation. Positive advice communicates the conditions for success; negative advice communicates the conditions for avoiding failure. Positive advice, or opportunities, might occur in general situations, specific situations or hypothetical situations. Some questions regarding the opportunities in general situations require the reader to infer advice from the answer. They include inferring an application in the reader's situation from the effects of the use of an object (*Uses*), a process (*Functions*), or a personal activity (*Purposes*). Other questions request generally applicable advice (*Lessons*). Still others questions concern advice in specific situations (*Opportunities*).

When a reader is only at the planning stages in some task, he or she will have hypothetical questions. Some abstract advice questions include contingencies. In particular, hypothetical advice questions concerning positive outcomes are classified as *Advantages*. Questions in which the outcome is unknown are placed in the *Hypothetical Lessons* category.

Questions concerning negative advice are classified as warnings of negative results (*Warnings*) or negative abstract hypothetical lessons (*Problems*). Other potential categories of negative advice symmetric with positive advice were not generated, because fewer questions of this type resulted from the content analysis of CAN.

Application questions typically contain domain knowledge in combination with a request for pedagogical knowledge useful in applying a received answer. As a result, categories were generated from questions that express explicit pedagogical intent such as occurrence of knowledge acquisition

or application concepts such as “learn”, “teach”, “lessons”, “advantage”, and “problems”. Categories identified from functional terms, for example, “uses”, and “purposes”, were also included because they implicitly concern the application of these functions in the reader’s situation.

Related Work on Question Taxonomies

Question taxonomies have been developed in reading, artificial intelligence, and cognitive psychology research and serve a number of purposes. I have selected three examples that, while different in many respects, are close enough to ASK Michael’s taxonomy to warrant a comparison. Each example makes an important point about the purpose of questions in understanding which I have tried to incorporate into the ASK Michael design.

AQUA is an artificial intelligence system that uses questions as the central processing construct in story-understanding. The taxonomy of questions in AQUA (Ram 1989) is tied to a classification of the goals of an understander in that questions are the means of serving those goals. Ram’s taxonomy consists of text goals, memory goals, explanation goals and relevance goals. A text goal forms when an understander performs syntactic and semantic analysis during parsing of a text. A memory goal arises when a dynamic memory (Schank 1982) is trying to judge similarity and form generalizations. An explanation goal forms when an understander attempts to resolve anomalies or build causal explanations of events. A relevance goal arises when an understander tries to identify aspects of the real world that are relevant to its own goals.

Each of the processes that give rise to a goal type are associated with a type of question. For example, explanation questions arise out of anomaly detection, explanation pattern retrieval (Schank 1986), explanation pattern application and hypothesis confirmation. These questions function in a detailed process model of understanding.

At an abstract level, AQUA’s approach to understanding compares favorably with ASK Michael’s. The four abstract categories of ASK Michael’s

<u>AQUA</u>	<u>ASK Michael</u>
Text Level Goals	Elaboration Questions
Explanation goals	Explanation Questions
Memory Goals	Comparison Questions
Relevance Goals	Application Questions

Figure 4-7: AQUA Knowledge Goals

interrogative taxonomy are similar to the four goals of Ram’s understander as depicted in Figure 4-7. On the surface, an ASK Michael topic elaboration question appears to serve many of the text level goals of the system—clarifying terms and

creating context for disambiguating terms. However, in ASK Michael topic elaboration questions also serve the higher level goals (interests) of the reader, a role text level goals do not play in AQUA. An ASK Michael explanation question serves the explanation goals of an understander as in AQUA; and an ASK Michael comparison question satisfies a memory goal which concerns the similarity assessment and comparison needs of the understander, as in AQUA. Finally, ASK Michael’s application questions align well with AQUA’s relevance

<u>QUALM</u>	<u>ASK Michael</u>
Causal Antecedent	Causes
Goal Orientations	Reasons
Enablement	Means
Causal Consequent	Results
Verification <sup>16</sup>	Causes
Instrumentality	Mechanisms
Concept Completion	Specifics.
Expectational	Reasons
Judgmental	Attitudes
Quantification	Amount
Feature Specification	Details
Requests	<i>inapplicable</i> <sup>17</sup>

Figure 4-8: QUALM's Taxonomy

goals which address the context in which knowledge will apply. Taken together, AQUA's knowledge goals support the design of the ASK Michael reading interaction around four basic interrogative functions.

QUALM is an artificial intelligence system that classifies questions in terms of a conceptual question taxonomy (Figure 4-8) as part of its attempt to understand and answer them (Lehnert 1978).<sup>15</sup> QUALM's question classifications represents its understanding of an input question it has

received. Determining its class tells the question answering system what kind of additional processing the question must undergo to be answered.

While QUALM's taxonomy is not as complete as ASK Michael's, it underscores the value of question classification as part of understanding. The ASK Michael indexer compiles questions that have been classified and answered into the system's reading interface. A reader can find his or her question by searching the appropriate category for a similar question. QUALM suggests that the understanding processes of a reader can best be served by a reading interface that uses the categories of understanding to organize likely reader questions.

<u>REACT</u>	<u>ASK Michael</u>
Confirm or Explain	Causes
Imagine Detail	Details
Recall Examples	Examples
Make Predictions	Futures
Attribute Detail	Details
Form Analogies	Comparables
Make Comparisons	Comparisons
Identify Implications	Results
Draw Conclusions	Results
Motivate the Lesson	Hypothetical
Evaluate	Warning or Opportunity
Identify Principles	Context

Figure 4-9: The REACT Taxonomy

REACT is a computational model of knowledge integration for machine learning (Murray 1988). Its taxonomy of questions classifies the natural elaborations<sup>18</sup> and continuations of knowledge as learning occurs (Figure 4-9). REACT's taxonomy does not use questions explicitly. It focuses on the state of knowledge after elaboration (in its indicative form) rather than before (its interrogative form). For example, elaboration by explaining starts with a base statement: "This

<sup>15</sup>Graesser's work is based on Lehnert's model (Graesser, Person, and Huber 1992).

<sup>16</sup>Verification concerns the truth value of a statement. ASK Michael treats verification as subordinate to the underlying question reformulated without the "Is it true that".

<sup>17</sup>The Requests category is actually an imperative and not a question at all. Because a question is shorthand for an indicative and imperative combined, it seems natural to expect that a reversed use would occur. An imperative might easily be expressed as a question without any indicative content. So, "Would you pass the salt?" means, "The salt is near you. Please pass it to me."

<sup>18</sup>This use of the term "elaboration" in Murray's (1988) work is more general than my use in this dissertation. The two should not be confused.

plant looks as if it has died." An elaboration might be: "Of course it died; it wasn't given any food; all living things die without food." Before the elaboration, an ASK Michael question might be, "Why did the plant die?"

The REACT model represents many of the kinds of questions in ASK Michael's taxonomy. It emphasizes the valid elaborations of knowledge that are needed for knowledge integration. The ASK Michael interface displays each question in the category of the taxonomy that best describes the elaboration of the central text that a reader will receive from the subsequent related passage. The REACT model of possible elaborations supports the claim that the ASK Michael arrangement of categorized links should enable a reader to successfully integrate the knowledge that a network of passages can offer.

To summarize, the related work presented here supports some basic design decisions of ASK Michael. The taxonomy of questions in the browsing interface is consistent with the kinds of knowledge goals operating in AQUA's process model of understanding. The use of classification in ASK Michael is consistent with a QUALM's process of question interpretation. Finally, ASK Michael's display of classified follow-up options around a central text is consistent with the REACT view of knowledge integration during learning.

### The Topic of a Question

In addition to its interrogative function, a reader's question has a topic. ASK

Manufacturing Industries
Printing Press Industry
The Patient Monitor Industry
The Ceramic Tile Industry
The Robotics Industry
Services Industries
The Construction Industry
The Auctioneering Industry
Postwar Nations
Postwar U.S.
Germany
Sweden
Switzerland
Shifting Nations
U.S. - 1980
U.K. - 1980
Emerging Nations
Japan
Italy
Korea

Figure 4-10: ASK Michael Topics

Michael makes little direct use of this portion of a question, given the open-endedness and potential complexity of topical taxonomies.<sup>19</sup> However, the model of conceptual indexing described in the next chapter (which was used to construct ASK Michael) includes topical categories to reduce the complexity of question-matching for the indexer. Along with its interrogative function, a question's topical assignment is input to a computer-assisted question-matching process which forms relative links.

However, topical categories are the basis of the topical zooming interfaces of ASK

<sup>19</sup>The theory of topical zooming is not very well developed in this research. The open-ended or abstract models used to organize topics for zooming reflect a pragmatic decision to adopt the topical organization of the source material until a better motivated approach can be developed for initiating an exploration of a non-linear text. Later work, for example, Trans-ASK, has made use of models of the user's task to support zooming (Bareiss and Osgood 1993).

Michael. They act as a coarse index to get the reader into potentially relevant areas of the ASK Michael database. The system organizes its topics hierarchically in an abstract set of classes and subclasses derived from the chapter and heading organization of CAN depicted in Figure 4-10. Each subclass contains an introduction (for general reader orientation) and a summary passage (for specific reader interests) which can orient a reader to the subtopic. (See Chapter 3 for the details of zoomer implementation.) For example, a reader with a question concerning the patient monitoring equipment industry selects the "Summary" passage under "The Patient Monitor Industry" subclass.

A reader uses the topical zoomers described in Chapter 3 to navigate this layered topic structure. However, topical zooming in ASK Michael is not designed to address a specific reader question. Zooming only narrows the context of a search for an answer. A reader always has a purpose for inquiring about a topic that is not reflected in the topic itself. The interrogative portion of the reader's question reflects that purpose. Therefore, a reader uses a combination of zooming and the more focused process of browsing to find an answer to a question.

### **A Model of Question-Answering in ASK Michael**

The utility of the question-and-answer dialog in ASK Michael depends upon finding answers to questions a reader is likely to raise. Thus, the problem for design of a non-linear reading system is to find an efficient and effective *model of question answering*. Researchers in cognitive psychology and artificial intelligence have proposed story understanding models for inferring answers to questions. They are the basis of systems that actually process the meaning of story texts (Lehnert 1978; Kolodner 1984; Dillon 1982; Trabasso, van den Broek, and Lui 1988; Ram 1989). In contrast, ASK Michael's approach stores and indexes rather than infers answers.

The essential difference between the two types of solutions to the question-answering problem is when and how inference is done. In a story understanding model, inference is done by the system at the time the reader asks a question. In contrast, the indexing approach displays the results of prior human inferences which are linked to questions readers select during reading.

Each approach has its place. The advantage of the indexing solution is simple and efficient navigation to new passages. The cost is the work of anticipating likely reader questions and locating the required answers. The advantage of the story understanding approach is its sensitivity to the dynamic character of memory and its corresponding ability to learn. Its cost is solving the representation and process problems of natural language understanding.

Given a static body of knowledge represented in a book such as CAN, and the complexity of story understanding systems, the advantages of indexing outweigh those of story understanding provided that an effective method of indexing can be found. The particular method of conceptual indexing used to



construct ASK Michael was based on the following model of question-answering.

ASK Michael's indices are generated by caching human inferences about the relationships between stories. Reader questions that arise in the context of reading one passage of text can be answered by other passages. The indexer must anticipate relevant reader questions, locate their answers, and make them available in the context in which readers will raise them. Thus, the model of question-answering in ASK Michael is based on the *relative indexing* of text.

The model defines a process of question-answering that indexers can use to perform relative indexing. It guides delineation of the context for raising questions, determination of likely reader questions, and location of appropriate answers.<sup>20</sup>

First, the determination of likely reader questions must be performed relative to a particular context. Contexts for generating questions are formed by segmenting texts into *content units* or passages. In general, boundaries can be drawn such that each passage contains enough material to clearly make a single main point without requiring the typical reader to reference additional material to comprehend it.

Second, within the context of a segment, the model of question-answering specifies how a text can be analyzed to predict the questions it raises. This prediction is based on predicting four types of reader ignorance (Dehn 1989), which correspond to four interrogative functions of questions described earlier in this chapter.<sup>21</sup> A reader may lack knowledge of basic topical concepts (topic elaboration), causal knowledge (explanation), comparative knowledge, or application knowledge. These types of potential reader ignorance suggest the types of questions an indexer should produce.

Third, after an indexer has predicted the questions raised by a segment, he or she locates the passages that answer them. This process is facilitated by representing each text passage in terms of the questions it answers prior to indexing, and then by matching them with questions raised. To set the scope of possible answers, each passage is represented by questions covering a range of content. To capture the most general answer a text can provide, a question is composed to reflect the single main point of the passage. A set of questions is also composed to reflect the most specific questions a text can effectively answer without frustrating a reader's purpose in asking. It is assumed that human indexers can infer the intervening levels of detail from these end-point questions.

With reader questions (questions raised) and text answers (questions answered) represented in the same form, question-answering can be reduced to a simple process in which the indexer assesses the similarity of questions raised

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<sup>20</sup>The practical application of this model is the subject of the next chapter. Therefore, this section provides only a broad overview.

<sup>21</sup>Because of the non-linear arrangement of pre-existing text in ASK Michael, a fifth kind of reader ignorance is also likely. In non-linear reading, a reader must skip around in a text, unaware of what the author has covered earlier in the original source material. As a result, a reader may require knowledge of the reading context established by the original author.

with questions answered during the indexing of the system. The pre-stored matches between these questions are the relative links between passages in the ASK Michael system.

Question-answering by question-matching is made tractable by classifying questions raised and questions answered by their interrogative functions and their topics. Question-matching is conducted within groups of questions belonging to each combination of interrogative function and topic category.

This simple model of question-answering by pre-storing question-matches is consistent with the model of conversational coherence presented earlier and the model of question-based interaction to be presented next. Its implementation is the subject of the next chapter.

## A Model of Question-Based Interaction in ASK Michael

The models of conversational coherence and question-answering by themselves do not completely solve the problem of supporting a coherent question-and-answer-based dialog in ASK Michael. The reader still needs a way to actually ask a question and the indexer who has cached the appropriate links between passages still needs a place to display these options to the reader. Thus, the *model of question-based interaction* is intended to specify how a reader accesses the indices produced by the question-answering method and organized by the conversational categories. This model underlies the design of the system's browsing interface and its one question-based zooming interface (which is described in the next section).

ASK Michael is based on a simple recognition model of interaction. A menu of explicit text questions is presented in the reading interface of the system. The reader's direct selection of a specific text question from the menu tells the system what question it should answer. The reader locates his or her question from among the pre-enumerated questions the system can answer. ASK Michael employs the conversational categories (presented earlier in this chapter) and menu-based selection to help a reader find the right question to ask.

Menu-based question-asking in ASK Michael is contextualized and answer-assured. The reading interface in ASK Michael presents a menu of questions to its user.<sup>22</sup> Only questions relevant in the context of a currently active passage and for which indexers of the system have pre-stored answers in the form of other passages are included in the system. The number of menu items presented is limited by the number of possible questions raised by a segment of text for which answer segments have been located.

The effectiveness of a context-specific menu of questions at simplifying interaction depends on the control of both the number and significance of

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<sup>22</sup>The design of ASK Michael's reading interface was inspired by the ASK Tom browsing interface. ASK Tom is a system for training trust bank consultants using the video stories of experts (Schank, et al. 1991; Ferguson, et al. 1992).

questions asked and the ease with which a reader can map mental questions to text questions in the reading interface. The size of text segments and their content affect the former, while question structure and link content affect the latter.<sup>23</sup>

First, text segment size limits the extent of a reader's question-asking. Every text segment raises some questions and provides answers to others. A shorter segment may not make a relevant point. It may be incomplete as an answer to a question raised elsewhere, and it may raise too few questions to be interesting. Conversely, a larger segment may not get to the point effectively. It may provide too much content to answer concisely a question raised in another segment, and it may raise too many questions whose answers would be digressions. For a text segment to make its point effectively in non-linear reading, the indexer of the system must strike a balance between these two extremes. The next chapter discusses how text was segmented by ASK Michael's indexers to solve this problem.

Second, question-asking by recognition requires a method for the reader to assess the similarity of a mental question to questions offered in the reading interface. ASK Michael provides the reader a structure within which to conduct similarity assessment. Given no shift in topic from that of the currently displayed passage, the reader determines the interrogative function of the question raised, for example, wanting to know the cause of an event. Because the browsing interface has been organized by interrogative function (for example, requests for causal or historical explanations), a reader locates the appropriate category (for example, *causes*) and searches for a match with the question raised (for example, "Why..."). When the match is exact, mapping a mental question to its indexer-generated text form is easily accomplished. However, when the match is imprecise, the mapping can require additional inference on the part of the reader. Links contain additional explicit annotation (described below) to support such inferences.

Should the reader decide to shift the topic, he or she turns to topical taxonomies (described earlier in this chapter) embodied in the zoomers of ASK Michael to locate a relevant passage.

Mapping a mental question to a question in the reading interface depends on a reader's innate ability to perceive a question's topical and interrogative functions. For example, while reading a passage about firing ceramic tile, suppose a reader raises the question:

- (2) *Why would a ceramic tile need to be fired twice or even three times?*

ASK Michael's interface does not present this question. However, near the text that raised Question 2, ASK Michael might display this text question:

- (3) *What is the purpose of the multiple firing of ceramic tile?*

The reader knows that Question 2 is a request for a causal explanation. The

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<sup>23</sup>The categorization of questions, discussed earlier, is also important.

system's browsing interface presents the reader with the option of looking for a match in the *causes* category. Given Question 3 in that category, a reader easily recognizes the equivalence of the interrogative function of the two questions ("Why" and "What is the purpose of") and the equivalence of the topical portion ("multiple" and "twice or three times").

When question-mapping is more complex, the additional information in an ASK Michael link assists a reader in performing the necessary inference. An ASK Michael link consists of a raised question, a bridge to an answer, and the name of the passage containing the answer. An indexer composes the text question to reflect a reader's likely question. The name of a passage, also assigned by an indexer, provides the reader with the main point of the answer passage. The bridging text between them provides information the reader may need in order to understand how the question is answered in the passage. For example, suppose a reader raises Question 2, and encounters this link in ASK Michael:

(4) *How are more expensive tile manufactured?*

Find out about the manufacturing of multiply-fired decorative tiles in:

Manufacturing Processes and Techniques in the Ceramic Tile Industry.

The mapping of Question 2 to Question 4 is uncertain because it is not clear that multiple firing will be covered in the topic part of Question 4. However, the bridging text of the ASK Michael link provides the reader with the additional information to facilitate the inference.<sup>24</sup>

This link content extends the range of questions a reader can map to ASK Michael's text questions. The original text of CAN does not explicitly address many questions a reader might raise, yet, they are often addressed implicitly. The question-asking model enables the indexer to provide specific information in links that the reader can use to navigate to passages from which answers can be constructed. For example, Question 1 posed at the beginning of this chapter requests an explanation of printing press worship. While the question is never addressed explicitly, its answer can be constructed by the reader from a passage about a type of printing that does not require typesetting and another passage that describes typesetting technology as inappropriate for printing the Japanese language. (Chapter 3 develops this example more fully.)

### **Other Models of Question-Based Interaction**

Many systems that use questions as the basis for interaction with a user are designed to enhance the natural process of thinking by encouraging people to ask good questions (Kass 1991; Graesser, Langston, and Lang 1992). As a result,

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<sup>24</sup>The section in the next chapter on question matching discusses the vagueness and ambiguity of questions.

they try to be general across domains and do not contain models of the domain in which they may be asked to function. The Sounding Board program (Kass 1991) does not answer a user's question; instead, it asks questions to inspire a user to think through a difficult problem. The program extracts a problem type from a user text entry and formulates a question from it. For example, should the user express a need for a computer, Sounding Board would classify this response as a *missing resource problem*. It would then ask the user the appropriate resource questions about why a computer is needed or how to procure a computer.

The important feature of Sounding Board for this discussion is its ability to function effectively in a question-and-answer dialog with a user without a model of the domain that is being discussed. ASK Michael has a similar goal which is realized very differently. The purpose of ASK Michael is not only to foster systematic user inquiry, but to engage in question-answering with only a minimal topical model of the domain in which it functions. Sounding Board used pattern matching to classify a user's response and to choose follow-up questions to ask. ASK Michael uses a menu-based question-asking approach and direct indexing of answers to guide a reader directly to an answer passage.

The domain-independent approach to question-based interaction of systems such as Sounding Board, frequently cannot express what a reader may want to ask, and more importantly, the system can never retrieve semantically meaningful answers. Sounding Board does not have any content to process. In contrast, there are systems that attempt to interact with a user using questions but also have domain content to communicate.

Like ASK Michael, the Point-and-Query (P&Q) interface implements question-based interaction by indexing its content to general questions that can be asked (Graesser, Langston, and Lang 1992). The combination of a text term and a general question is then indexed directly to an answer text. In the P&Q interface, user queries are standardized around sets of questions specific to the function of a phrase in a text. Given the phrase "Saxophone", the standard questions are: "What does X mean?, What are the properties of X?, What does X look like, and What are the types of X?"

The ASK Michael approach generalizes the idea of connecting generic questions to phrases in the text. Like P&Q, ASK Michael's eight conversational categories are its eight generic questions (Figure 4-11). Unlike P&Q, ASK Michael neither ties specific instance of its questions to the words of the text nor limits

Context	<i>What is the context of X?</i>
Specifics	<i>What specific details are available about X?</i>
Causes	<i>What are the causes of X?</i>
Results	<i>What are the results of X?</i>
Analogies	<i>What is analogous to X?</i>
Alternatives	<i>What are the alternatives to X?</i>
Warnings	<i>What should X not be used for?</i>
Opportunities	<i>What should X be used for?</i>

Figure 4-11: Mapping Abstract Questions

strengths and weakness of P&Q.)

questions to the generic forms. As a result, its questions are free to express implications in the text and, indeed, any content an indexer deems appropriate for a reader. (See Chapter 2 for a more detailed analysis of the

## A Model of Interestingness in ASK Michael

ASK Michael places intrinsically interesting questions in both its browsing interface and in one of its zooming interfaces to solve the problem of inspiring an interest in a reader without a specific question. ASK Michael's ability to generate interest in readers is derived from a *model of interestingness* based on Schank's (1979) work. The effectiveness of the model is dependent both on the understanding of what makes something interesting and on the appeal of questions to readers as good representations of intrinsic interest. The combination can make questions tantalizing.

An anomaly is interesting (Schank 1979). Questions specifically composed to reflect an anomaly present in the text they index, are intrinsically interesting. For example, consider the question:

- (4) *When might it be necessary to fire all your employees in order to succeed in an industry?*

This question presupposes a naive model of normal business operations in which employees account for the success of a company. The question suggests that it is possible to be successful without employees, which is anomalous.

These questions are incorporated into the browsing interface of ASK Michael in the context of passages they index just as any other non-anomalous question would. However, these questions can stand alone as relevant indices independent of a specific passage because they are intrinsically interesting. ASK Michael's "Interesting Themes" zooming interface is based on this idea. Like the browsing interface of the system, it invites the reader to select a question from one of its categories. It employs a taxonomy of anomaly types generated from the interrogative function categories to organize questions in the interface. The taxonomy was formed by adding an indicator of anomaly to the label of the

**Unusual Elaborations:** Adjustments to the specificity of an unusual topic under consideration and slight digressions like clarifying the meanings of strange terms or describing odd situations in which the topic arises.

*strange contexts:* unusual contexts within which a piece of information fits.

*unusual specific:* odd example of a general principle or strange details of a situation.

**Strange Explanations:** Explaining or giving unusual background and describing odd outcomes as a means of gaining understanding.

*atypical causes (or earlier events):* how unusual situation developed.

*strange results (or later events):* odd outcomes of situations.

**Odd Comparisons:** Making strange comparisons with other situations at the same level of abstraction as the current situation as a means of gaining understanding.

*surprising analogies:* unexpectedly similar situations from other contexts.

*unexpected alternatives:* especially unusual approaches in other contexts.

**Unusual Applications:** The application of unusual knowledge or carrying away an odd lesson, either negative or positive, for use in the reader's situation.

*odd opportunities:* advice about strange things to capitalize on in a situation.

*strange warnings:* advice about odd things that can go wrong.

Figure 4-12: The Intrinsically Interesting Question Categories

normal interrogative categories. The modified categories are listed in Figure 4-12.

## Summary and Conclusion

Questions form the basis of the four different models presented in this chapter which are intended to meet the four requirements of conversational reading.

- The interrogative and topical question taxonomies are designed to make reading coherent. This **model of conversational coherence**, inspired by Schank's (1977) "Conversational Associational Categories", is based on the simple observation that questions have an easily identified interrogative function as well as topical content. An abstract version of the interrogative taxonomy organizes the reading interface of ASK Michael, and a more detailed version improves the efficiency of question-based indexing of the system.
- The **question-answering model** is the basis of a method of indexing text so a reader's interests will be satisfied. It goes beyond providing simple answers to individual reader questions to support the rich indexing necessary for exploring text via a coherent pattern of follow-up questioning.
- The recognition **model of question-based interaction** lies behind the requirement to make reading a responsive question-and-answer dialog. By actually displaying with each passage the questions likely to be raised by it in the mind of a reader, the system can provide him or her a menu of questions to ask, thus avoiding the problems of natural language understanding that a free-text question-asking model would create.
- The **model of interestingness** provides less interested readers with a means of generating an interest. It is based on the combination of Schank's (1979) theory of interestingness and the taxonomy of interrogative functions. Based on this model, indexers compose intrinsically interesting questions for the browsing and question-based zooming interfaces of ASK Michael. The categories of this model also organize ASK Michael's question-based zoomer.

These models are responsible for the level of functional integration in ASK Michael's zooming and browsing interfaces. The zoomers of ASK Michael function together to cover the basic kinds of prior interests and questions a reader may have before or develop during reading. The "Story Sets" zoomer provides a reader with *general topical* access to the network of stories. The "Story Titles" zoomer provides direct access to any story in the database for a reader interested in a *specific topic*. The "Overview" zoomer depicts the *abstract topical*

*relationships* between topics in the database. The browsing interface presents the *specific relationships* between stories in the database to the reader. Finally, the "Interesting Themes" zoomer addresses the reader who may not have developed an interest in the ASK Michael content. Whether a reader's interests are developed or undeveloped, general or specific, relational or featural, ASK Michael has an interface that applies.

This chapter has described the theory of questions that underlies the design of the interfaces for and the conceptual indexing of ASK Michael in terms of four interrelated question-based models. The next chapter describes the actual practice of the question-based indexing of systems like ASK Michael.



## Chapter 5

# Question-Based Indexing

### Introduction

The utility of a system such as ASK Michael depends entirely upon the quality of its indexing links. The generation of these links is therefore critical in the construction of such systems. However, the generation of semantically meaningful indices for hypertext systems is in general a difficult problem, which remains something of a black art, dependent upon the efforts of talented and experienced individuals (Spiro and Jehng 1990; Bareiss and Osgood 1993). The practical construction of ASK Michael-style systems requires the specification of a well-defined and efficient method of index generation. In this chapter, I present the question-based indexing method developed during the construction of ASK Michael.

The question-based method depends mainly upon the enumeration of a set of questions raised by each segment of text in the target content, and a set of questions answered by that segment. The final product of this process is a network formed by connecting segments that raise particular questions to other segments that answer those questions.

Figure 5-1 provides an example of question-based indexing. Initially, the indexer reads the text and composes questions like those depicted in the figure. The indexer then scans the questions recorded for all passages looking for

matches between questions raised and questions answered. A match becomes a link in the target system. For example, Question 1 raised in Passage 1 matches Question 4 answered in Passage 2. The match forms a link between the passages labeled by Question 1.<sup>25</sup>

PASSAGE 1: While weak in natural endowments, Germany enjoys other advantages decisive to upgrading industry. One is a pool of high-wage but highly educated, skilled, and motivated workers. German workers take unusual pride in their work, particularly in producing quality goods. Germany also enjoys a large number of qualified, white-collar personnel, especially in scientific and technical fields. It has a deep scientific and technical knowledge base, dating back to the late nineteenth century when Germany was the birthplace of modern science. Infrastructure is also well developed and of generally high quality, though not a compelling advantage in any industry. (CAN: p. 368)

A Question raised:

(1) *What contribution to competitive advantage do natural resources in Germany make?*

A Question answered:

(2) *What special contributions to industry success come from the German labor force?*

PASSAGE 2: Germany enjoys relatively few natural resources and almost none that had remained a significant advantage in international competition in recent decades. Iron ore and coal reserves were important to the formation of the steel industry. German coking coal deposits are among the finest in the world, and coke and related items represent the one German industry with a major export position that is closely tied to raw materials. The German chemical industry historically used coal as a feedstock, though it became the world leader while it still imported coal tar from Britain.

However, Germany's overall situation is one of disadvantages not advantages, in natural factors. Many natural resources are not found in abundance, and arable land is in tight supply relative to domestic needs. Energy costs are relatively high. The northern regions of Germany with the greatest natural endowments are in economic decline. What is now East Germany contained some of Germany's most abundant resources. Yet Germany's loss of natural factors of production may have been a blessing in disguise. It created pressures to move into more technically advanced industries and segments. (CAN: p. 368)

A Question raised:

(3) *How have West Germany's natural resource problems become a blessing?*

A Question answered:

(4) *How much has Germany's natural resource base contributed to overall competitiveness?*

Figure 5-1: An Example of Question-Based Indexing

<sup>25</sup>Note that this is not a direct syntactic link; issues in question-matching will be discussed later.

The question-based indexing method consists of four steps which are carried out with the assistance of a computer-based indexing tool. The steps are:

1. **Preparation for Indexing.** In this step, the indexer characterizes likely readers in order to better target indexing results to the identified reading audiences.
2. **Content Analysis.** In this step, the indexer segments the text into passages. He or she lists the *questions raised* and the *questions answered* by each passage in preparation for the relative indexing of passages for the browsing interface of ASK Michael.
3. **Question Classification.** In this step, the indexer assigns each question raised and each question answered a *topical category* and one or more *conversational categories*. The conversational categories are used to classify the interrogative purpose of questions. These two taxonomies reduce the complexity of searching through lists of questions during question-linking and assure the coherence of ASK Michael's browsing interface.
4. **Question-Linking.** In this step, the indexer selects sets of questions raised and answered by topic and conversational category and infers matches. He or she then verifies the appropriateness of each link and the question that labels it.

The remainder of this chapter is organized around the four steps of question-based indexing, illustrated with examples from the actual indexing of the ASK Michael system.

## Step One: Preparation for Indexing

A user of ASK Michael will generate questions, as he or she reads. These questions may result from the reader's lack of *knowledge* that is required for comprehension of the text, from the idiosyncratic *interests* of the reader, or from the requirements of a *task* the reader is engaged in. Indexing the text requires an indexer to predict the questions that will be raised by typical readers. In effect, the indexer must engage in a form of *role-playing*, approaching the text as he or she imagines a particular reader might and generating the questions that might be expected to occur to that person. While in the final analysis success at this process depends upon the intelligent imagination of the indexer, the role-playing process can be organized and directed to maximize the chance of generating likely questions.

Every individual user of the system will, of course, have his or her own idiosyncratic interests and concerns. Furthermore, it is virtually impossible for a single indexer to read a passage and imagine every question anyone might form about that passage. A better approach is to make a list of plausible reader "profiles" before beginning the indexing process, and systematically consult them during indexing. Figure 5-2 presents a list of roles for ASK Michael

**Sample Experienced Reader Roles**

1). I am an amateur student of international corporate competitive strategies. How do national policies impact corporate competitiveness?

2). I am participating in an international finance seminar at the local community college. How does the current international business climate compare to the climate 10 years ago?

**Sample Novice Reader Roles**

1). I want to invest in some diversified multi-national corporations. What should I watch out for?

2). I am a high-school senior who has to write a paper for my current events class about how some company in a foreign country got to be successful in making a product for the US market. What foreign products and companies have been especially successful in the U.S.?

Figure 5-2: Modeling Reader Roles

indexers.

## Step Two: Analysis of Source Content

Analysis of the source material is central to its indexing. The ASK Michael approach consists of three analyses, conducted in succession: (1) breaking the text into manageable, self-contained units or *text segments*, (2) enumerating *questions raised* by a segment,<sup>26</sup> and (3) and enumerating *questions answered* by a segment. The results of each analysis are recorded relative to a specific passage from CAN.

### Analysis 1: Segmenting Stories<sup>27</sup>

Segmenting a text in an intelligent and principled way can provide a reader with background necessary for comprehension and help a reader maintain interest in the text. To achieve these goals, the indexer must segment the text into relatively self-contained units. The content of each unit should be limited to making a single main point. Each unit should also contain enough material to stand alone as a coherent whole. Achieving this balance underlies the segmenting methods

<sup>26</sup>Indexers of Trans-ASK segmented text and developed questions answered in one step, and combined the questions raised and linking activities in a second step. They did not make a questions raised list prior to linking. This approach takes advantage of the limited availability of answers, propagating them to the stories where they may be raised. However, it provides no method of extending the acquisition of knowledge to other sources, because it creates no record of the kinds of knowledge needs a reader may develop during reading.

<sup>27</sup>The term "story" will be used interchangeably with the term "passage" in this chapter. It has come into use among researchers at the Institute for the Learning Sciences to describe a unit of media that has coherence and makes a point. It is not limited to narrative, but includes most genres of information.

developed for ASK Michael indexing.

### Segmentation Methods and Problems

During the construction of ASK Michael, the text of CAN was initially segmented by the *topical structure* found in the headings and sub-headings of CAN.

However, the heading structure of CAN was often not fine-grained enough to produce segments that answered a single main question. Smaller segments were defined by identifying *topic shifts* within the CAN sections. For example, the CAN section about Switzerland with the heading "The Role of Government"

The Swiss government has historically had a benign or positive influence on national competitive advantage in Swiss industry. The Swiss federal system has guaranteed little intervention in most industries. Subsidies are low by international standards, and public spending is modest. Swiss companies have been free to internationalize, and government-business relations are generally pragmatic and oriented toward problem solving. The Swiss government at the various levels has had a good record in factor creation, particularly in the area of education.

Swiss neutrality and political stability have played a positive role in industry. Swiss companies are politically acceptable in nations where firms from other nations are not. Commercial contacts have always been possible with all three major European power centers (France, Germany, and the United Kingdom). Switzerland has attracted regional headquarters of foreign firms as well as international organizations and institutes such as the United Nations and CERN, the leading European center for nuclear research. These employ highly skilled people and create sophisticated home demand that is uniquely internationalizable for some products and services. (CAN: pp. 327-328)

#### — SEGMENT BREAK —

Competition policy is perhaps the single greatest weakness in Swiss government policy toward industry. In areas such as telecommunications, brewing, truck manufacture and others, protected local monopolies or sanctioned cartels have led to inefficiencies, lack of innovation, and sometimes large-scale failures (such as the low- and medium-priced watch industry and the leading truck producer, Saurer). Other cartels have artificially driven up the price of imported goods, and government has sanctioned or created standards and regulations that result in de facto protection for still other Swiss industries. The result, as in Japan, is a dual economy in which many competitive industries stand in stark contrast to a large group of inefficient and protected sectors.

Swiss government intrusion in banking has also had significant costs. The imposition of transaction taxes has driven away important markets from Switzerland in areas such as precious metals trading, Eurobonds, investment banking, and mutual funds. There is also a growing tendency for the Swiss government to regulate firms in areas such as environmental protection, labor, and social security. While some of these regulations will benefit Swiss industry by sensitizing Swiss firms to problems that will become important elsewhere, on balance the trend is ominous. Many Swiss regulations, such as restrictive labor regulations governing such things as overtime and night work, are creating rigidities that will blunt innovations and upgrading. (CAN: p. 328)

Figure 5-3: The Segmenting of Text

shown in Figure 5-3 begins with a description of the positive role of government in Swiss industry and concludes with the negative role. This passages was broken into two segments, each making a single main point. In general, segments that make only a single main point are the ideal, provided they supply enough background to be read without confusion. This segmenting strategy of looking for topic shifts in the lowest level of heading structure insures that a less knowledgeable reader will receive much of the background needed for understanding.

However, when pursuing an answer to a specific question, a knowledgeable reader may want to skip the background material to view that portion of a segment that most directly answers the question. To accommodate this reader, the portion of the segment that directly answers a specific question must also be identified. When a question is composed as described in the following sections of this chapter, the indexer can mark a specific portion of the segment to which the question most directly applies. The ASK Michael program can use this identified portion of a segment to scroll a display text segment directly to an answer. The first time a reader navigates to a passage, the system positions him or her at the beginning of the segment. For subsequent entries to the same passage, the system positions the reader at the portion of the segment that provides the specific answer to the question.<sup>28</sup>

### **Analysis 2: Generating the Questions Raised by Each Segment**

In the second phase of content analysis, the indexer analyzes a text segment in an attempt to predict the questions it may raise in the mind of a reader. One important aspect of predicting questions raised involves effectively predicting four kinds of reader ignorance (Dehn 1989) which correspond to the four kinds of the conversational categories described in Chapter 4. A reader may lack topical knowledge (elaboration) , causal knowledge (explanation), comparative knowledge, or application knowledge. These forms of potential reader ignorance specify the types of questions an indexer should produce.

A novice reader especially requires *background* knowledge, which consists of basic topical and casual knowledge of the domain—the first two kinds of conversational categories. Background questions arise during reading when unfamiliar terminology is used or too much knowledge of basic domain structure and dynamics is assumed by the text (Spiro, et al. 1988).

A more knowledgeable reader may have background knowledge but may lack *applied* knowledge—the last two kinds of conversational categories. Applied questions arise during reading when a reader tries to use advice given directly in the text or constructed from it by comparison with existing cases.

Because of the non-linear arrangement of text in ASK Michael, a reader

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<sup>28</sup>This facility is similar to the Intermedia blocks and links capability (Yankelovich, et al. 1988). Because the solution was arrived at late in the indexing process, the ASK Michael system has only a few links of this type.

also lacks a fifth kind of knowledge. He or she will require knowledge of the *reading context* established by the original author. Reading context questions arise when a reader, who has been skipping around in a text, is unaware of what the author has covered earlier in the material.

Simulating ignorance of background material, applied material and the reading context was difficult in ASK Michael indexing. As an indexer learns the source material incidentally through the reading necessary for analyzing it, he or she has progressively more difficulty writing questions raised. To prolong his or her ability to simulate reader ignorance, an indexer can read segments in reverse order to disable the book author's plan for building up this knowledge in his or her reader. He or she can systematically analyze the author's background passages and context setting passages after analyzing the passages for which they are prerequisites.

Questions predicted from these forms of ignorance must reflect the reader's purpose in asking. The premise behind ASK Michael indexing is that the reader has broader goals than just obtaining a simple answer to a single question. The indexer attempts to capture these goals by looking one step beyond a predicted reader question to the purpose the reader may have in asking it. For example, in analyzing the story "The Printing Press Industry", the indexer predicted this question would be raised:

(5) *Who invented the printing press?*

It would be a mistake to view this question simply as asking for a single word answer: "Gutenberg". Such questions actually involve a broader interest, in this case, perhaps, an interest in the historical context. Thus, a highly specific question like Question 5 invites an indexer to make links to stories that cannot support a reader's additional questions. This can be remedied to some extent by replacing narrowly conceived questions with questions general enough to cover an entire area of interest. For example, Question 5 was replaced by the question:

(6) *What is the origin of the printing press industry?*

Based on an indexer's simulation of ignorance and attention to likely follow-up questions, I have developed three specific techniques for composing questions raised.

#### Technique 1: Questions Raised Through Direct Analysis

An indexer can use the five kinds of likely reader ignorance as a checklist of suggested questions to raise. Through modeling this ignorance, a number of questions will come to mind directly as a passage is read. Many will be answered within the same passage and are not incorporated in the indexing. Others will remain unanswered and are recorded. For example, from a simple reading of the text in Figure 5-4, the indexer recorded Question 14 (topical knowledge),

Information availability in Switzerland represents another weakness for the upgrading process. It lacks a well-developed business press, and most Swiss rely on foreign publications. Government statistics are nearly nonexistent. Few studies and reports are available to create an awareness of future competitive and technological developments. Each Swiss company and budding Swiss entrepreneur must create information to a far greater extent than in nations such as Japan and the United States. (CAN: p. 321)

Questions raised:

- (7) *Why doesn't Switzerland have a well-developed business press?*
- (8) *What are the other weaknesses in the Swiss upgrading process?*
- (9) *What impact does having to create and maintain its own information have on a Swiss company's competitiveness?*
- (10) *Why doesn't the government produce economics statistics?*
- (11) *What statistics are available in other nations like Japan and the U.S.?*
- (12) *What's an example of another government that does not keep statistics?*
- (13) *What are economics statistics used for?*
- (14) *What reports and statistics do companies in Switzerland create?*

Figure 5-4: Text-Based Questions Raised

Questions 7, 9 and 10 (causal knowledge) , Questions 8, 11 and 12 (comparative knowledge), and Question 13 (application knowledge). Answers to these questions also provide knowledge of the reading context.

Technique 2: Questions Raised by Comparisons in the Text

A complex text will, in general, contain many implicit and explicit cross-references to other passages. An indexer can easily locate text-based comparison and stated question cross-references in the text because only a shallow understanding of the context is required. For example, in Figure 5-5, the indexer predicted that a passage about exports of one nation would raise questions about exports of another nation and recorded these instances of implicit comparison with the export positions of Japan and Korea. Figure 5-6 gives examples of several questions that Michael Porter explicitly enumerates in the text. The indexer extracts these questions raised and associates them with the immediately preceding text.

The top fifty industries in terms of export share account for 42.4 percent of total Swiss exports. This figure falls to 37.6 percent if the traded goods are eliminated and the next ranking industries substituted. The figure is lower than nations such as Japan and Korea and is indicative of the wide range of Swiss market positions.(CAN: p. 308)

In-Text Comparison Questions raised:

- (15) *What is the range of market positions in Japan?*
- (16) *What is the range of market positions in Korea?*

Figure 5-5: Text-Based Comparisons



Was American confidence misplaced? Did America emerge from the 1960s as an environment in which many industries could renew and regenerate themselves? Were American companies too preeminent and too complacent? These questions will serve as a useful backdrop against which to examine the postwar economic development of other leading nations. (CAN: p. 307)

Explicit-Text Questions raised:

- (17) *Was American confidence misplaced?*
- (18) *Did America emerge from the 1960s as an environment in which many industries could renew and regenerate themselves?*
- (19) *Were American companies too preeminent and too complacent?*

Figure 5-6: Explicit Text-Based Questions

### Analysis 3: Generating the Questions Answered

In the third phase of the content analysis, the indexer composed a list of questions that a text segment can answer. I developed two techniques to generate questions answered. An indexer can compose questions directly from the points made in the text and can generate additional questions answered from the text structure itself.

#### Technique 1: Producing Questions Answered from Story Points

The indexer can identify questions answered by extracting the main point and subordinate points from each text segment. Each segment makes a main point that can be translated into a *point question*. For example, one story's main point describes the intellectual assets of the postwar U.S., and the indexer records the corresponding question:

- (20) *What intellectual assets did the U.S. acquire during WWII?*

The indexer also converts subordinate points into questions. For example, one subordinate point of the same story led the indexer to compose the question:

- (21) *How did the American university system contribute to postwar U.S. economic success?*

To generate questions, the indexer must not only locate points in the text, but he or she must also select an appropriate level of abstraction for the corresponding questions. If the indexer is to produce high quality links between passages via question-matching, questions answered must be composed at a level of abstraction representative of the content of the passage from which they were taken. The indexer of ASK Michael composed general questions for the maximum level of abstraction the passage can support and specific questions to represent the major subordinate points of a text. The most abstract question of a passage is its point question, for example, Question 20.<sup>29</sup>

<sup>29</sup>See the section on vagueness and ambiguity in question-matching later in this chapter for

(such as timber and soybeans) and in those where technological and skill requirements are modest and technology is widely available. An example is the construction of civil projects (such as apartments and schools) with a low engineering content. Korean firms have enjoyed international success in such projects, based in part on the availability of low-cost disciplined Korean labor. However, firms from nations with even lower wages are supplanting Korean firms, and competitors from more advanced nations such as Italy are sourcing cheap labor pools locally in nations where they bid on international contracts or from other developing countries (for instance India), nullifying the Korean advantage. (CAN: p. 77)

Figure 5-7: Balancing the Representation of Details

Composing specific questions can be difficult. Not every sentence makes a point worthy of a question answered. When indexing ASK Michael, the indexer analyzed a text segment *for the points it makes, not for every fact it states*. From these points are composed questions predicted to satisfy the general reader. Questions based on other details of the text should be omitted. For example, a sentence in Figure 5-7 states that "Korean firms have enjoyed international success..." An indexer should not reflexively compose the question: "Did Korean firms enjoy international success....?" unless the question forms a good index to one of the points of the passage. One of the specific points of the story is the contrast of basic and complex factor conditions. This question answered for the story in Figure 5-7 reflects that point:

(22) *What's the difference between a basic factor condition and a more complex one?*

Basic factors remain important in extractive or agriculturally-based industries. The indexer's prediction of how satisfying a passage will be as an answer to a reader's question serves as the guideline for how specific a given question answered should be.

### Technique 2: Representing the Structure of Documents as Questions

An indexer can miss two kinds of relationships in the source material. First, he or she may not consistently generate indices to background material essential for understanding stories; and second, he or she may not catch important, but often implicit connections between sections of the source text that have been arranged by the author for the specific purpose of cross-comparison. To solve these problems, the indexer can generate additional questions answered from the pre-existing heading structure of the source material. These questions standardize the background material made available to readers and create complete cross-referencing of parallel sections in the content.

Before questions drawn from the structure of the text can be reliably composed by the indexer, he or she must first represent the heading structure. Two levels of representation are needed, one to label the sections that contain the

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details.

- 1). **The German Printing Press Industry:** A disagreement between the developers and their backers played a large role in the early relocation of the printing press industry from England to Bavaria, a major factor in the industry's success.
- 2). **The U.S. Patient Monitor Industry:** Innovation in electronics spurred by World War II gave the US patient monitoring equipment industry an advantage over the older European industry.
- 3). **The Italian Ceramic Tile Industry:** Reconstruction of a devastated Italy after World War II, coupled with scarce wood supplies produced strong demand for ceramic tile giving rise to the Italian success in that industry.
- 4). **The Japanese Robotics Industry:** The Japanese improved the quality and reliability of robots they imported from the US to gain the advantage in that industry.

Figure 5-8: Parallel Content between Story-Sets in ASK Michael

material the author is comparing and another to group these sections together. *Story-sets* represent the sections to be compared. The *supertopic* groups the sections together. The passages within each story-set contain the specific topical elements to be compared. For example, in CAN Chapter 5, Michael Porter presents four competitive successes in different industries that can be grouped under the "Manufacturing Industry" supertopic. Each of the four story-sets within the supertopic has the same outline: introduction, early history, domestic rivalry, factor creation, home demand, and summary. The paraphrases of four industry passages shown in Figure 5-8 illustrate the kind of parallelism found across the four story-sets.<sup>30</sup> These passages all deal with the history of one nation's success in an industry.

#### Standard Background Questions for Story-sets

Browsing frequently leads a reader to the stories of a particular story-set, from other story-sets far removed from the immediate context. Similarly, less knowledgeable readers may lack sufficient background to understand a story. *Standard background questions* direct a reader back to other parts of the story-set that provide background and context knowledge. For example, in the story-set concerning "The German Printing Press Industry", some of the standard background questions are:

- (23) *Who are the world leaders in the printing press industry?*
- (24) *What are the three types of printing techniques?*
- (25) *How long has Germany dominated this industry?*
- (26) *Where did the printing press come from?*

<sup>30</sup>These representations of topical structure and the introduction and summary passages contained within the structure were used in the construction of the zoomers of ASK Michael.

The answers to these questions provide background across the whole story-set. The indexer of ASK Michael formulated a group like this for each story-set and distributed it so that the reader could ask them at each segment of the story-set.

The indexer uses several techniques to produce standard background questions. First, the main point question of each passage serves as the default source of standard background questions. Second, a review of other questions answered by each passage may uncover some that are of particular help in understanding the whole story-set. Third, some questions answered are intrinsically interesting and may be included in the standard background grouping to keep a reader engaged.<sup>31</sup> Finally, the text contains signals to the location of background material, for example, "Before we begin...." or "Now that we have introduced...."

#### Related Topic Questions for Story-sets

The supertopic/story-set structure assists the indexer in generating a set of questions that capture the parallelism of the content. Explicitly representing parallelism in question form provides the reader with specific content cues to the related passages. For example, four story-sets containing passages drawn from Chapter 5 of CAN list the top fifty industries. Two are depicted in Figure 5-9 for illustration purposes. Question 27, a question answered for Switzerland, was

<p><u>Top Fifty Industries in Switzerland</u> Table 7-5 lists the top fifty Swiss industries in 1985 in terms of world export share. (CAN: p. 308)</p> <p><u>Related Topic Question Answered</u> (27) <i>What are the top 50 industries in Switzerland?</i></p> <p><u>Related Topic Questions Raised</u> (28) <i>What are the top 50 industries in the U.S.?</i></p> <hr/> <p><u>Top Fifty Industries in the U.S.</u> One way to gain an initial understanding of the patterns of competitive success in U.S. industries is to examine the top fifty American industries in 1971 in terms of share of world exports, shown in Table 7-2 (I will discuss data for 1985 in Chapter 9). (CAN: pp. 284-286)</p> <p><u>Related Topic Question Answered</u> (29) <i>What are the top 50 industries in the U.S.?</i></p> <p><u>Related Topic Questions Raised</u> (30) <i>What are the top 50 industries in Switzerland?</i></p>
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Figure 5-9: Parallel Passages for Related-Topics Questions

<sup>31</sup>A model of interesting questions was discussed in Chapter 4.

added to the passages for the Postwar U.S., Sweden, and Germany as a question raised. The process was repeated with the Postwar U.S., Sweden, and Germany serving as the sources of questions answered respectively. For each parallel segment of a story-set, the indexer produces a set of *related topic* questions (one for each of the other parallel story-sets) to provide the basis for cross-connecting parallel segments during question-matching.

In summary, developing questions answered is a knowledge-intensive activity for an indexer. He or she must read and understand the text, then formulate both abstract, "big picture" questions and detailed questions leaving unimportant or incompletely developed details unindexed. The indexer can develop additional questions from the topic structure of the source material represented by story-sets within supertopics. From story-sets, the indexer can identify some questions as necessary background questions answered. He or she can also prepare for the linking of parallel passages by adding related topic questions.

### **Step Three: Question Classification**

In the third step, the indexer of ASK Michael classifies the questions produced by content analysis. Similar questions raised and answered can be grouped by category to facilitate question matching, the primary method of locating links in question-based indexing.

However, questions raised and questions answered differ in an important respect that affects classification. For matching to be successful, the meaning of a question raised must be construed narrowly enough to classify it as unambiguously as possible. In contrast, the meaning of a question answered should be construed broadly enough to classify as many of its ambiguous senses as possible. The broad classification of questions answered relative to questions raised maximizes the chance that an answer can be found for a given question raised within a given question category.

To classify questions, an indexer employs taxonomies for both the topic and the interrogative purpose of questions—the same basic taxonomies used respectively in the zooming and browsing interfaces of ASK Michael. The indexer assigns a question, first to one or more topic classes, then to one or more conversational categories. These two classification schemes operate independently to cut the complexity of matching.

#### **Topical Classification**

The indexer can classify questions by *topic* as determined by the story-set to which it belongs and by the concepts contained in the text of the question itself.

First, a question inherits the name of the story-set in which it originates as its primary topical classification. For example, in ASK Michael "Postwar U.S." is the name of the story-set that encompasses the stories about the United States'

rise to economic prominence after World War II. Each question raised or answered in every passage within the set received the topic label, "Postwar U.S."

Second, the indexer assigns additional topical categories to questions that contain references to topics corresponding to other story-sets. For example, within the German story-set in ASK Michael, the question "How does Germany's postwar success compare to that of the U.S.?" also received the "Postwar U.S." topic label because it mentions the "U.S." An indexer need not make fine-grained topical distinctions because topical categories are kept very general. They are only intended to narrow the context in which matching is performed by the indexer; they do not directly produce the matches.

The classifications formed by topical labeling of questions have several uses beyond managing question-matching complexity. First, they form the topical zooming interface for the reader. Second, the topical classes can become a way of organizing and accessing stories during the indexing process. The classes can form local environments by which to subdivide indexing work. For example, one indexer can work on linking "Germany" stories while another can work on "Switzerland" stories which can make it easier for an indexer to produce the close connectivity that should exist among members of a story-set. Cross-links between the story-sets can be added when the work of the indexers is combined.

### **Conversational Classification**

Independent of topical classification, the indexer determines the interrogative purposes of questions and manually assigns them one or more subcategories of the detailed taxonomy presented in bold type in Figure 5-10. This dual classification of questions facilitates the matching of specific questions raised with specific questions answered.<sup>32</sup>

The eight conversational categories of ASK Michael's browsing interface form the top level of the taxonomy of interrogative purposes. However, the top level categories are somewhat too general to make the fine-grained distinctions that are useful in reducing the complexity of indexing. A more specific classification facilitates question-matching by grouping questions of more specific (less ambiguous) types. For ASK Michael indexing, the specific taxonomy of Figure 5-10 was empirically derived by analyzing over 2,000 questions produced during the content analysis of CAN. The detailed question subcategories were grouped under the appropriate conversational category as shown. (See Chapter 4 for a more detailed description of these categories.)

Classifying questions requires an indexer to understand each question's meaning before assigning it to a subcategory. Sometimes, determining the precise meaning of a question can be difficult. Questions may contain ambiguities, misleading semantics, combinations of subcategories, expressions of quantification, and requests for verification of some state of affairs—all of which

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<sup>32</sup>See Chapter 4 for details on the purpose of using questions as indexical representations as well as for the details of the conversational classification model.

TOPIC ELABORATION	COMPARISON
<u>Context</u> 1. Context 2. Attitudes <u>Specifics</u> 1. Explicit Details a. Amount b. Parts c. Kinds d. Facts or Details 2. Implicit Details or Examples 3. Concept Definitions 4. General Descriptions	<u>Analogies</u> 1. Simple a. Superlatives/diminutives b. Comparatives c. Comparables 2. Complex a. Patterns b. Relationships <u>Alternatives</u> 1. Contrasts 2. Parallel Related Topics
EXPLANATION <u>Causes</u> 1. Causality a. History 1). Origins 2). History b. Causation 1). Causes 1). Impersonal Mechanisms 2). Personal Means 2. Enablements/Impediments a. Reasons b. Resources c. Roles <u>Results</u> 1. Agent Actions 2. Temporal Events 3. Future Predictions 4. Actual Results	APPLICATION <u>Opportunities</u> 1. Abstract Advice a. Inferred 1). Personal Purposes 2). Object Uses 3). Process Functions b. Actual Lessons 2. Specific Opportunities 3. Hypothetical Advice a. Hypothetical Lessons b. Advantages <u>Warnings</u> 1. Warnings 2. Problems

Figure 5-10: The Conversational Taxonomy

complicate classification.

### Disambiguating Questions

As natural language representations, the interrogative purpose of questions is often ambiguous, which can cause an indexer to assign semantically different questions to the same class. For example, consider this question about design:

(31)      *How is a robotics system designed?*

This question requests either information about a design process (the *means* subcategory) or by implication, information about simply the elements of a robotics system (the *details* subcategory). The indexer classifies an ambiguous question by all of its meanings. An indexer cannot classify a question by its interrogative term alone to make correct assignments. For example, "How" does not just connote *means*. The domain concepts themselves, for example, "design",

enter into the determination (see, for example, the integrated processing hypothesis of Birnbaum 1986).

### Classifying Questions with Misleading Semantics

A question may have misleading semantics which can cause an indexer to misclassify it.<sup>33</sup> To solve the problem, an indexer again applies his or her knowledge of domain concepts. Consider the following two examples. In the first example, a question concerns a definition or *description* of an entity called a strategy:

(32) *What was the chief competitive strategy of the leading German printing press firms?*

A strategy describes a means of achieving a goal. So the question is actually semantically equivalent to the *means* question:

(33) *By what means did the leading German printing press firm gain a competitive advantage?*

In the second example, a "How" question might be misclassified as a *means* question:

(34) *How is basic research conducted in the German printing press industry?*

More appropriately understood, this is a question about the *kinds* of research that are done in the press industry:

(35) *What kinds of research are done in the German printing press industry?*

Should an indexer correctly classify Question 35, but misclassify Question 34, the opportunity to match them during question-linking will be missed.

To solve this problem, an indexer must take care to semantically process questions during classification and not be overly influenced by their morphology or syntax. These examples illustrate that composition and classification of questions cannot be done without a grasp of basic domain concepts, like "strategy".

### Combinations of Conversational Subcategories

Questions often contain phrases that fall in two or more conversational subcategories. Before describing the technique employed in ASK Michael indexing, consider the kinds of combinations that can occur. Some combinations are a product of the domain concepts themselves. For example, this question contains a combination of the *means* subcategory (see Question 31 above) with a

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<sup>33</sup>A reader might also misclassify a question he or she has raised. The indexer can anticipate these misclassifications during link formation by placing a copy of the link in the corresponding class of the browsing interface.



The composition of the Swiss economy is like that of the German economy (see below) in a number of respects. Both have strength in chemicals, machinery, machine tools, precision mechanical goods, optical products, and textiles. Switzerland's position in these industries, however, tends to be more specialized and focused on the most sophisticated segments. German companies tend to offer broader lines, though they also usually compete via differentiation. Switzerland's position is much stronger than Germany's in services and in marketing-intensive consumer goods. Germany, in contrast, is strong in materials and transportation equipment where the Swiss position is minor. Both the similarities and differences between the Swiss and German economies are instructive for understanding the sources of national advantage. (CAN: p. 318)

Figure 5-11: A Comparison Story

*superlatives* qualifier:

(36) *What's the most expensive part of robot design?*

Given the *superlative*, "most expensive", the indexer is faced with the problem of how to classify this question as *superlative means*.

Other combinations arise out of the topic mirrored in each question raised and answered by the passage. For example, the story presented in Figure 5-11 is cross-topical which complicates conversational classification of the questions raised and answered by it. This question involves *comparison of details*:

(37) *What industries are both Germany and Switzerland strong in?*

When classifying a question containing a subcategory combination, the indexer was forced to place it in all the subcategories of the combination (Bareiss and Osgood 1993)—the solution adopted for handling ambiguous questions. In principle, this simple feature vector scheme cannot represent the meaning of composed subcategories, but this compromise turns out to be sufficient for indexing as long as the collections of questions are small—a few dozen per subcategory. However, as systems grow beyond a few hundred stories and a few thousand questions, a more expressive method of representing the meaning of composed subcategories may become necessary.

The compromise also causes the location of a link in the browsing interface to become ambiguous. The solution to this problem can be formed by viewing the conversational taxonomy as a model of strategic search for information which an indexer can use to select a single location for a multi-class question. An indexer anticipates a reader's pattern of searching for questions to ask. A reader first looks for direct advice (the Applications categories of *Warning* and *Opportunities*). Should that search fail, he or she may locate applicable advice in comparable situations (the Comparison categories of *Analogies* and *Alternatives*). Should that search fail, the reader may construct advice from causal knowledge of the domain (the Explanation categories of *Causes* and *Results*). Finally, if all else fails, the reader may turn to the basic details, contexts, examples, and facts of the domain for some help in developing an understanding

of the domain from which advice might be constructed (the Topic Elaboration categories of *Context* and *Specific*).

By assuming that readers use this strategy, an indexer can transfer a question occurring in several categories to the browsing interface of ASK Michael in the category of highest precedence in this search order.

### Expressions of Quantification in Questions

When a text raises or answers a question regarding a specific quantity, for example, "how many" or "how much", qualitative as well as quantitative matches can be adequate responses. For matching to succeed, the indexer must not presuppose one specification of quantity over another when classifying questions; questions requesting a quantity must be classified identically. For example, some questions that request quantities are:

- (38) *How much of Japanese production is exported?*
- (39) *How many manufacturers produced robots in 1980?*
- (40) *How important is software to robot design?*
- (41) *How profitable is the robotics industry?*
- (42) *How highly automated can a plant be using robots?*
- (43) *How big is the Japanese robotics industry?*

"How much", "how big", "how many" request quantitative answers, but "how important" or "how highly automated" request qualitative answers. "How profitable" is ambiguous. The indexer of ASK Michael assigned the subcategory *amount* to any question containing quantification to avoid distinguishing among these interrogative terms which could inhibit question-matching.

### Reformulating Verification Questions

Verification questions are generally composed of a statement of presumed fact prefixed by "Is it true that..." and for that reason might be classified as *details*. For example, consider this request for confirmation:

- (44) *Is it true that Germany dominates the printing press industry?*

In the context of a sustained interaction with a system like ASK Michael, such answers would prove to be insufficient and a terse "yes" or "no" answer would inevitably be followed by other questions, for example, "Why...?", a *reasons* question. In the rare instances in which an indexer composed a verification question, it was classified by the subcategory of the probable follow-up question. In most cases, the question was actually replaced by the most likely reader follow-up question when links were constructed for ASK Michael.

In summary, questions raised and questions answered are classified by topic and by conversational category to facilitate question-matching, the next step of

question-based indexing. Classifying questions conversationally was complicated by the problems of natural language understanding including question ambiguity, misleading semantics, compositions of subcategories, quantification and truth confirmation. In each case they were solved in ASK Michael by either an additional application of domain knowledge or an implementation compromise.

### **Step Four: Question-Linking**

The final step in the process of question-based indexing is to construct links between stories. The basic link in ASK Michael is produced by matching a question raised with a question answered drawn from the same topical and conversational categories. Question-linking is done in three phases: establishing limits, question-matching, and link formation.

First, each unique combination of topical and conversational category limits the scope within which an indexer matches questions. A computer-based tool was developed to organize and manipulate classified questions. The tool assists the indexer by displaying questions raised and questions answered within the scope of these class combinations.<sup>34</sup>

Second, the indexer matches questions drawn from the topically and conversationally equivalent sets developed using the tool. Each question raised and question answered within a group is a candidate for matching. Within the limits of the equivalence class, a human indexer can easily recognize the semantic connection between two questions.

Third, each match is converted into a link. An indexer selects a question raised and a question answered, and the indexing tool forms a default link for the indexer's approval. The indexer decides what wording changes (if any) are needed before accepting the link. The tool installs an accepted link between stories into the database. In the event that the two matching questions differ in meaning, the indexer also prepares a bridge that describes how a passage answers a question. A bridge is a simple phrase that appears in the link between the question raised and the name of the passage containing the answer. It provides the reader with the knowledge needed to understand the connection between the question and the answer that he or she will receive. The indexer repeats the second and third activities until all matching questions within the two sets have been identified.

In this section, I present examples of simple and complex question-matching as well as several additional ways to form links for ASK Michael.

#### **Forming Links by Simple Question-Matching**

Many question-matches require little inference. The indexer finds these links by

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<sup>34</sup>See the tool interface in Figure 5-14 in the next section.

- |      |   |
|------|---|
| (45) | <i>How is ceramic tile made?</i>                |
| (46) | <i>How is ceramic tile made?</i>                |
| (47) | <i>How is designer tile made?</i>               |
| (48) | <i>How is a designer tile made?</i>             |
| (49) | <i>What is involved in ceramic tile design?</i> |
| (50) | <i>How is tile manufactured?</i>                |
| (51) | <i>How is ceramic tile made?</i>                |

Figure 5-12: Ceramic Tile/*Means* Questions Raised

matching morphological or semantically equivalent questions. For example, Figure 5-12 shows the questions raised within the "Italian Ceramic Tile Industry" topic and the *means* subcategory of the conversational taxonomy. (Duplicate questions occur in

Figure 5-12 because these same questions were raised in several passages.) The questions answered in the same class are presented in Figure 5-13. Questions 45, 46, 50, and 51 in Figure 5-12 match question answered 52 in Figure 5-13. Using the indexing tool mentioned above, the indexer marks the four questions raised and the one question answered. The tool displays a candidate link; the indexer verifies its accuracy and saves the link.

- |      |  |
|------|--|
| (52) | <i>How are ceramic tiles made?</i>   |
| (53) | <i>How did the synergism of tile equipment producer and tile manufacturer help to insure Italian leadership?</i> |
| (54) | <i>How did home demand for ceramic tile help the Italian industry?</i>   |
| (55) | <i>What marketing channels for ceramic tile have recently been used Germany and France?</i>                      |
| (56) | <i>How did Italian manufacturers of tile market them abroad?</i>   |
| (57) | <i>How did the Italian ceramic tile industry open large new markets in the US?</i>                               |
| (58) | <i>How did Italian manufacturers of tile overcome the disadvantages of opening US markets?</i>                   |
| (59) | <i>How was the entry into the US market financed?</i>  |

Figure 5-13: Ceramic Tile/*Means* Questions Answered

### Forming Links by Complex Question-Matching

Indexers find it difficult to match questions differing in meaning and abstraction level. They face two problems: *question vagueness* and *question ambiguity*.

#### Vagueness in Question-Matching

Question vagueness is the problem of forming a link when one of the questions (either raised or answered) in one passage is about something general while the potentially matching question of another passage is about something specific. Questions can be vague *topically* and *conversationally*.

Vagueness may occur in the span of topics covered by a question. For a topically vague question raised, a representative answer is sufficient; a comprehensive answer is not needed, because a vague question raised implies a good deal of reader ignorance. Even a partial answer will be relevant to the reader. For example, the text may provide several stories that would answer the question raised:

- (60) *What impact did WWII have on European economic competitiveness?*

A general discussion of the common themes of European postwar reconstruction or even an interesting specific example would be acceptable answers. For example, any one of these questions answered could be matched to Question 60:

- (61) *What impact did WWII have on German economic competitiveness?*
- (62) *What impact did WWII have on English economic competitiveness?*
- (63) *What was the effect of WWII reconstruction on postwar French industry?*

Prior to matching, the indexer must have put Question 60 into the topic categories for the individual nations of Europe and the *results* conversational category. Combining taxonomies, an indexer can easily perform the match in the appropriate equivalence classes. For example, an indexer will find Questions 60 and 61 in the Germany/*results* combined class. The indexer can infer a match between them by noticing that a question about Europe can be answered in part by a passage providing an answer to the same question concerning Germany.

On the other hand, a topically vague question answered cannot be used by itself to match a specific question raised. It defines an upper bound, but not a lower bound on the applicability of a particular passage. It provides too little information about the content of a passage to be of use in matching topically specific questions raised. For example, suppose a passage has raised Question 64 and Question 65 is a potentially matching question answered.

- (64) *How is designer ceramic tile made?*
- (65) *How is ceramic tile made?*

No match can be inferred, because an indexer cannot assume that a passage about ceramic tile specifically addresses designer ceramic tile.

This problem was solved in ASK Michael by producing upper and lower bound questions answered for a passage as described previously in the content analysis section. After reading an entire passage, the indexer composes the most abstract question the passage can possibly answer to form an upper bound question. This question answered will match any similar question raised at the same level of abstraction or above. For example, given Question 65 as an upper bound for a passage, a question raised at its level of generality or above will match, such as:

- (66) *How are various types of floor and wall coverings made?*

The indexer also composes specific questions that a passage can adequately answer. No more topically specific question will match as illustrated by the earlier example, where Question 64 could not be reliably matched with Question 65, because it was topically more general.

Defining upper and lower boundaries improves the effectiveness and efficiency of matching. If a match cannot be inferred definitively from the upper bound question because its vagueness exceeds that of the raised question, then the match (if one exists) will be caught by the lower bound question.

Vagueness may also occur in the conversational (interrogative) purpose of a question. A conversationally vague question raised determines the specificity of the minimal acceptable answer. A question with a specific purpose cannot provide a good answer to a question raised with a more general purpose. When a reader raises a question with a more general purpose, he or she is defining a scope for the answer. The indexer utilizes this scope in assessing the adequacy of potential answers during question-matching. For example, suppose the general question arises:

(67) *What is the history of the printing press?*

A conversationally specific question answered that conceivably could be matched to it is:

(68) *What is the origin of the printing press?*

However, Question 67 is an inadequate answer to Question 68. An origins answer will not cover the scope of a history question. An indexer matches a conversationally vague questions raised with semantically equivalent (or even more vague) questions answered, for instance, another history question in the above example.

The converse matching problem occurs when an indexer attempts to match a conversationally specific question raised with a conversationally vague question answered. A conversationally vague question answered can be matched with a more specific question raised. The reader who raises a specific question will accept an answer of smaller scope than the reader who raises a conversationally more general question. Because each category of the hierarchy of the conversational taxonomy covers its subcategories, an indexer can assume a more general question answered will cover the scope implied by a more conversationally specific question raised. For example, suppose a question of specific comparison has been raised:

(69) *How much greater is the volume of German exports than that of Italy?*

Clearly, this specific question can be answered by the following more conversationally general question:

(70) *How do the volume of German exports compare to those of Italy?*

Should the passage Question 70 represents fail to cover the specific comparison, it was a mistake to have labeled it with such a general question during content analysis.

### Ambiguity in Question-Matching

Sometimes a question raised is not vague but ambiguous. Ambiguity is the

problem of selecting which of several possible question meanings should be used in matching. An indexer requires both basic domain knowledge and knowledge of the properties of conversational taxonomy to match ambiguous questions. For example, suppose the indexer encounters the question:

(71) *What is a printing press?*

This ambiguous *definitions* question could mean:

(72) *What does a press look like?*

(73) *What are the physical parts that constitute it?*

(74) *What are the functional systems that make it work?*

(75) *What is a printing press used for (its applications)?*

The indexer uses his or her domain knowledge to recognize the printing press as a device. One property of a device is that it can be defined by its *functions, uses*, or the *details* of its structure, all of which are subcategories in the conversational taxonomy. To promote successful matching, all *functions, uses* and *details* questions about tools or devices were also assigned to the *definitions* conversational subcategory.<sup>35</sup> Given this mapping of subcategories, an indexer can easily find a match to this *functions* question raised in the *definitions* subcategory:

(76) *What does a printing press do?*

### **Additional Question-Based Links from the Structure of the Content**

The indexer using question-based indexing forms important additional links from the structuring information in point questions, story-sets and supertopics. They join other links formed by question-matching in the browsing interface of ASK Michael, preserving the simplicity of the conversational metaphor of reading in ASK Michael.

During content analysis, the indexer composed standard background questions to provide a reader with necessary information and generated related topics questions to represent cross-connections between parallel passages. Once identified by the indexer for a story-set, standard background questions were placed into each passage of that story-set as questions raised. They promote access to the basic questions of a less-knowledgeable reader, and they meet the reader's need for context during non-linear reading. The indexer composed related-topic questions to promote the cross-linking of passages. A similar question answered was generated for each parallel passage in a story-set. Each question answered for a given passage was then assigned to each of the parallel

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<sup>35</sup>Though not described here, similar inferences were made for events. An event confounds history and causes. Acceptable explanations can be in either form: a prior event explains a current event (history), or activity of an agent explains an event (causes). Questions in either category are replicated in the other when equivalence classes are formed for matching questions.

passages as a question raised. Links were formed for both standard background questions and related topic questions via normal question-matching activity.

Links can also usually be made between successive passages drawn from a linear text. For the successive passages in ASK Michael, two links were inferred by the indexer, a link from the earlier story to its successor and a link from the successor to the earlier story. For example, the ASK Michael indexer defined two text segments that originated in successive passages of CAN, labeling them:

German Natural Resource Factor Conditions  
Factor Conditions which Upgrade German Industry

To capture this sequential relationship of passages for ASK Michael, the indexer formed a link between them by adding the following questions to the questions raised collection of the each passage respectively:

- (77)        *What other resources did Germany have?*
- (78)        *What contribution did natural resources in Germany make?*

Question 77 represents the alternative resources implied in the story "Factor Conditions which...". Question 78 represents the reverse connection.

## **Evaluating the Conceptual Indexing of the System**

The steps of question-based indexing were repeated on successive chapters of CAN. The results were inspected, verified, and corrected as necessary after each chapter was incorporated into the system. In this section, I outline the verification procedures used for segmenting text, generating questions, and linking passages.

First, original segmentation decisions can be checked via a review of certain questions answered. Each question answered applies to a range of source text. The indexer reviews and selects questions answered that have generality and significance. The range of applicability of these questions defines a useful segment which the indexer can use to validate initial ASK Michael segmenting decisions.

Second, the separation of content analysis and question-matching makes it possible for an indexer to evaluate the completeness and relevance of the questions composed during the content analysis step. Completeness can be measured by the number and significance of questions left unanswered after question-matching is concluded. By reviewing these questions, an indexer can verify the completeness of the finished system, and can better decide whether to search for more links or to acquire more content (if available) to cover unanswered questions raised.

The outline of the original source material can also function as a check on the completeness of question-based linking. The content analysis techniques of question-based indexing should naturally reproduce the author's original structure of main points as a small subset of the overall indexing, of course. The



topology of the author's outline was used by the ASK Michael indexer to check for completeness in the question-based links found by question-matching. For example, questions raised by the content of one passage may be answered in passages that originated in the subsequent passages of CAN. Similarly, parallelism in the book's outline should result in cross-links. The indexer checks each sequential pair and each parallel pair of stories to verify that each is linked in both directions.

The completeness of linking can be measured by the number and significance of unmatched questions answered. During construction, an indexer can inspect unused questions answered to assess how complete the questions raised are for a body of material. The indexer of ASK Michael installed some overlooked questions answered as questions raised as a result of this review of the system.

The symmetry of some link types can also be used to validate the completeness of linking. Because of the conversational semantics of link labels, many links between passages should be symmetrical or reciprocal. For example, an analogy link to a passage should be paired with a reverse link between passages in the same conversational category. The question-matching method builds one-way links between passages. Reciprocal links should emerge naturally if the reciprocal question is raised in the question answered passage. Therefore, no explicit decision about whether a link is bi-directional should be necessary. Reciprocal semantics include pairs of links labeled *Context / Specifics*, *Analogy / Analogy*, *Alternatives / Alternatives*, and *Causes / Results*. However, the indexer reviewed links in ASK Michael to confirm the existence of reciprocal links.<sup>36</sup>

## A Computer-Based Indexing Tool

During the indexing process for ASK Michael, a computer-based indexing tool maintained the representations created by the indexer including text segments, story-sets, topics, questions raised, questions answered, and links. The tool supports the formation of links between passages in all the ways described in this chapter. For example, a question-matching screen for the ASK Michael tool is presented in Figure 5-14. By marking a question raised, such as Question 79 in the figure, and a question answered, such as Question 80, a link is automatically formed at the bottom center of the screen in Figure 5-14. Saving the link (Clicking the Save Button in the lower right of the figure) automatically installs it in the database.

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<sup>36</sup>More recent indexing tools, such as those that constructed Trans-ASK automatically produce reciprocal links (Bareiss and Osgood 1993).

Questions Raised:	55: The Ceramic Tile Industry Question Classification	Questions Answered:																														
<p>--MEANS:</p> <p>BC7). *How is ceramic tile made? ← 79</p> <p>BG12). *How is ceramic tile made?</p> <p>BG2). *How is designer tile made?</p> <p>BN3). *How is a designer tile made?</p> <p>BA6). *What is involved in ceramic tile design?</p> <p>BR4). *How is tile manufactured?</p> <p>BA7). *How is ceramic tile made?</p> <p>--MECHANISMS:</p> <p>BF1). *What is the problem with using red clays for ceramic tile?</p> <p>--ORIGINS:</p> <p>BL3). *How did Italian tile industry firms first move into international markets?</p> <p>BN4). *How did the trade organization, Assopastrelle get started?</p> <p>BG3). *How did the Italian tile equipment manufacturing get started?</p> <p>--PROBLEMS:</p> <p>BJS). *What is the problem with red clays?</p> <p>BP6). *What is the problem with red clays in the Italian ceramic tile industry?</p> <p>--PURPOSES:</p> <p>BM2). *What else have Italian trade associations for ceramic tile done?</p> <p>--REASONS:</p> <p>BC1). *What is it about ceramic tile making that allows so many small companies to flourish?</p> <p>BA2). *Why did the ceramic tile industry develop in the Sassuolo region?</p> <p>BF2). *Why had Italian tile manufacturers been dependent on foreign equipment manufacturers?</p> <p>BG13). *Why was Italian demand so sophisticated?</p> <p>BA3). *Why are there so many ceramic tile firms?</p> <p>EH1). *How did these small Italian ceramic tile manufacturers continue to innovate so freely?</p> <p>BL5). *Why was tile making equipment sold to competitors while K&amp;B couldn't sell their press to competitors of their buyers?</p> <p>BK1). *Why was there a temporary slow-down in demand for ceramic tile in 1963-64?</p> <p>BL1). *Why is Italy ahead in many building industry exports?</p>	<p>--MEANS:</p> <p>BB4). *How are ceramic tiles made? ← 80</p> <p>BF2). *How did the synergism of tile equipment producer and tile manufacturer work to raise Italian leadership?</p> <p>BG1). *How did home demand for ceramic tile help the Italian industry?</p> <p>BG2). *What marketing channels for ceramic tile have recently been used Germany and France?</p> <p>BK2). *How did Italian manufacturers of the market them abroad?</p> <p>BN1). *How did the Italian ceramic tile industry open large new markets in the US?</p> <p>BM2). *How did Italian manufacturers of tile overcome the disadvantages of opening the US market?</p> <p>BM3). *How was the entry into the US market financed?</p> <p>--MECHANISMS:</p> <p>BJS). *How do tunnel kilns work?</p> <p>--ORIGINS:</p> <p>BC1). *Where did the ceramic tile industry originate?</p> <p>BC11). *How did Assopastrelle, the industry association for ceramic tile, get started?</p> <p>BC2). *How did Italy's Ceramic Tile industry evolve after WWII?</p> <p>BC3). *What precursor industries gave rise to the ceramic tile industry in the 13th century?</p> <p>BN2). *How did the designer tile innovation come about?</p> <p>--PROBLEMS:</p> <p>BQ2). *Is it a problem that Italian ceramic tile equipment manufacturers sell to international competitors?</p> <p>--PURPOSES:</p> <p>BG6). *Did other nations adopt the retail tile outlet approach of Italy?</p> <p>BH6). *What is the purpose of Assopastrelle, the Italian ceramic tile industry association?</p> <p>BN5). *What is the third firing technique for?</p> <p>--REASONS:</p> <p>BR1). *What is the competitive advantage of Italy in the ceramic tile industry?</p> <p>BC4). *Why did the ceramic tile industry flourish in Italy?</p> <p>BC6). *Why did so many Italian sports car engineers end up in the ceramic tile industry?</p> <p>BDS). *Why are white clays preferred over red in ceramic tile manufacturing?</p> <p>BD4). *Why was the Italian market for ceramic tiles more sophisticated than others?</p> <p>BGB). *Why did the rebirth of tile in separate stores have such a large impact on the success of the Italian industry?</p> <p>BI1). *Why were Italian ceramic tile producers struggling to reduce labor costs in the early 1970s?</p> <p>BA6). *Why has Italy's ceramic tile industry been so successful?</p> <p>BNM). *Why were the U.S. and Germany not as competitive in ceramic tile as Italy?</p>																															
Dest(Early Ceramic Tile Industry History)	Link(Products and Processes of the Ceramic Tile Industry)																															
Type(Means)	Type(Means,Mechanisms)																															
<table border="1"> <tr> <td>Ordered by Category</td> <td>Questions Raised Tools</td> <td>How is ceramic tile made?</td> <td>Questions Answered Tools</td> <td>Save</td> </tr> <tr> <td>Target Window: Stories</td> <td>Unlock Sources</td> <td>Find the answer in:</td> <td>Unlock Sources</td> <td></td> </tr> <tr> <td>Class:</td> <td>Find Again</td> <td>Products and Processes of the Ceramic Tile Industry</td> <td>Find Again</td> <td></td> </tr> <tr> <td>Backup Save To: Install: The Ceramic Tile Industry</td> <td>Clear View</td> <td></td> <td>Clear View</td> <td>UnSave</td> </tr> <tr> <td></td> <td>Use Raised Question</td> <td></td> <td>Use Answered Question</td> <td>HELP</td> </tr> <tr> <td></td> <td>Installed Already?</td> <td></td> <td></td> <td></td> </tr> </table>	Ordered by Category	Questions Raised Tools	How is ceramic tile made?	Questions Answered Tools	Save	Target Window: Stories	Unlock Sources	Find the answer in:	Unlock Sources		Class:	Find Again	Products and Processes of the Ceramic Tile Industry	Find Again		Backup Save To: Install: The Ceramic Tile Industry	Clear View		Clear View	UnSave		Use Raised Question		Use Answered Question	HELP		Installed Already?					
Ordered by Category	Questions Raised Tools	How is ceramic tile made?	Questions Answered Tools	Save																												
Target Window: Stories	Unlock Sources	Find the answer in:	Unlock Sources																													
Class:	Find Again	Products and Processes of the Ceramic Tile Industry	Find Again																													
Backup Save To: Install: The Ceramic Tile Industry	Clear View		Clear View	UnSave																												
	Use Raised Question		Use Answered Question	HELP																												
	Installed Already?																															
Repositioned and padded questions reinstalled in fields.																																

Figure 5-14: ASK Tool Link Formation

## Summary of the Question-based Approach

It is natural for readers to have questions about the texts they read. It is equally natural for authors to answer questions they think readers will have in the texts they write. This is precisely the principle behind question-based indexing. An indexer breaks texts into segments. For each segment, he or she prepares a list of questions the text answers, and another list of questions the text raises. The question lists accumulated from all passages are classified by topic and conversational purpose.

These classified questions are the input to the process of linking that transforms a linear text into a non-linear text. Using a computer-based tool to manage the classes, an indexer instructs the computer to place the questions raised in a given combination of topical and conversational categories alongside the questions answered of the same combination of categories. The indexer scans the two columns, finds and marks a good match between a question raised and a question answered, and saves the link. The indexer repeats the process until no additional matches can be located in that combination. The indexer then selects another combination and repeats the search for links. This method capitalizes on the relative strengths of the human indexer and the computer. The indexer writes

questions; the computer sorts them; the indexer recognizes links; the computer saves them.

The question-based method has many advantages over unprincipled, *ad hoc* methods. First, content analysis is simplified by separately generating questions answered and questions raised. Each activity is simpler for indexers when it is done independently of the others. Developing questions raised is easier when an indexer is unfamiliar with the content. Reading text segments out-of-context prolongs indexer ignorance. On the other hand, an indexer benefits from familiarity with the content while developing questions answered. In contrast, *ad hoc* methods are less effective because an indexer inadvertently learns too much content to be effective at noticing the novice-level connections to background material; and without a rational decomposition of indexing work for large amounts of source material *ad hoc* methods soon become impractical.

Second, the well-defined and principled steps of the method allow an indexer to maintain indexing consistency and to achieve completeness. Consistency is maintained by using the cues of the text to develop text segments, questions raised, and questions answered and by the stable taxonomies used in question classification. Completeness is achieved by iterative refinement of the system using the verification and validity checks afforded by the independence of the various steps of the process. In contrast, *ad hoc* methods of indexing can produce great variability in content and quality, because they lack principled ways of verifying the consistency and completeness of the system.

Third, the method effectively reduces the complexity of the indexing task for large collections of stories. An indexer can generate questions in one or two passes of the text and question classification in one pass of the questions. A computer-based tool then enables retrieval of equivalent categories of questions which assist an indexer in linking the passages in a final pass through the categories. It assists specifically by limiting what the indexer must search. The complexity of question-matching is reduced by the combination of topical and conversational classification of questions. *Ad hoc* methods have much higher complexity because they require indexer memory of source content, repeated searching of that content, and exhaustive comparison of passages.

As of this writing, the following ILS systems have been constructed by question-based indexing: ASK Michael, Advise the President (Ferguson, et al. 1992), ORCA (Bareiss and Slator 1992), TaxOPS (Slator and Riesbeck 1991), Victor, Trans-ASK (Bareiss and Osgood 1993), ASK How It Works (Kedar, et al. 1993), ASK North West Water, ASK Little Village, and Engines for Education. These applications are targeted at training, information browsing, design, advice giving, simulation, and consulting in a variety of domains. The question-based indexing method has proven to be universally applicable across these tasks and domains.

The question-based indexing process does have its limitations, however. The informality of questions as representations of necessity limits the role of a computer in the indexing process. If a computer-processable representation for passages could be developed, the computer's role in indexing could be extended

to actually propose links, a possibility explored in the next chapter.

## Chapter 6

# Dynamic Indexing

### Introduction

Question-based indexing can be difficult to apply in certain environments. In particular, the effectiveness of the method is diminished with a very large text database, because the method is essentially a manual process.<sup>37</sup> The heart of the method is the question-matching step in which questions that readers are likely to raise are matched to questions that represent the available answers. In a large database, the many questions and many variations in question wording produced by indexers using the method complicate this matching process. Yet, because questions are an informal representation, the matching process cannot be readily automated. In Trans-ASK, for example, indexers reached a point at which they could no longer manage the approximately 20,000 questions of the full system.<sup>38</sup> The taxonomies used to reduce the complexity of question-matching were overwhelmed by the magnitude of the content of the system. To index a system of this size, indexers found it necessary to subdivide the system into 33 individual systems with a corresponding risk of losing interconnectivity.

This problem is not unique to pre-indexed systems such as Trans-ASK. A similar problem arises in a dynamic authoring environment in which users of a non-linear reading system similar to ASK Michael may add passages to it in

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<sup>37</sup>In ASK Michael the method resulted in several hundred segments linked by several thousand questions. Its indexing is within the capabilities of the question-based method. Systems larger by an order of magnitude can benefit from an approach that can be more fully automated.

<sup>38</sup>Trans-ASK, a large-scale hypermedia system that operates in the domain of military transportation planning, contains 1,200 video segments divided into 33 individual groups (Bareiss and Osgood 1993). An *indexer saturation problem* can occur in systems of this magnitude or larger.

response to what they read. Question-based indexing is a formal process involving a computer-based tool and a dedicated indexer who systematically performs the steps of the method. The process is not suited to casual use by an user who has just added a passage to a text database. One example of a dynamic authoring system is School Stories,<sup>39</sup> a project that shared many of the research themes of ASK Michael. In particular, School Stories employs ASK Michael's conversational model of reader interaction with a conceptually indexed database of text segments.

School Stories differs from ASK Michael, however, in that instead of pre-indexing an existing source of text, the system allowed readers to respond to existing database passages by composing new passages. In the School Stories project, a group of seven ILS faculty and graduate students employed a collaborative writing system, called GroupWrite, to share stories. Over a period of a few weeks, they produced a corpus of 66 stories via *responsive story-telling*. This activity greatly exacerbated the indexing problem, since not only did individual authors have difficulty remembering the contents of the text database, but in many cases, they had not seen most of it. As a result, stories were typically connected to the database by only a single link to the story which prompted its input. Looking for more links via question-based indexing or any other manual method was impractical.

The problem facing the individual author in School Stories is analogous to the one faced by indexers of Trans-ASK. Even with system functions to assist in the process, an indexer's knowledge of existing database content is often inadequate to support comprehensive indexing of new content. In this chapter, I introduce a general solution to this problem called *dynamic indexing*.

## Solving the Indexing Problem

The requirements of a dynamic indexing solution were developed from an analysis of the kinds of links missing from the School Stories database. Many were missing simply because participants had no way of knowing the relationships between their new stories and other stories in the database without searching it. Others were missing because the responsive story-telling links created in School Stories were typically similarity-based (for example, *Analogies* or *Alternatives* links in the ASK Michael classification), that is, participants were reminded typically of comparable stories by existing stories. As a result, non-similarity-based links were often missing (especially, *Context*, *Specifics*, *Causes* and *Results* links).

A method for indexing a new story to an existing database of stories must produce these various types of missing links. It must infer links both from the

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<sup>39</sup>School Stories is a hypertext system that provides its readers with facilities to compose and share stories about their K-12th grade school experiences. A reader may respond to any story in the system by writing a new story which is automatically linked to it.

new story to the stories of the existing database as well as from the stories of the database to the new story, and it must infer all the types of links specified by the conversational model of ASK Michael. To be practical, the method must not depend on an exhaustive manual search of the database, or an automated solution to the unsolved natural language understanding problem. Instead, a hybrid of manual and automated approaches is desirable in which indexing is broken down into specific manual tasks which take advantage of the strengths of human indexers (semantic processing, similarity assessment, and complex inference) and automated tasks which exploit the strengths of a computer (database maintenance, exhaustive comparison, and simple inference).

Thus, effective indexing requires a story representation that can be easily processed by both computers and humans. It must be expressive enough for the human to create and maintain, yet precise enough for the computer to process via rules. To keep the complexity of these representations to a minimum, only information about a story that is necessary for the function of the inference rules should be represented. Given these desiderata, simple inference rules were developed for each type of story relationship; and a simple story representation was defined from the data requirements of these rules.<sup>40</sup>

These rules and representation definitions were compiled into a computer-based tool, the Dynamic Indexing Tool (DynaDex), which enables a user to represent stories and to execute the inference procedures of dynamic indexing. Figure 6-2 presents DynaDex's Frame Editor which displays a domain independent representation frame instantiated with fillers drawn from a hierarchical list of vocabulary terms. The editor enables the writer/indexer to create, edit and delete frames and assign slot values. The figure also shows a small portion of one of the domain specific concept hierarchies, namely, the fillers for the slot that describes an agent's actions (the **IntentionType** slot). The semantics of the frame are a standard causal story. For example, the top five slots shown in Figure 6-2 state that a student actually did disrupt class with a positive outcome for the student. The purpose of other slots of the frame will be discussed in a later section.

### **An Example of Dynamic Indexing**

Before beginning a detailed discussion of the representation, its use in inferring links, or the theory underlying dynamic indexing, here is a brief example of how the story in Figure 6-1 might be indexed to an existing database of stories.

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<sup>40</sup>An inference rule performs linking activity between two stories by first checking to see that certain conditions are met. If they are, then a link is proposed. The conditions process information recorded for the two potentially linked stories.

One problem for smart kids is to keep from boring them in school. Each year that I was in school, my teachers had to find some way to keep me out of trouble since I was both bored and rambunctious. In the second grade I ran messages for the teacher. In the third I built baseball parks out of oak tag. In the fourth I wrote songs. These events turn out to be most of what I remember from those years. School for me was one long attempt to avoid boredom and trouble.<sup>41</sup>

Figure 6-1: A Story Entitled *Handling the Troublemaker*

A user of the Dynamic Indexing Tool is just finishing the representation for the new story shown in Figure 6-1. After inspecting the representation for Scene 0 (Figure 6-2), the user decides that the value of one of the highlighted phrases, "Disrupt Class", does not accurately reflect the content of the story and double clicks on it. A menu of permissible replacement phrases is displayed. The user selects "Show Lack of Interest" which is a little more to the point of the story. Once the user is satisfied with the representation, he presses "Save" to record the new story.

When representing a new story, a user selects items from the existing menus of vocabulary terms whenever possible to maintain consistency and parsimony in the representation. When the proper vocabulary terms are not available in the menu, the user can add them to the domain hierarchies using the hierarchy editor (not shown). Similarly, the user may create as many of these frames as are needed to adequately represent the goals, plans and actions of the agents in a story.

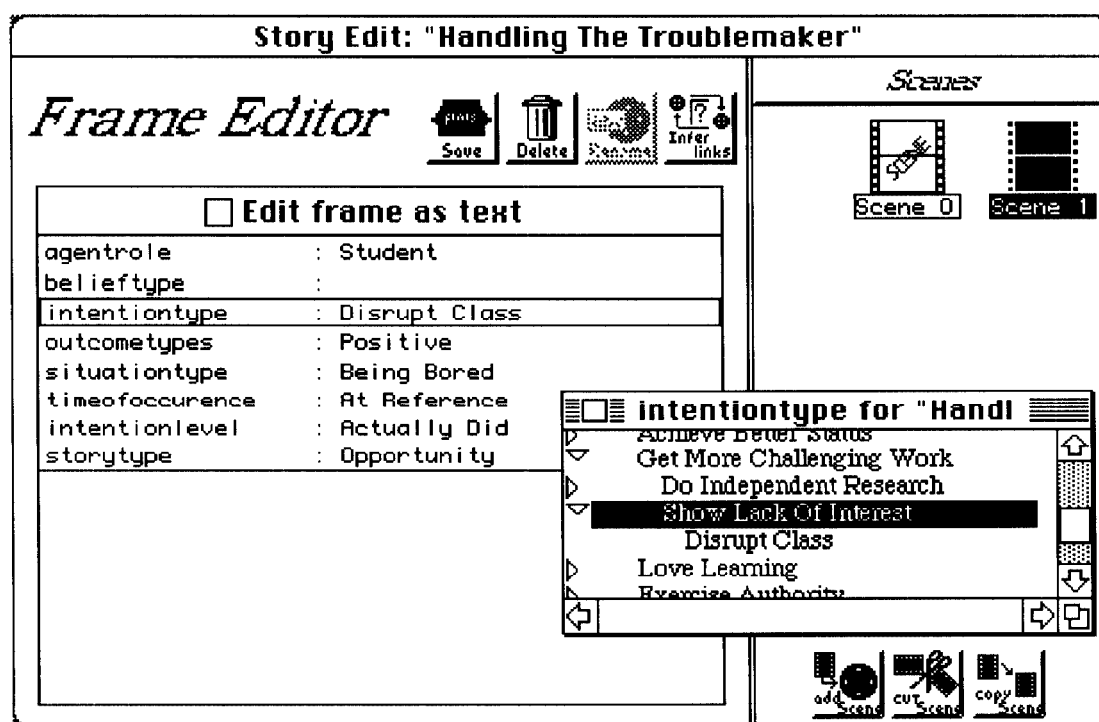


Figure 6-2: Editing the Frame of a Story

<sup>41</sup>This story was written by Roger Schank for School Stories.



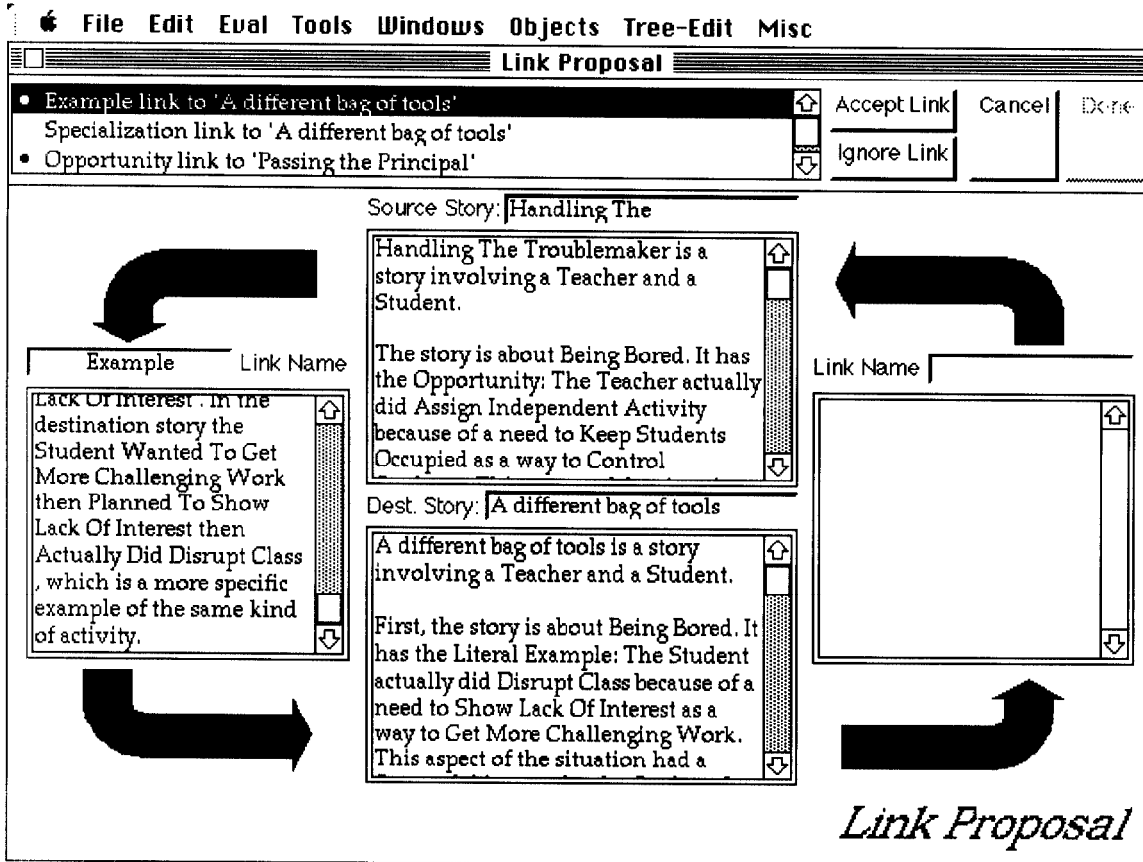


Figure 6-3: The Link Proposal Process

Once a story has been represented, link inference can be initiated by a user.

*The user presses "Infer Links" (top center of Figure 6-2) The system displays proposed links to and from the user's story in the top field of the screen shown in Figure 6-3. The user clicks on each link to review the system-generated explanation for it (the left or right box depending on link direction). The user presses "Accept Link" to confirm the validity of proposed links (identified by "•").*

For each proposed link, the corresponding rule prepares a text summary for the two linked stories and an explanation of the relationship between them to help the user decide which links to accept. For example, in Figure 6-3, an *examples* link is proposed to the story shown in Figure 6-4.

Internally, dynamic indexing processes predefined inference rules which have been written to relate the frames of a new story with those already stored in the database. The rules have been composed for each relationship specified by the ASK Michael conversational categories. For example, the link highlighted in Figure 6-3 was inferred by a rule which states that an *examples* link (a type of *specifics* link) can be inferred when similar agents of two frames from different stories are engaged in causally related activities, one more specified than the other, and the frame for the more specified activity is explicitly marked as an

I had learned to do integrals by various methods shown in a book that my high school physics teacher, Mr. Bader, had given me.

One day he told me to stay after class. "Feynman," he said, "you talk too much and you make too much noise. I know why. You're bored. So I'm going to give you a book. You go up there in the back, in the corner, and study this book, and when you know everything that's in this book, you can talk again."<sup>42</sup>

Figure 6-4: A Story Entitled *A Different Bag of Tools*

example. The conditional side of this rule is satisfied because the database contains the frame shown in Figure 6-5. The rule first determines from the domain hierarchy (Figure 6-6) that the **IntentionType** slot filler *Disrupt Class* for the frame in Figure 6-5 is a specialization of the filler *Show Lack of Interest* for the same slot in Figure 6-2. Because the frame in Figure 6-5 has the **StoryType** slot

<b>AgentRole</b>	<i>Student</i>
<b>BeliefType</b>	
<b>IntentionLevel</b>	<i>Actually Did</i>
<b>IntentionType</b>	<i>Disrupt Class</i>
<b>OutcomeTypes</b>	<i>Successful</i>
<b>SituationType</b>	<i>Being Bored</i>
<b>TimeOfOccurrence</b>	<i>At Reference</i>
<b>StoryType</b>	<i>Literal Example</i>

Figure 6-5: A Different Bag Scene

filler *Literal Example*, the system proposes an *examples* link between them.

This simple example gives a general account of the function of the dynamic indexing tool which enables the work of dynamic indexing to be shared by the computer and the human user. The computer role complements the human role in which, initially, the indexer of a new story can extract the information required by the

representation framework. The computer can infer links by processing each rule against the representation for the new story in correspondence with the representations of existing database stories. Finally, the links inferred can be reviewed by the human user to verify their relevance. Accepted links can be installed by the system in the database of stories.

Dynamic indexing changes the role of the indexer in the question-based method from searching for links to inspecting, editing and approving them. The human user must be kept "in the loop" to do the semantic processing necessary for this part of conceptual indexing. However, the computer is able to come close to the goal of proposing the links that human indexers would have generated for two simple reasons. Similarity is represented by the indexer not computed by the

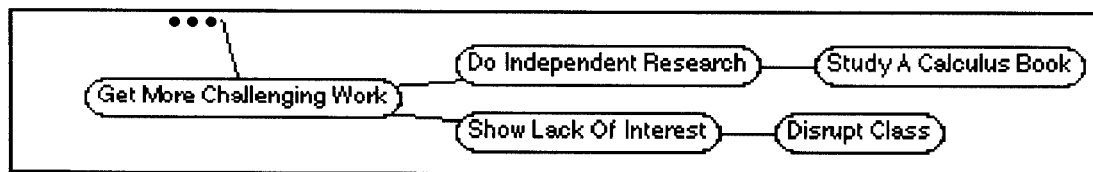


Figure 6-6: Concept Hierarchy for IntentionType Fillers Near *Disrupt Class*

<sup>42</sup>This story was extracted by Ian Underwood for School Stories from Feynman, R. (1985) *Surely you're joking, Mr. Feynman: adventures of a curious character*. New York: W. W. Norton.

machine and the representations compile some inferences that are too difficult for machine inference. Representing similarity provides the indexer precise control over inference. Compiling some inferences in the representation enables redundant inferences—if a link between stories is not inferred from basic information about a story it may be inferred from some of the compiled information.

The following sections provide processing detail and the theory behind the representation and indexing of stories.

## Inside Dynamic Indexing

Dynamic indexing is based on two underlying assumptions about indexing. First, it is assumed that knowing how two stories relate requires less than full understanding of these stories. For example, in order to establish that a *results* link between two stories is appropriate, one need only determine that two stories concern similar actions by similar agents, and that the second story states the results of the action while the first story does not.

Second, the approach also assumes that rules can be written for each conversational category that defines precisely the information and the method needed to infer a corresponding relationship between passages. For example, the *results* inference described above requires that the representation of stories include the agents involved, their activities, and the outcomes of those activities.

These two assumptions underlie the design of the Dynamic Indexing Tool that provides a framework for representing of stories, a set of rules that can infer links, and a case-based retrieval function to assist with the representation task.

### The Representation of Stories

The story representation for dynamic indexing has been chosen carefully to operate as an intermediary between human authors and the computer (*cf.*, Lemke and Fischer 1990). The representations must be simple enough to be interpretable, editable, and selectable by humans, yet formal enough to serve the input needs of the automated link inference process.

Underlying dynamic indexing is a single representational scheme that is much more limited in depth and complexity than the deep representations of knowledge attempted in systems like CYC (Lenat, et al. 1990).<sup>43</sup> The representation is based on a naive model of intentionality expressed at three levels. At the most detailed level for the system, a *scene* describes a single agent's activity (*cf.*, Universal Indexing Frame, Schank and Osgood 1991). A *situation* is a group of interacting agents represented by their respective scenes, and a *story* is composed of a number of situations arranged in temporal sequence or as a chain of causal interactions. Figure 6-7 illustrates how these three levels might be

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<sup>43</sup>As noted earlier, indexing can be conducted without deep understanding of the text.

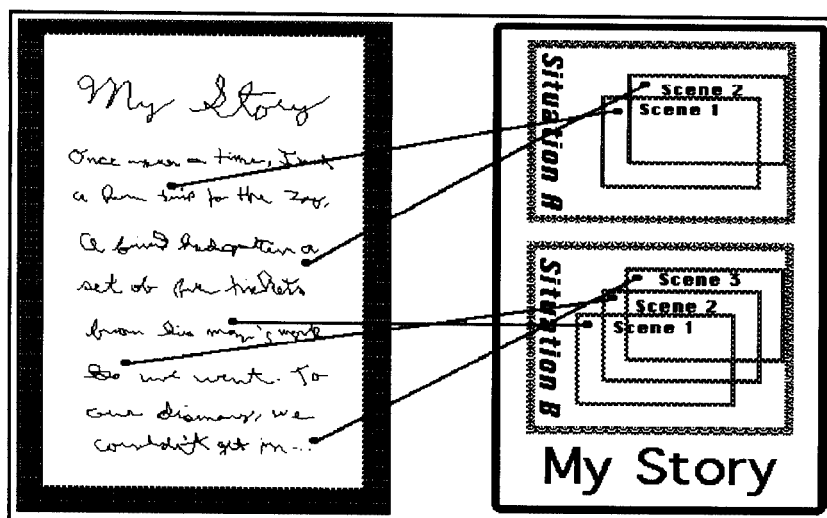


Figure 6-7: The Structure of Story Representations

extracted from the text of a story.

The representation is simple, indexical, and natural for human indexers to employ and is just detailed enough to support the types of inference needed to recognize relationships between stories. Specifically, the representation consists of a domain-independent representational frame and domain-specific concept hierarchies for instantiating the frame's slots with fillers. This approach enforces consistency of feature selection by writer/indexers as they represent their new stories and formalizes the data structures needed by the link inference procedures.

### The Representational Frame

In the School Stories application, the representational frame or *scene* represents a

Senior year I took AP Chem. with R. K., an ex-cop, who really looked the part. Anyway, senior year was basically an exercise in not screwing up so badly that whatever college you chose would change its mind. Needless to say, atomic orbits were not terribly pressing issues for us at that point...

Of course there was still the matter of getting grades. As you can imagine, we learned nothing in this class. All there was to base our grade on was one or two pathetic assignments. We had a final coming up that we had no idea how we were going to pass. Finally, we struck a deal with R. K.. We could either take the final or take the AP test. We realized that the AP test wouldn't be graded in time to be included in our grade, so R. K. would have to give us grades without ever testing us.

Of course we all signed up for the \$44 test...It became something of a scandal; the head of the department got wind of what we did and wanted to call off the deal; but we went nuts, and finally forced them to keep their end of the bargain...<sup>44</sup>

Figure 6-8: A Story Entitled *A Deal's a Deal*

<sup>44</sup>Story written by Andy Fano for School Stories.

<b>AgentRole:</b> <i>class</i> —the role the agent plays in the story <b>BeliefType:</b> <i>having no basis for grading forces good grades</i> —the agent's belief inducing the goal <b>IntentionLevel:</b> <i>actually did</i> —the level of intentionality(either goal, plan, or act) <b>IntentionType:</b> <i>get good grades</i> —the specific goal, plan or action of an agent <b>OutcomeTypes:</b> <i>successful</i> —the results of the specific goal, plan or action
<b>SituationType:</b> <i>overruling a teacher</i> —a name linking multiple interacting frames <b>TimeOfOccurrence:</b> <i>after reference</i> —sequencing information for frames <b>StoryType:</b> <i>literal example</i> —story application information

Figure 6-9: The Slots of the Representational Frame

single action in the intentional chain of a story (for example, Figure 6-8).<sup>45</sup> The frame consists of an intentional subframe (upper portion of Figure 6-9) which captures agent intentionality and a relationship subframe which compiles higher order relationships in this story to facilitate certain types of inferences. The vocabulary terms of the concept hierarchies fill these two groups of slots.

The intentional subframe represents the intentionality of a single agent independent of domain. The semantics of this portion of the frame refer to the intentional chain (Schank and Abelson 1975). Agents play roles and have beliefs that influence their selection of a course of action. To play out those roles, agents establish goals and plans to achieve them. Actions based on those plans and goals yield both intended and unintended results. Figure 6-9 briefly describes the content of each frame slot. For example, the frame presented in Figure 6-9 says: *a class actually did get good grades* because they believed that *having no basis for grading forces good grades* and this had a *successful* outcome for them.

The relational subframe in Figure 6-9 represents agent interactions, temporal sequencing, and compilations of story attributes. Since most School Stories entries involve interactions among multiple agents, sometimes with conflicting goals, the representation employs multiple frames—one or more for each agent (*cf.* the Universal Indexing Frame, Schank and Osgood 1991).<sup>46</sup> Frames for multiple agent interactions, or *situations*, are grouped by assigning a common value to the **SituationType** slot of each frame.<sup>47</sup> For example, an infatuation situation is captured by selecting *Student Infatuation* to fill the **SituationType** slots of frames representing the intentional activity of a *student* and a *teacher* respectively.

<sup>45</sup>In the Trans-ASK application of dynamic indexing discussed later in this chapter, the frame included an agent's goal, plan and, action with expected and unexpected outcomes.

<sup>46</sup>The complete description of interactions among agents may require representation of (possibly flawed) models of the intentionality of an agent upon which other agents in the story are acting. Dealing with stories that require this depth of representation is beyond the scope of this work. However, because the goal is to discover the relationships that occur to people spontaneously, deep psychological models of human intentionality are not needed. All that is required is enough specificity and sophistication in the fillers to infer a relevant link.

<sup>47</sup>The grouping function of this slot is specific to the School Stories application and is not representative of other applications of dynamic indexing, for example, Trans-ASK, where the grouping of frames was unnecessary.

The vocabulary term chosen to fill a **SituationType** slot also describes the nature of the relationship between interacting agents. It, in essence, compiles the writer/indexer's inference about the interaction of agent activities which avoids the processing necessary to infer the nature of the relationship from a more elaborate representation at the scene level. For example, to infer *student infatuation* directly from frames for the involved agents would require the encoding of knowledge about the pattern of interactions that constitute infatuation. It is easier for the writer/indexer to draw this inference directly than to provide the underlying representation necessary to enable automated inference.

The **TimeOfOccurrence** slot sequences scenes in stories to establish qualitative causal/temporal relationships. For example, the term *at reference* indicates the relative point in time of the main action of the story. Drawing a lesson from the story happens *after reference*, a later time designation.

The **StoryType** slot again compiles an writer/indexer's inference about a story. It contains information that identifies possible uses for the story or the level of abstraction of the story content. For example, the value for this slot may be *Warnings* for a story that contains useful cautionary advice. It may be a *Literal Example* for a story that is a good explicit example of something.

This slot structure is specific to the School Stories application. The dynamic indexing of Trans-ASK, described in a later section, employed a frame structure similar to School Stories (Bareiss and Osgood 1993). In general, each application of dynamic indexing may require a different variant on the intentional chain representation.

### Domain Hierarchies

Fillers for the slots of the frame are selected from domain specific concept hierarchies. *A priori* enumeration of all slot fillers is not intended. Instead, an initial enumeration was entered to serve as an example for its incremental extension. The hierarchies evolve gradually as writer/indexers add concepts to them as required by the stories they are representing.

The hierarchies have a simple semantics. The lines of connection in Figure 6-7 between concepts in the hierarchy define the conceptual specialization of the domain. The peer relationships among concepts sharing a single parent in the hierarchy define the similarity of domain concepts.

The lines of connection organize the filler vocabulary. Fillers are chosen from pre-enumerated taxonomies—one taxonomy for each slot of the frame. When selecting a value for a slot in a story frame, the writer/indexer visually traverses the hierarchy of key domain concepts associated with that slot until a value is found to represent some aspect of the story. Figure 6-10 depicts a portion of the taxonomy from which fillers are selected for the **IntentionType** slot.

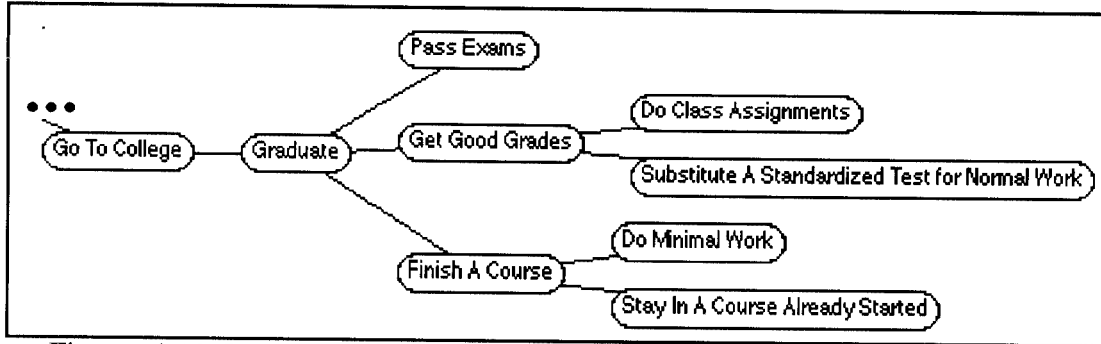


Figure 6-10: IntentionType Slot Concept Hierarchy Near *Get Good Grades*

The semantics for the lines of connection between terms in each hierarchy depends on the slot for which it provides fillers. The semantics are intentional for the hierarchy associated with the **IntentionType** slot. For example, *getting good grades* is a way to *graduate*. The semantics are categorical for other hierarchies. In the **AgentRole** slot, for example, *girls* are a kind of *student*.

The horizontal relationships of each concept hierarchy capture similarity relationships in the domain. The similarity of concepts in a domain, for instance, *School Stories*, is represented in enumerated equivalence classes, not computed from features (*cf.*, Porter 1989). For example, Figure 6-10 displays a section of the concept hierarchy including the **IntentionType** slot filler, *get good grades*. From the peer relationships shown in the figure, goals other students might need to pursue in order to *Graduate* are to *Pass Exams* or *Finish a Course*.

Representing similarity was chosen for dynamic indexing, first, because the similarity assessment capabilities of people can out perform any feature-based automated similarity assessment method. Second, the assessment is best conducted in the target system's task context. In *School Stories* this context is established by authors who have just been reminded of and written a story. It is at that point that similarity is most readily recognizable in the domain hierarchies.

The design decision to represent not compute similarity guides the growth of the concept hierarchy as writers/indexer add and represent stories. When a new story requires a concept not represented in the existing hierarchy, a writer/indexer enters the new term in the hierarchy by determining its similarity to pre-existing fillers. The new term is compared with each set of existing peer terms and is added to hierarchy at the point where similar terms are found.

To summarize, each of the slots in the frame representation plays a specific role in making the representation task tractable for people while taking advantage of the more developed data organization and presentation capabilities of the computer. First, the frame representations and their domain concept fillers function as an *interlingua* between computer and human. A natural language generation function that translates frames to text makes the representation even more accessible to human interpretation, because it embodies the semantics of the frame slots explicitly. Second, the frame structure with its hierarchy of fillers

enforces consistency in representation, so new concepts are created only when they are needed. As they are created, the semantics of the domain concept hierarchy both vertically and horizontally helps humans keep them organized and judge their similarity efficiently. Third, the representation captures three levels of detail which humans find intuitive for representing narrative stories. Finally, other judgments that humans easily make about the use of stories and their temporal sequencing are supported directly by the representation. In this way, the frame representation works with the domain concept hierarchies to carefully partition the task of representing stories between human and computer according to the strengths of each.

### A Method of Inferring Links

Dynamic indexing proposes links between stories via predefined inference rules. In School Stories, automated inference helps a writer/indexer find appropriate links between the story he or she has just composed and the existing stories of the database. The system processes the representation of a new story using inference procedures that define the ways in which two stories can be related. Using these procedures, every frame of the new story is processed against the frames of every other story represented in the system's database.<sup>48</sup>

In the simple example presented earlier, the representation was sufficient to infer a possible *examples* link (Figure 6-3 and Figure 6-5).<sup>49</sup> Other inference procedures may also connect these same two stories for other reasons. For example, a *similarity* link would be proposed because each has the slot filler: **SituationType**: *Being Bored* (Figure 6-11). The writer/indexer can accept one or both of these links for inclusion in the School Stories system.

<b>AgentRole</b>	<i>Student</i>	<b>AgentRole</b>	<i>Student</i>
<b>BeliefType</b>		<b>BeliefType</b>	
<b>IntentionLevel</b>	<i>Actually Did</i>	<b>IntentionLevel</b>	<i>Actually Did</i>
<b>IntentionType</b>	<i>Show Lack of Interest</i>	<b>IntentionType</b>	<i>Disrupt Class</i>
<b>OutcomeTypes</b>	<i>Successful</i>	<b>OutcomeTypes</b>	<i>Successful</i>
<b>SituationType</b>	<i>Being Bored</i>	<b>SituationType</b>	<i>Being Bored</i>
<b>TimeOfOccurrence</b>	<i>At Reference</i>	<b>TimeOfOccurrence</b>	<i>At Reference</i>
<b>StoryType</b>	<i>Opportunity</i>	<b>StoryType</b>	<i>Literal Example</i>

Figure 6-11: A *Similarity* Link in Addition to an *Examples* Link

In addition to finding links, the combination of inference procedures and story representation successfully excludes some close, yet inappropriate links. How well the approach excludes near misses depends largely on the assignment of filler terms to equivalence classes in the concept hierarchies. The system

<sup>48</sup>Processing is done via deductive retrieval (Charniak, et al. 1987) not exhaustive comparison.

<sup>49</sup>In a group story-telling environment authors' links have analogical semantics, because different authors do not generally tell causally connected stories. In the case of an *examples* link, one story is an example of the kind of thing discussed in general terms by a story which is probably by another author.



AgentRole	Student
BeliefType	
IntentionLevel	Actually Did
IntentionType	Leave Class
OutcomeTypes	Successful
SituationType	Getting What You Want
TimeOfOccurrence	At Reference
StoryType	Literal Example

Figure 6-12: A Scene from *A Deal's a Deal*

interprets as similar the assignment of concepts as peers in the intentional hierarchy, for example, agents who do similar things for the same reasons. This explicit representation of relevant similarity prevents inadvertent feature matching via superficial similarity. For example, the frame represented in Figure 6-12 does

not produce an *examples* link for the story represented on the left in Figure 6-11. Like the frame on the right in Figure 6-11, it contains the **StoryType** slot filler *Literal Example*. However, the **IntentionType** filler *Leave Class* (Figure 6-13) is not a specialization of *Show Lack of Interest* (Figure 6-6). Therefore, the *examples* link is not proposed. In other words, unless superficially similar acts are done for the same reasons the acts are considered dissimilar.

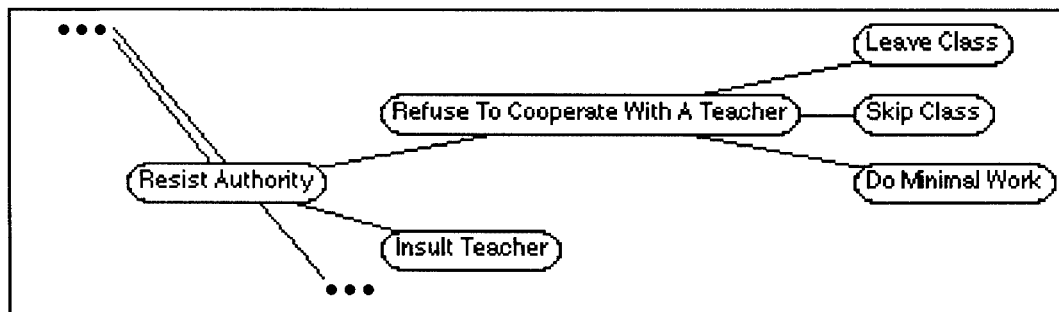


Figure 6-13: Concept Hierarchy for IntentionType Fillers Near *Leave Class*

### A Model of Story Relationship

The inference procedures for dynamic indexing are based on a simple model of story relationships. The possible types of story relationships correspond to specialized senses of the categories of the conversational model used in *School Stories* and *ASK Michael*.<sup>50</sup> As a reminder, the model introduced in Chapter 1 is summarized here.

The topic **Elaboration** relationships concern both adjustments to the specificity of the topic under consideration as well as slight digressions like clarifying the meanings of terms or describing situations in which the topic arises. Stories which shift the focus toward more general topics are pointed to by the *Context* relationship, while ones that shift it toward more detail (including examples) are pointed to by the *Specifics* relationship.

The **Explanation** relationships concern human understanding of phenomena in terms of antecedents and consequences of actions or events.

<sup>50</sup>See Chapter 4 for details of this theory.

Stories that involve antecedents are pointed to by the *Causes/Earlier Events* relationship, and stories that involve consequences are pointed to by the *Results/Later Events* relationship.

The **Comparison** relationships concern human understanding of one situation in terms of another. Stories that are similar in some respect are pointed to by the *Analogies* relationship. Stories with an important or interesting difference are pointed to by the *Alternatives* relationship.

The **Application** relationships concern the uses of knowledge in situations. Stories that warn of pitfalls in the use of knowledge are pointed to by the *Warnings* relationship. Stories that tell of successful applications of knowledge are pointed to by the *Opportunities* relationship.

### The Inference Rules

The categories of possible story relationships define general types of inference procedures. Each category of relationship is defined operationally in terms of a set of rules that infer links of that category.

This section enumerates each rule implemented in the system and explains its function. Each description is written assuming that a writer/indexer has just written a new story which is ready to be linked to existing stories in the database. In reality, rules are also written to infer links from existing stories in the database to the new story. Some of these rules propose reciprocal links (bi-directional interconnection of a pair of stories), when appropriate. To facilitate comprehension of their function, the rules listed below are paraphrased in English. Each rule is followed by a more detailed account of its function.<sup>51</sup> The inference rules are:<sup>52</sup>

Topic **Elaboration** links:

**Rule 1:** One story is context for another if it is about something more general. *In a new story scene if the parent concept of the situation or the agent's activity occurs in an existing database story scene, the generalization<sup>53</sup> link to that existing story is proposed.*

**Rule 2:** One story provides specifics for another if it is about something more specific. *If on the other hand it is a subordinate concept that is present in the existing database story scene, then the specialization link is proposed.*

**Rule 3:** One story can provide a context for understanding an example in another. *When a generalization link has been proposed and the existing database story scene also has the story type of literal example, then a context link is also proposed.*

**Rule 4:** A story that provides specifics for another may also provide a particular example of the specific. *When a specifics link has been proposed and the existing database story scene also has the story type of literal example, then an examples link is also proposed.*

<sup>51</sup>The summaries of the link rules have not included the mapping of the information requirements of inference to the actual sources of that information in the slots of the intentional frame (See Figure 6-6). The descriptions include enough detail to infer which slots are processed by which rules, however.

<sup>52</sup>See the Appendix for a list of actual DynaDex rules.

<sup>53</sup>Figure 6-14 shows the mapping of rule results to the conversational categories.

Context <—> Generalization and Context
Specifics <—> Specialization and Examples
Causes/Earlier Events <—> Temporal History, Causal History, and Reasons
Results/Later Events <—> Temporal Results and Causal Results
Analogies <—> Similarities
Alternatives <—> Differences
Warnings <—> Warnings
Opportunities: <—> Opportunities

Figure 6-14: Mapping Specific Inferences to the Conversational Categories

**Rule 5:** One story may just be a good example of something dealt with in another story. *When a new story scene specifies the same agent activity or the same situation as an existing database story scene and when the new story scene is not represented as being a literal example, but the existing story scene is, then the examples link is proposed.*

#### Explanation links:

**Rule 6:** Something that happens earlier in time is history if it is part of the same situation. *When absolute temporal information is available in a new story scene, and when an existing database story scene describes the same situation or similar agent activity and has an earlier absolute time designation, the temporal history link is proposed.*

**Rule 7:** Something that happens later in the same situation is a result. *Otherwise the temporal results link is proposed.*

**Rule 8:** If something in one story is a cause of something in another than the stories are causally related. *When absolute temporal information is not available in a new story scene, and when an existing database story scene has the same agent activity but an earlier position in the goal-plan-act sequence of the intentional chain, a causal history link is proposed.*

**Rule 9:** The things in one story that are caused by things in another are results. *A causal results link is proposed if the existing database scene is later than the new story scene in the goal-plan-act sequence.*

**Rule 10:** The way something turns out in one story suggests how things will turn out in a similar story. *A causal results link is proposed if the new and existing database story scenes are about similar situations or have similar agent activity and the existing database story scene can provide the new scene with missing outcome information.*

**Rule 11:** What someone believes in one story can suggest one thing someone else might believe in another similar story. *Also, when a new story scene is missing a belief to explain an agent's activity or situation, reasons links are proposed to any existing database story scenes that can supply one.*

**Rule 12:** What someone does in one story can suggest what someone else might do in a similar story. *A reasons link is proposed if the new and existing database story scenes are about similar situations and the existing database story scene can provide the new scene with missing agent activity information.*

#### Comparison links:

**Rule 13:** If people either believe or do similar things or get themselves into similar situations in two different stories, then the stories are analogous. *If a new and an existing database story scene both have agents with similar beliefs, situations, or activities, then a similarities link is proposed between them.*

**Rule 14:** If stories are similar, but people either believe or do something different or get themselves into a very different situation then the stories are alternatives. *However, if in otherwise similar story scenes, dissimilar values are found in exactly one of the slots used above to compute similarity, then a differences link is proposed instead.*

**Application links:**

**Rule 15:** One story can give helpful warnings if another story is similar. *In similar new and existing database story scenes, if one is a story of the type that offers warning advice and the other does not, then a warnings link is proposed from the former to the latter.*

**Rule 16:** One story can suggest good opportunities to pursue if another story is similar. *In similar new and existing database story scenes, if one is a story of the type that offers advice regarding an opportunity and the other does not, then an opportunities link is proposed from the former to the latter.*

Processing the Rules

A dynamic indexing rule consists of conditions and actions, which are processed by simple inference. The conditions access domain hierarchy fillers in the frame slots of story scenes for their processing. The actions generate links and explanations to help the writer/indexer assess the validity of the proposed link.

Each rule has been written to infer links between a single story frame and the frames of other stories of a database. As a result, each frame representing a new story is independently passed to the inference process.

The Boolean functions of the conditional part of a rule reference the domain concept hierarchies associated with the slot values for a new story frame, for example, agent activity fillers in the **IntentionType** slot (Figure 6-15). In concept, these functions compare the domain concept fillers of slots from one of the representation frames of a new story with fillers of slots for all other frames in the story base looking for similarities, which is not an efficient process. In practice, the rule conditionals are evaluated by traversing the nodes of the domain concept hierarchies (*cf.*, deductive retrieval, Charniak, et al. 1987), not exhaustive comparison. The slot values for the new story frame are the starting points for these traversals. The search for frames meeting a criterion is conducted by traversing links between frames and the domain hierarchy. Similarity of two filler terms is assessed by whether or not they share a parent node in the hierarchy.

A link is proposed for each existing story frame meeting the conditional tests of the rule relative to a new story frame. The action side of a rule can create and explain one or more links for each qualifying frame. For example, a *context*

<b>IF</b>	A new story scene is missing a filler for the <b>IntentionType</b> slot
	<b>AND</b>
	A filler can be supplied from an existing story scene that has a similar filler for the <b>SituationType</b> slot,
<b>THEN</b>	Make a reasons link between the new story and the existing database story that supplied the filler
	<b>AND</b>
	Give the explanation that the situations are the same but since the agent activity of the new story is missing it might be the same activity as the database story.

Figure 6-15: The Function of Inference Rule 12

The source story is about *Being Bored* (source frame **SituationType** slot) but we do not know the activity of the *Student* (source frame **AgentRole** slot). The destination story is about the same (or a similar) situation. In it the *Student* (destination frame **AgentRole** slot) *actually did* (destination frame **IntentionLevel** slot) *show a lack of interest* ( destination frame **IntentionType** slot).

Figure 6-16: A Rule Explanation

rule proposes a *context* link from the new story to each of the stories bound from the conditional processing. Because *context* has a reciprocal relationship with *specifics* it also proposes a *specifics* link from each bound database story to the new story.

When a rule is satisfied, the rule's action creates an explanation from a text template stored with the rule to assist the writer/indexer in judging the relevance of the proposed link(s). By caching these explanations with the links proposed, human users of the system are better able to judge the relevance of the proposed link at the end of the link proposal process. For example, when Rule 12

fires, it fills in the bound values for slots in the parenthetical expressions (below) from the two stories being linked creating the explanation in Figure 6-16.

- 1). Warnings
- 2). Opportunities
- 3). Similarities
- 4). Differences
- 5). Reasons
- 6). Causal results
- 7). Causal history
- 8). Temporal results
- 9). Temporal history
- 10). Context
- 11). Examples
- 12). Specialization
- 13). Generalization

Efficiency in rule processing stems from deductive retrievals from a database organized specifically to support it, rules that make several links simultaneously, and rules that take advantage of available bindings to produce both links and text explanations.

After the processing of rules is complete, links inferred by more complex rules are presented first while more basic links are proposed later in the sequence. For example, when a *warnings* link is proposed between two stories, the *similarities* rule

will fire, too. The *warnings* link is placed before the *similarities* link in the proposed list. The link precedence order for rules is shown Figure 6-17.

Figure 6-17: Rule Precedence

### Case-Based Representation

In addition to its basic representation and inference facilities, DynaDex contains a case-based retrieval function to assist human users with the story representation task. The function gradually shifts some of the details of the representation responsibility from humans to the computer as the system acquires the stories of the domain. Eventually, most new stories can be represented by drawing some combination of the events and activities of agents from existing stories. Assembling new representations from existing frames has utility because filling out frames can be difficult.

To represent a story, the writer/indexer can choose one of several questions (Figure 6-18) about his or her new story, based on which questions he

or she feels would be easiest to answer. An example will clarify how this works.

*Suppose the story to be represented is about a student who is bored. The user clicks on the question, "What is the story about?"*

A question is answered by selecting one of the fillers from the domain concept hierarchy associated with the question.

*The user chooses "Being Bored", a domain concept filler from the hierarchy associated with the selected question.*

The system limits the user to selecting one of the top four questions in Figure 6-18 initially. After selecting and answering the question, two types of results are displayed graphically. One type of selection is a single scene that may be chosen as representative of the new story. Another type of selection represents a group of several scenes that must be further reduced before a writer/indexer can make a final selection. In this latter case, the indexer/writer is asked the one question from the top portion of Figure 6-18 that will best differentiate among the several scenes represented in a group.

*The system displays several alternative frames. One represents a group of frames that needs to be further reduced. The user clicks on the graphical item representing this group and the system directs the user's attention to the question, "Who are the actors in the story?" The user clicks on it and selects "Student" and "Teacher" from the domain concepts contained in the **AgentRole** slots of the group's scenes. The system extends the graphical representation to show the selections of the user from this group.*

<b>AgentRole</b>	<i>Who are the actors in the story?</i>
<b>SituationType</b>	<i>What is the story about?</i>
<b>TimeOfOccurrence</b>	<i>When did the events occur?</i>
<b>StoryType</b>	<i>What type of story is this?</i>

<b>BeliefType</b>	<i>What does this agent believe?</i>
<b>IntentionType</b>	<i>What are the agent's intentions?</i>
<b>OutcomeTypes</b>	<i>What happened in the end?</i>
<b>IntentionLevel</b>	<i>How were the intentions carried out?</i>

Figure 6-18: The Case-Based Retrieval Questions

If the top four questions of Figure 6-18 are unsuccessful at fully discriminating a selection group down to individual frames, then the user is offered the opportunity to answer any combination of the last four questions of Figure 6-18. The case retriever locates the best overall set of frames to

include in the selection as determined by the maximum number of features from the case base that match the answers given.

As questions are answered and graphical representations of possible frame representations are built up, the writer/indexer evaluates the potential applicability of each of these frames using the same natural language generation function that displays stories in text form (see Figure 6-4). Because the function employs the semantics of the frame, it is easy to quickly review its meaning.

Based on the writer/indexer's evaluation, he or she locates and selects the best set of existing frames as a default representation of the new story. Typically,

in the School Stories domain, the writer/indexer selects one frame from among those displayed to represent each activity of each agent in the story. The selection need not be complete or correct because the writer/indexer can process any needed changes, additions or deletions using the editing functions of the system.

## Tests of Dynamic Indexing

Dynamic indexing has been applied in the domain of School Stories, where 66 stories about K-12 school experiences were cross indexed. It has also been applied to the domain of Trans-ASK, where 47 stories previously indexed by the question-based method were re-indexed for comparison purposes using the dynamic indexing tool.

### Improving the Sparse Indexing of School Stories

The original 66 School Stories were sparsely indexed by their authors. In all, the authors only produced 46 links among them. Nine seed stories were entered before the authoring process began. Initially, authors were given the chance to either respond to an existing story or to enter a new story without specifying how it was related to the others. Twelve independent stories were entered by participants before that function was disabled, and further activity was limited to responsive story-telling. An abstract representation of the authoring pattern is shown in Figure 6-19. The results of authoring activity were as follows: five of the original seed stories and one of the participant's stories initiated chains of responsive story-telling as shown in the six independent hierarchies of Figure 6-19. Three of the eight seed stories remained unlinked. One was hand-linked to

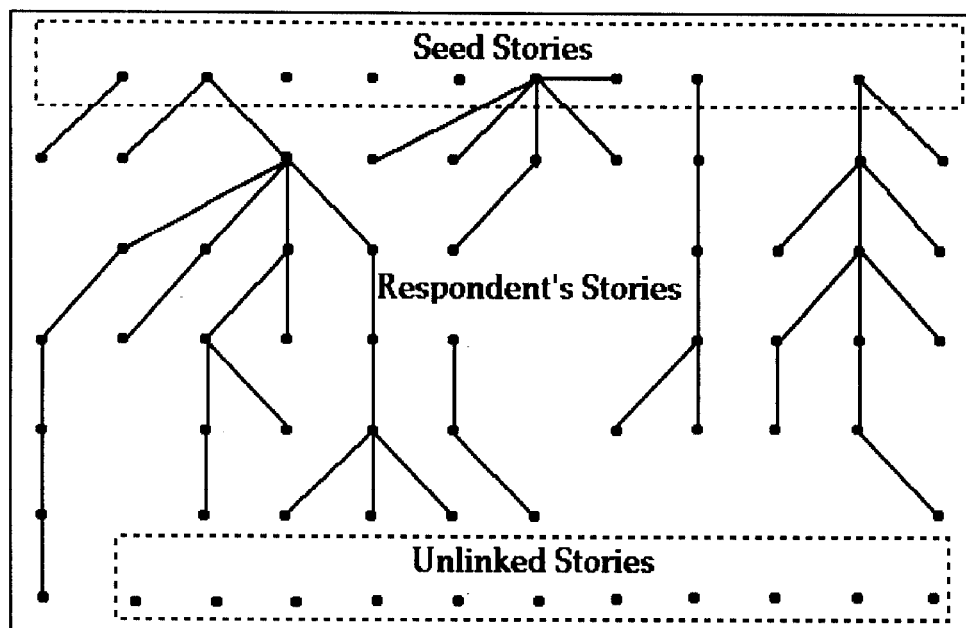


Figure 6-19: School Stories Authoring Pattern

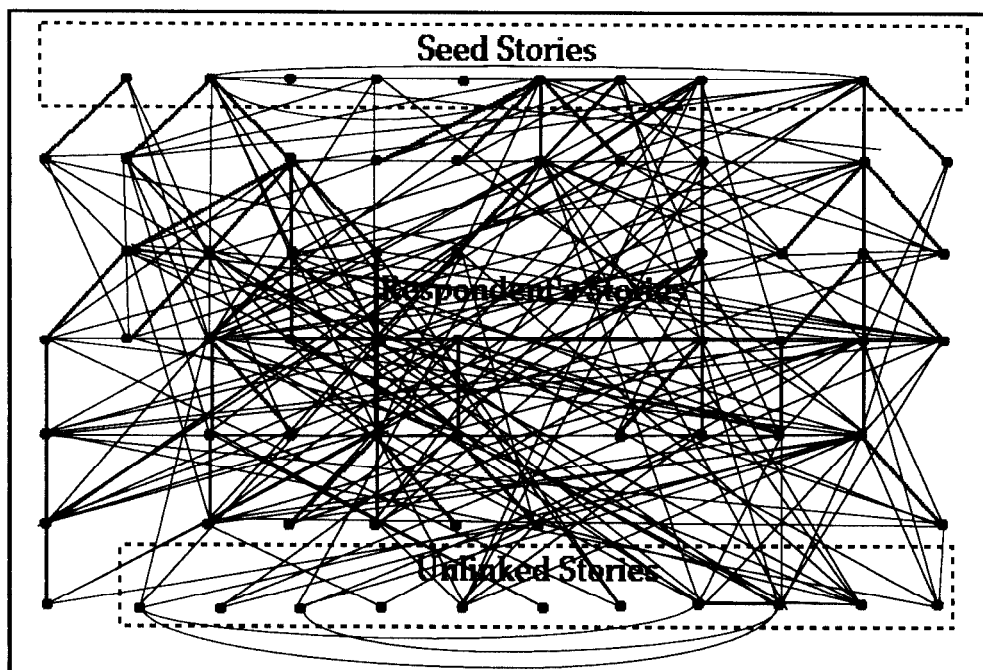


Figure 6-20: Additional School Story Links from Dynamic Indexing

another seed story. Eleven of the twelve independent stories did not elicit any responses during the short time the system was available; these remained unlinked. Overall, the average connectivity produced was 0.7 links per story.

Dynamic indexing was applied to School Stories as part of the development of the DynaDex tool. The results were a significant increase in the density of linkages. The typical connectivity of a given screen improved to an average of 6.7 links per story (Figure 6-20).

These results cannot be directly compared to the indexing humans would do for these stories, because no manual indexing of the stories was attempted. However, I evaluated each dynamically proposed link for the soundness of its explanation and its relevance for the two stories it indexed. Only links that passed this evaluation were included. On average seven of every ten links proposed were accepted.

Each link proposed by dynamic indexing was evaluated, and most links accurately reflected valid story relationships. First, many simple equivalence relationships were correctly predicted. For example, two stories about *being bored* were linked by an *Analogies* link. Second, other more complex similarity relationships were correctly predicted. For example, the system proposed a *results* link between two stories in which students actually did use similar methods of *redressing unfair treatment*. The second story suggested a possible outcome of the attempt to redress unfair treatment, because the first story did not specify an outcome.<sup>54</sup>

Evaluation of the proposed links also disclosed some of the limitations of

<sup>54</sup>Note that many of the relationships found have an analogical character.



the current implementation. Chief among them is the sensitivity of inference to inconsistencies and limitations of the representation. Of the incorrect links proposed by the system many resulted from shifting and inconsistent interpretations of concepts in the system. For example, a **SituationType** slot with filler *Being Bored* was used to describe a student getting into trouble with a teacher as well as a student irritated by having to wait in line for school to open. An *Analogies* link was proposed between these stories; however, their similarity is dubious.

Other incorrect links were proposed as a result of the decision to represent as similar concepts that share the same parent concept. While this works well for the concept hierarchies with categorical semantics, for example, in the agent hierarchy a *friend* is similar to *another student*, it is less successful with the intentional chain semantics of the concept hierarchy for agent actions. For example, *beating someone up*, *belittling someone's efforts*, *pointing out other's mistakes*, and *threatening physical harm* are all ways to *get even* and are considered similar for the purposes of inference. However, when the stories take place in very different settings, similarity-based links between them are often not warranted. No satisfactory solution has been found for this problem.

Finally, a few incorrect links resulted from several overly general rules. In particular, similarities proposed solely on similar or equivalent fillers for the **SituationType** slot were found to be in error. For example, one story about *having an unusual ability* was linked to a story about *exceeding expectations*. Upon closer inspection, the first story concerns a student's ability to win money from other students playing cards. The second story concerns completing the spelling books for several grade levels above the student's current level. Errors like this distant and probably unwarranted inference might be corrected by further specializing rules that rely on essentially a single similarity.

### The Dynamic Indexing of Trans-ASK

Trans-ASK is a large-scale hypermedia system that operates in the domain of military transportation planning (Bareiss and Osgood 1993). It is intended to serve as a job aid, training tool and a reference tool for officers assigned to the United States Transportation Command. The system contains the expertise of 33 experienced transportation planners, all of whom were active during the Gulf War with Iraq. Currently, the system contains about 1,200 video stories with over 20,000 links generated using the question-based method described in Chapter 5.

Two Northwestern University undergraduates tested DynaDex on a portion of the Trans-ASK database as their senior project. They knew nothing about the domain, yet were able to use the tool to represent and propose links among 47 stories, comprising one of the Trans-ASK subordinate databases.<sup>55</sup> For

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<sup>55</sup>Trans-ASK is so large that the indexing job was divided into smaller units. Interviews with each of the 33 experts were placed in a separate story database and independently indexed by the question-based method. Certain globally relevant questions were set aside for later cross-indexing

the Trans-ASK domain, they developed a frame representation, domain concept hierarchies and rules for four of the eight conversational categories. They operated without any knowledge of the manual links already produced for Trans-ASK; yet, a preliminary evaluation indicates that a high degree of overlap between the manual and the inferred indices were achieved (Bareiss and Osgood 1993). Of the 126 links proposed by the system for the 47 stories, 78 were correct as proposed, 26 were reversed (indicating a clerical error in representation), and eleven were incorrect. These results have not yet been compared formally to manual indexing.

In summary, these two experiences with dynamic indexing demonstrate its potential and provide some lessons. While it has only been tried on a small scale, the method did locate many relevant indices between stories. For systems in which indexing is being conducted in conjunction with authoring, dynamic indexing can assist the authors in completing the indexing of their new text passages.<sup>56</sup> For systems with large databases that index existing material, dynamic indexing can assist human indexers in finding links.

The quality of the inferred links is completely dependent upon the quality of the underlying representations. Errors in domain hierarchy representation can generate false assessments of similarity, generalization/specialization and causal relationship. However, assuming representation mistakes can be kept to a manageable level as the method scales up and assuming domain theory hierarchies do not become unmanageable, dynamic indexing can be employed successfully to index a very large corpus of stories.

## Conclusion

Dynamic indexing can be a useful approach to solving the indexer saturation problem encountered in large-scale indexing projects such as Trans-ASK and the sparse indexing problem that arises in dynamic collaborative authoring systems such as School Stories. It can be adapted to applications in other domains. The most straightforward application of dynamic indexing is in domains which involve the human intentional chain. These applications can use the existing frame structure and concept hierarchies populated with the concepts of the new domain. DynaDex as currently implemented is sufficiently general to function in such a domain with no code changes.

Dynamic indexing is still applicable in domains where human intentionality is less central. The rule and frame structure is adaptable to such a

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which linked databases together via a second question matching session.

<sup>56</sup>In the experience reported here, actual story authors were not involved in the indexing trials because the experiment with School Stories was suspended pending the development of DynaDex. With the implementation of the CBR interface for representation, the natural language generation facility, and the link explanations, I believe that authors can indeed represent their own stories, given some initial introduction to the process.

new domain with minor coding changes. The functionality of the domain concept hierarchies is completely general and can organize the concepts of the new domain with no code modifications.

Dynamic indexing enabled the creation of a useful computer-based tool, in which human indexers represent stories to the tool and approve the links it proposes. The tool infers links from these representations using human-defined rules. This partitioning of indexing tasks balances the strengths of humans and computers enabling the indexing of large scale or dynamically changing databases of stories which can be very difficult for either humans or computers to do alone.

## Chapter 7

# Research Contributions and Opportunities for Future Work

This dissertation has addressed how reading a text can be improved by conceptual indexing. This concern with reading originated in the observation that linear text creates problems for authors who are limited in their ability to satisfy the knowledge needs and divergent interests of readers. Although hypertext was a step in the right direction, this dissertation has presented new solutions to these problems based on several key ideas summarized in this chapter.

### Research Contributions

My research has produced contributions in three areas:

- **Conversational Reading:** The ASK Michael prototype was constructed as a platform for studying how reading might be improved by applying a model of conversation to organize a reader's interaction with a text. The conversational reading approach, exemplified in the finished ASK Michael system, improves the responsiveness, coherence and relevance of text.
- **Question-Based Indexing:** To create ASK Michael, a new method was

needed to conceptually index its source text, Michael Porter's "The Competitive Advantage of Nations". Question-based indexing and its associated computer-based indexing tool, were developed to meet that need.

- **Dynamic Indexing:** Concern for the tractability of question-based indexing as databases grow very large or as updates to them become frequent, led to the development of dynamic indexing and an automated tool which implements it.

In this section, I discuss these three contributions and the ideas that underlie them, and I identify some common threads in this research.

### **Conversational Reading: Organizing a Reader's Interaction with Text**

Conversational reading addresses several interrelated problems with linear text. First, reading raises multiple questions; yet, an author will have difficulty addressing them all in a linear text. In contrast, a non-linear text arrangement such as hypertext provides, solves some of the problem by providing a reader with a choice of follow-up passages at natural points in the reading process where questions arise. However, hypertext, by itself, is insufficient to be responsive to the knowledge needs and interests of a reader, because the labels for its links do not clearly spell out the questions to which the reader will receive answers.

To support a question-and-answer dialog between a reader and a text, a reader needs a way of communicating his or her question to the system. ASK Michael uses a simple recognition model of question-based interaction to make it easy for a reader to ask unambiguous questions. Assuming the answer can be made available, a reader asks a question by selecting it from a uniform and simple interface menu. The question text, an informative name for the answer passage, and an explanation of the connection between them are included in the link to assist a reader in selecting a question to ask. The options open to a reader can be kept to a manageable number because only questions that pertain to a displayed passage are included in the interface. For example, in a passage that describes the purposes and types of patient monitor devices, a reader may ask, "Who manufactures them?" The reader need only locate this question or its semantic equivalent in the reading interface to obtain an answer.

Second, coherence can be lost in reading passages that were originally written to be read in a linear sequence. Some of this lost coherence can be restored by displaying the questions available to a reader within categories derived from a taxonomic model of conversational coherence. The four classes of the taxonomy represent the most general kinds of questions a reader is likely to raise during reading. Topic *elaboration* questions are useful for fine tuning the topic of the text being read. *Explanation* and *comparison* questions lead to passages that can help a reader understand a text. *Application* questions access passages that can satisfy a reader's desire to know how to use the knowledge gained

through reading. For example, after reading a passage concerning worship of the printing press, a reader may desire an explanation of this practice. The reading interface provides a natural place to look for an answer in its *causes* category.

Finally, readers with diverse backgrounds and interests cannot be easily accommodated by a linear text because it is limited in the choices it can offer. In reading a typical text, a reader may need to skim, consult back-of-the-book indices, or use other strategic reading skills to locate a suitable passage. However, linear text can be restructured non-linearly so that individual passages are accompanied by indices which lead to other passages that can better satisfy a reader's interests because of the choices available. Hypertext takes this approach, but because of its inability to structure and unambiguously label its indices in the reading interface, a reader's interests may go unaddressed even when relevant content is available.

The key to satisfying reader interests is first, to unambiguously label possible follow-up passages with the questions they answer so that a reader can recognize that interest in the options the system provides. Then, to provide those options in the context of a given passage, the system should include as many potentially relevant questions as possible. Some questions are relevant in the local context of a given passage because they are stated explicitly or implied in the passage itself. However, other more global interests, not expressed or implied by a text, become relevant as readers become familiar with the wider context of passages in the system. Typical hypertext systems cannot include questions concerning these sorts of interest, because their indices are tied directly to the words of the text which do not mention them. In contrast, ASK Michael can include them, because its indices are not limited to the words of the text. For example, after reading a passage that concerns the kinds of assistance that the Swiss government provides its industry, the surrounding context of passages from CAN invites a comparison with the role of Swedish government in industry. In ASK Michael, this relationship is supported via a Swedish government assistance question in the reading interface for the Swiss passage.<sup>57</sup>

### **Question-based Indexing: Using Questions to Conceptually Index Text**

The creation of texts for conversational reading is completely dependent on generating the required conceptual indices. Question-based indexing is a method of conceptual indexing which is based on the simple observation that readers can obtain answers to their questions if those questions can be anticipated and answers for them can be cached. This idea is embodied in the question-answering model of ASK Michael in which indexing has been formalized into a few simple steps. Using the method, answers to likely reader questions are determined by segmenting text into passages which serve as contexts for indexing, by predicting the questions that are likely to be raised by a passage. Links are generated by representing passages with the questions they answer,

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<sup>57</sup>See Chapter 5 for details on how these kinds of indices were generated in ASK Michael.

and matching them with questions raised by other passages. The method has some distinct advantages:

- **Effective Task Decomposition:** Given the necessary tools to facilitate communication and coordination, this method enables a staff of indexers to share the indexing of a single text because many of the steps of the process can be done independently.
- **Consistent Indexing:** Question-based indexing can approach completeness and consistency in its indexing of source material through an incremental process of evaluating unused questions raised and questions answered. Unused questions raised can guide the acquisition of new content. Unused questions answered provide opportunities for adding overlooked links, thus enriching the connectivity of the system.
- **Efficient Matching:** Question-based indexing is possible because text questions are a useful representation of anticipated reader interests (questions raised) and the knowledge contained in a text (questions answered). This representation can support a natural human process of assessing the similarity of questions raised with questions answered to generate links. In turn, this matching process can be made efficient by classifying questions which serves to limit the scope of the search for similar questions to those in the same category.

#### **Dynamic Indexing: Partially Automating the Conceptual Indexing of Text**

Dynamic indexing is an alternative to the question-based approach that can improve the efficiency of conceptual indexing in some situations. If the representations used in indexing can be made more precise than text questions, more of the linking process can be automated. This can shift more of the burden of indexing from the indexer to the computer, thus enabling the indexing of larger databases of text than might otherwise be possible.

The dynamic indexing process depends on an allocation of responsibilities to indexer and computer that is well within the capabilities of each: The indexer represents a story by selecting domain concepts from an indexer-extensible domain concept hierarchy to instantiate one or more representational frames. The computer executes simple inference rules upon these frames to propose links for each of the conversational categories that enumerate the ways stories can be coherently connected. Finally, the indexer evaluates and approves system proposed links by considering explanations provided by the system.

Dynamic indexing encourages consistency in locating relevant indices, especially those common repetitive links that may be missed in indexing a large database of text. Links are proposed by systematically executing rules to infer all potentially relevant links between all potentially related passages. The quality of the results is, however, dependent upon the adequacy of the *representation*.

## Common Research Themes

Three significant common themes emerge from these discussions of conversational reading and conceptual indexing. The first theme is the use of questions for reading and indexing. A reader can judge the relevance of a follow-up passage from its question label without having to read it first. An indexer can record his or her prediction of likely reader knowledge needs and interests in question form. He or she can also abstract the content of a text by composing a set of questions answered. Using question-based indexing, the indexer can link two passages by matching their respective questions raised and answered without consulting the passages.

Second, the observation that the interrogative function of a question can be classified using a series of categories, inspired by Schank's Model of Conversational Coherence, has been pivotal in this research. The model organizes the browsing interface and also the "Interesting Themes" zooming interface of ASK Michael. In question-based indexing, a generalized version of the taxonomy suggests the kinds of questions that should be raised during content analysis and a specialized version classifies questions to reduce the complexity of question-matching during link generation. In dynamic indexing, the taxonomy specifies the set of rules for inferring links.

Third, the four general interrogative purposes of questions (Elaboration, Explanation, Comparison, and Application) establish a precedence used to order links in conversational reading, question-based indexing and dynamic indexing. While not yet confirmed by experimental study, it is plausible that humans first look for advice, then, failing to find it, a comparison from which advice can be inferred by analogy, then a causal explanation, and finally, conceptual details of the domain from which an explanation can be inferred. In conversational reading, the conversational categories which organize the browsing interface, are arranged in this order. In question-based indexing, links generated from multiply classified questions were placed in the category of highest precedence. Similarly, links proposed by dynamic indexing were proposed for indexer acceptance in this order.

## Ongoing Research

Collaborative writing is a natural extension to the idea of non-linear reading systems based on the metaphor of conversation. The same model of conversational coherence that organized ASK Michael can organize an authoring system in which prospective authors participate in a real, albeit computer-mediated, conversation. More specifically, authors can build a structured record of a dialog, in contrast to traditionally ill-structured newsgroups or email. The GroupWrite system used in the School Stories project discussed in Chapter 6 is an example of such a collaborative authoring environment.



My ongoing research is concerned with exploring the properties of conversational writing, emphasizing the indexing requirements for various kinds of collaboration in which authors participate. In the limited experiences with the GroupWrite software to date, the idea of conversational writing has begun to take shape.

Like conversational reading, conversational writing is non-linear and is guided by the categories of conversational coherence that organized ASK Michael's content. An initial passage can be elaborated in a variety of directions specified by this model. Each elaboration is automatically linked to the passage that inspired it. The order in which elaborations are created is not fixed. Authors have a great deal of freedom to respond naturally to the content they read. The result is a rationally-organized document that grows to mirror the relational structure of the collective thought behind it.

Conversational writing can involve a variety of modes of collaboration. In a basic collaborative interaction, one author replies to or elaborates another author's passage, indexing the response within one of the conversational categories. In an inquiry interaction, one author poses a question in response to another author's passage to which any member of the community may respond. Finally, in an indexing interaction, an author may notice and add a connection between two passages he or she has read.

GroupWrite supports all the collaboration modes described above. However, it has seen only limited use. The primary problem that emerged during the use of the system was the pattern of sparse indexing (discussed in Chapter 6) which dynamic indexing was designed to address. To date, an integrated version of GroupWrite and DynaDex has not been deployed for use by real users. Given the state of the two systems, this is the logical next step in this research.

## **Future Directions**

Additional research is needed to address some of the limitations of the methods and systems presented in this dissertation. Future research directions include addressing the limitations of conversational hypermedia systems, question-based indexing, and dynamic indexing.

### **Improving Conversational Hypermedia Systems**

Conversational reading, as implemented in ASK Michael, is indexed for topical zooming and conversational browsing. However, ASK Michael's zoomers were not based on a principled understanding of why a reader might want to access the text of a book like CAN. Similarly, the indices displayed in the conversational categories of its browsing interface are displayed in no particular order within category. The consequences of these limitations are that a reader must expend additional effort using the zooming and browsing interfaces to find and read

relevant passages.

In the following subsections, I propose the use of task models for improving the utility of zooming and the use of the reader's navigation history to improve precision in browsing.

### Task Models for Zooming

This research has largely ignored an important determinant of effective conversational interaction. The reader may consult text to obtain advice related to the performance of a specific task. The utility of abstract knowledge of intellectual tasks for problem solving has long been recognized by the AI and cognitive science research communities, which have produced a range of models including Sussman's (1975) and Sacerdoti's planning critics, Wilensky's (1982) meta-plans, Schank's (1982) thematic memory structures, Chandrasekaran's (1983) generic tasks and the KADS model (Wielinga, Schreiber, and Breuker 1992). Much human problem solving is organized around abstract task models (cf. situated cognition, Brown, Collins, and Duguid 1989), and thus a similar organization should prove useful for organizing the memory of a hypermedia instructional system. It can provide readers more power to locate relevant material than a task-independent topical interface such as an ASK Michael zoomer, because its presentation of options to the user is aligned with the user's task.

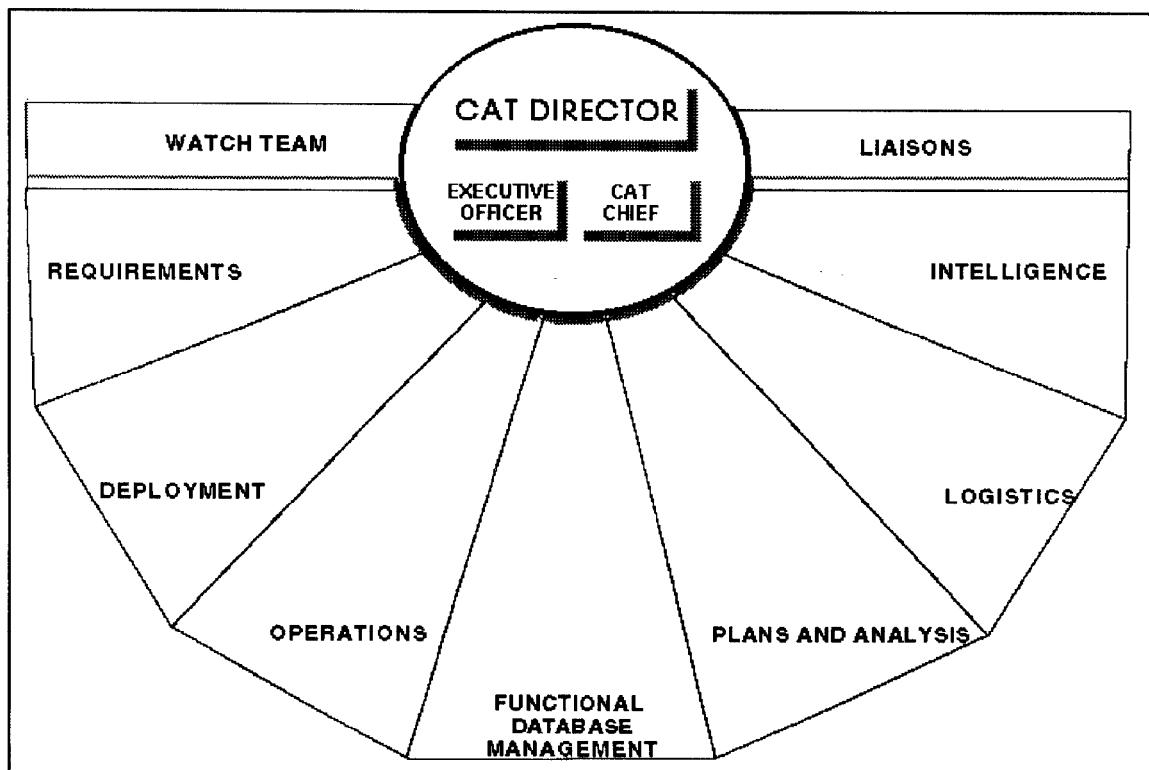


Figure 7-1: The Functional Roles of the Crisis Action Team (CAT)

The application of task models for both navigating and indexing hypermedia is a promising direction for this research. Others at the Institute for the Learning Sciences have begun to apply task models to assist navigation in a variety of domains including military transportation planning, the Trans-ASK system (Bareiss and Osgood 1993), and genetic counseling, the Sickle Cell system (Bell, Bareiss, and Beckwith 1994). For example, the Trans-ASK system, described earlier in this dissertation, uses a model of the user's task to organize zooming.

1. Maintaining awareness and status of the situation and operation.
2. Identifying transportation requirements.
3. Verifying the accuracy of requirements.
4. Monitoring sustainment requirements (e.g., food and other supplies for deployed troops).
5. Ensuring that valid and prioritized requirements are entered into JOPES (the computerized Joint Operations Planning and Execution System currently used by the military).
6. Reviewing the direct communication between the users of transportation and the providers (i.e., the transportation component commands or TCC's).
7. Coordinating changes to requirements and other priorities.
8. Ensuring that transportation requirements for TRANSCOM/TCC personnel required in forward positions are included in the overall plan.
9. Monitoring the overall scheduling process.

Figure 7-2: Tasks of a CAT Officer in the US Transportation Command

*Suppose a new requirements officer is using the system. Beginning with the diagram in Figure 7-1, the user selects "Requirements" and is presented with the list of requirements tasks shown in Figure 7-2.*

*The user selects item number 5 and is shown a list of potential problem areas (Figure 7-3). After selecting one problem to pursue, the system presents a relevant*

- JOPES data is inaccurate.
- The situation has changed making requirements outdated.
- Priorities are changing very rapidly.
- Users are not familiar with or cannot use JOPES.
- JOPES is not being used by other commands.

Figure 7-3: Problem Selection in Trans-ASK

*video, and the user is free to explore related material using the Trans-ASK browsing interface (which is similar to ASK Michael's).*

This brief example illustrates the effectiveness of a task model at quickly guiding the user to an applicable story. However, applying such a model in a system trades the general applicability to a variety of users for power in supporting the information needs of a single task-engaged user. The future research problem concerns how to extend the generality of such systems for a diverse audience while preserving the power of task-based indexing.

In general, a reader comes to a text affected by four basic influences: a role, a task, prior experience, and an interest level. First, the role sets an abstract context within which to anticipate the reader's knowledge needs. It influences the appropriate level of detail, background knowledge and even likely questions by specifying a likely set of possible reader tasks.<sup>58</sup> In the above example,

<sup>58</sup>This was the approach taken in Trans-ASK (Bareiss and Osgood 1993).

knowledge of the reader's role (a new requirements officer) was used to narrow the selection of tasks the system presents to the user.

Second, the reader's task orientation, or problem solving goals, defines the relevance of follow-up content. In the above example, the user selected a specific problem from among those likely to accompany the chosen task. The user then viewed a task-relevant video which because of its content is likely to be linked to task-relevant follow-up.

Third, a reader's prior experience plays an important role in the design of a task-oriented zooming interface. Readers less experienced in the tasks of a domain require more opportunities to acquire background, find explanations, and access definitions for terminology. More experienced readers will find such indices extraneous. The above example from Trans-ASK contains novice level indices because it is targeted at the new officer. Addressing the needs of the more experienced user without cluttering the interface with novice level indices is an open problem.

Finally, whether a reader's interest is casual or deliberate determines the specificity of the knowledge the system should present. It should include the specific questions of the deliberate reader engaged in a task, as well as the more general and introductory questions of the casual reader with little task influence. The Trans-ASK system does not address the needs of casual user. ASK Michael does not address the needs of a task-engaged user. How to serve both types of users in the same system is also an open problem.

The task models which can structure zooming in hypermedia systems might also be applied to improve question-based indexing. Question-matching could be simplified by classifying the questions according to a general model of the activity in which the reader is likely to be engaged as well as by topic and the conversational model. The current method of grouping questions in preparation for matching, described in Chapter 5, combines topical and conversational categories. By classifying questions by task, topic and conversational category the efficiency of searching for matches to questions raised could be improved, because the groups of potentially matching questions would be smaller.

Analogously, in dynamic indexing, if the representation is extended appropriately, new task-based inferences might be possible. Domain hierarchies of role, task, and problem (such as those presented in the above example) could be created, which new rules could process. How to best apply this opportunity to include task information in link inferences is a matter of future research.

### Using Shifting Category Semantics to Improve Browsing

The previous history of passages and questions a reader has read in a session with the system might be used to improve browsing, because the semantics of the general categories of the browsing interface shift slightly depending on how the reader comes to the text. For example, a reader may navigate via a *results* link from one passage to a second passage. If, after reading that passage, the reader pursues an *alternatives* link to a third passage, the system can infer an interest in

*alternative results*. In the browsing interface of ASK Michael, the *alternatives* questions displayed in the interface can be reordered placing any links carrying a secondary classification of *results* at the top of the stack.

### Improving Question-based Indexing

In spite of its demonstrated effectiveness, several opportunities exist for improving question-based indexing. First, the question has limitations as a representation for indexing text. Because it is an informal representation, a question can be difficult to process by automated means. The precise representations and indexing rules of dynamic indexing were developed to address this problem. However, other solutions are worth exploring. If a better representation of the topical portion of questions could be found, indexers could classify questions more precisely, narrow the scope of the topical contexts in which question-matching is performed, and thus, reduce its complexity. Alternatively, constraining the representation of text to standard question formats in place of indexer-generated free-text questions can enable some automated question-matching.

Second, the conversational taxonomy has limitations as a means of classifying questions. Many indexer-composed questions were complex enough to require assignment to multiple categories of the taxonomy. However, in ASK Michael, indexers were unable to represent the real semantics of a multi-class question (for example, a question that requests *superlative means* or an *alternative result*). A new classification scheme that captures the meaning of these compound categories could more precisely classify such questions to improve the question-matching process.

### Improving Dynamic Indexing

The preliminary results of dynamic indexing suggest many opportunities for improving the process. First, dynamic indexing has not been subjected to controlled testing to determine its effectiveness in real indexing situations. While informal tests of the approach look promising, more exhaustive testing will certainly uncover additional issues. One likely area of concern is the ability of a real user community (especially, non-indexers using GroupWrite) to index their own stories with this approach. If integrated authoring and indexing proves to be too cumbersome for some authors, it may be necessary to centralize indexing of some newly written stories in the distribution function of GroupWrite where dynamic indexing can be performed by an indexer experienced with the function of the tool. Alternatively, further improvements to the tool may simplify its use for authors. Possible improvements include functions for locating domain concepts more easily, simplifications in the story editing interface, and improvements to the question dialog in the case-based representation function.

Second, the current implementation of dynamic indexing does not produce a label for the link between passages it proposes. Question-based

indexing has the distinct advantage of producing a usable label for a link (the question raised) as a by-product of its indexing. It may be possible to add a text template for the proposed question to the right-hand side of each link inference rule. In practice, such a proposed question will almost certainly need to be user editable.

Third, the consistency of story representation depends on the level of detail that an indexer pulls out of the text. To represent the significant actions of agents in a text, the indexer instantiates a set of frames with vocabulary terms selected from domain concept hierarchies. The dynamic indexing approach does not limit an indexer to a specific number of frames and it permits unlimited extension of the domain concept hierarchies from which fillers for the slots of frames are selected. Guiding this underconstrained process more effectively is an open research problem for the method. Providing a set of standard frames and concept hierarchies for particular classes of domains is one possible approach.

Fourth, the domain concept hierarchies serve two basic functions in dynamic indexing. They organize the indexer's search for domain concepts during story representation, and they specify the basic relationships among concepts (similarity, generalization/specialization, and causal) used by inference rules. These two functions are in basic conflict because similarity and non-similarity relationships are conflated in a single hierarchy. On the one hand, as the number of categories in the system grows, it is desirable to simplify an indexer's search for a concept to represent a story by inserting generalization nodes into the hierarchies. On the other hand, the current implementation of the inference rules which processes causal relationships cannot distinguish these generalizations from the reasoning chain. As a result, vacuous reasons are inserted into explanations, for example, the middle element of wanting to *play baseball* as a way to *play a game* as a way to *have fun*. Causal domain concepts should be represented in separate concept and intentional hierarchies to solve this problem.

## Conclusion

Conceptual indexing of a non-linear text can be accomplished effectively and efficiently using approaches such as question-based indexing and dynamic indexing. Many practical applications of this research can already be found at the Institute for the Learning Sciences. To date, ten ASK systems have been produced using question-based indexing, and a variety of tools have been written for use by professional indexers engaged in the indexing of text, video, and other media. Initial experimentation has begun on applications of dynamic indexing to some of these projects as well.

Application of conceptual indexing to the creation of corporate memories, reference works, performance support systems, and collaborative work environments is already beginning to impact educational and business environments. It is my hope that the research presented in this dissertation will

contribute to the solution of real-world problems that people face when structuring and accessing large bodies of information.

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## Appendix: Inference Rules in Dynamic Indexing

### Elaboration Inferences

#### RULE 1: Generalization & RULE 2: Specifics

```
(defrule generalization-1 ;; general/specific links for a situation
:lhs (and (path ?scene ?x :situationtype :parents :used-in)
          (or (empty-filler ?x :storytype)
              (and (path ?x ?y :storytype)
                    (not (is-named ?y literal_example))))))
:rhs ((generalization
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" the source story is about "
             (str ?scene :situationtype)
             ". The destination story is about "
             (str ?x :situationtype) ", a more general situation of the same kind. "))
      (specialization
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" the source story is about "
             (str ?x :situationtype)
             ". The destination story is about "
             (str ?scene :situationtype) ", which is a more specific situation of the same kind. "))))

(defrule generalization-2 ;; general/specific links for intentional activity
:lhs (and (path ?scene ?x :intentiontype :parents :used-in)
          (or (empty-filler ?x :storytype)
              (and (path ?x ?y :storytype)
                    (not (is-named ?y literal_example))))))
:rhs ((generalization
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" in the source story the "
             (str ?scene :agentrole) " "
             (str ?scene :intentionlevel) " "
             (str ?scene :intentiontype)
             ". In the destination story the " (str ?x :agentrole) " "
             (str ?x :intentionlevel) " "
             (str ?x :intentiontype) ", which is a more general activity of the same kind. "))
      (specialization
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" in the source story the "
             (str ?x :agentrole) " "
             (str ?x :intentionlevel) " "
             (str ?x :intentiontype)
             ". In the destination story the " (str ?scene :agentrole) " "
             (str ?scene :intentionlevel) " "
             (str ?scene :intentiontype) ", which is a more specific activity of the same kind. "))))
```

```
(defrule specialization-1 ;; general/specific links for a situation
:lhs (and (path ?scene ?x :situationtype :children :used-in)
          (or (empty-filler ?scene :storytype)
              (and (path ?scene ?y :storytype)
                   (not (is-named ?y literal_example))))))
:rhs ((specialization
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" the source story is about "
             (str ?scene :situationtype)
             ". The destination story is about "
             (str ?x :situationtype) ", which is a more specific situation of the same kind. "))
      (generalization
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" the source story is about "
             (str ?x :situationtype)
             ". The destination story is about "
             (str ?scene :situationtype) ", which is a more general situation of the same kind. "))))
```

```
(defrule specialization-2 ;; general/specific links for intentional activity
:lhs (and (path ?scene ?x :intentiontype :children :used-in)
          (or (empty-filler ?scene :storytype)
              (and (path ?scene ?y :storytype)
                   (not (is-named ?y literal_example))))))
:rhs ((specialization
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" in the source story the "
             (str ?scene :agentrole) " "
             (str ?scene :intentionlevel) " "
             (str ?scene :intentiontype)
             ". In the destination story the " (str ?x :agentrole) " "
             (str ?x :intentionlevel) " "
             (str ?x :intentiontype) ", which is a more specific activity of the same kind. "))
      (generalization
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" in the source story the "
             (str ?x :agentrole) " "
             (str ?x :intentionlevel) " "
             (str ?x :intentiontype)
             ". In the destination story the " (str ?scene :agentrole) " "
             (str ?scene :intentionlevel) " "
             (str ?scene :intentiontype) ", which is a more general activity of the same kind. "))))
```

### **RULE 3: Context & RULE 4: Examples**

```
(defrule context-1 ;; context/example links in which to understand examples of a situation
:lhs (and (path ?scene ?x :situationtype :parents :used-in)
          (path ?scene ?y :storytype)
          (is-named ?y literal_example))
:rhs ((context
       :from (story-of ?scene)
       :to (story-of ?x)
```



```

:say (" the source story is about "
      (str ?scene :situationtype)
      ". The destination story is about "
      (str ?x :situationtype) ", which is a more general context of the same kind. ")
(example
:from (story-of ?x)
:to (story-of ?scene)
:say (" the source story is about "
      (str ?x :situationtype)
      ". The destination story is about "
      (str ?scene :situationtype) ", which is a more specific example of a situation of the same kind. ")))

```

```

(defrule context-inverse-1 ;; inverse context/example links in which to understand examples of a situation
:lhs (and (path ?scene ?x :situationtype :children :used-in)
          (path ?x ?y :storytype)
          (is-named ?y literal_example))
:rhs ((context
:from (story-of ?x)
:to (story-of ?scene)
:say (" the source story is about "
      (str ?x :situationtype)
      ". The destination story is about "
      (str ?scene :situationtype) ", which is a more general context of the same kind. ")
(example
:from (story-of ?scene)
:to (story-of ?x)
:say (" the source story is about "
      (str ?scene :situationtype)
      ". The destination story is about "
      (str ?x :situationtype) ", which is a more specific example of a situation of the same kind. ")))

```

```

(defrule context-2 ;; context/example links in which to understand examples of intentional activity
:lhs (and (path ?scene ?x :intentiontype :parents :used-in)
          (path ?scene ?y :storytype)
          (is-named ?y literal_example))
:rhs ((context
:from (story-of ?scene)
:to (story-of ?x)
:say (" in the source story the "
      (str ?scene :agentrole) " "
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype)
      ". In the destination story the "
      (str ?x :agentrole)
      (str ?x :intentionlevel) " "
      (str ?x :intentiontype) ", which is a more general activity of the same kind.")
(example
:from (story-of ?x)
:to (story-of ?scene)
:say (" in the source story the "
      (str ?x :agentrole) " "
      (str ?x :intentionlevel) " "
      (str ?x :intentiontype)
      ". In the destination story the " (str ?scene :agentrole)
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype) ", which is a more specific example of the same kind of activity. ")))

```

(defrule context-inverse-2 ;; inverse context/example links in which to understand examples of intentional activity

```

:lhs (and (path ?scene ?x :intentiontype :children :used-in)
          (path ?x ?y :storytype)
          (is-named ?y literal_example))
:rhs ((context
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" in the source story the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype)
            ". In the destination story the " (str ?scene :agentrole)
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype) ", which is a more general activity of the same kind. "))
      (example
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" in the source story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype)
            ". In the destination story the " (str ?x :agentrole)
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype) ", which is a more specific example of the same kind of activity. "))))

```

## RULE 5: Examples

(defrule example-1 ;; close explicit example of intentional activity from source

```

:lhs (and (same ?scene ?x :intentiontype)
          (path ?x ?z :storytype)(is-named ?z literal_example)
          (or (empty-filler ?scene :storytype)
              (and (path ?scene ?y :storytype)
                   (not (is-named ?y literal_example)))))
:rhs ((example
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" in the source story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype) ". The destination story is a good example of the "
            (str ?x :agentrole) ", who "
            (str ?x :intentionlevel)
            " the same thing. "))))

```

(defrule example-inverse-1 ;; close explicit example of intentional activity from destination

```

:lhs (and (same ?scene ?x :intentiontype)
          (path ?scene ?z :storytype)(is-named ?z literal_example)
          (or (empty-filler ?x :storytype)
              (and (path ?x ?y :storytype)
                   (not (is-named ?y literal_example)))))
:rhs ((example
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" in the source story the "
            (str ?x :agentrole) " "

```

```

(str ?x :intentionlevel) " "
(str ?x :intentiontype) ". The destination story is a good example of the "
(str ?scene :agentrole) ", who "
(str ?scene :intentionlevel)
" the same thing. "))))

(defrule example-2 ;; close explicit example of a situation from source
:lhs (and (same ?scene ?x :situationtype)
          (path ?x ?z :storytype) (is-named ?z literal_example)
          (or (empty-filler ?scene :storytype)
              (and (path ?scene ?y :storytype)
                    (not (is-named ?y literal_example))))))
:rhs ((example
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" the source story is about "
             (str ?scene :situationtype)
             ". The destination story is a good example of the same thing. "))))

(defrule example-inverse-2 ;; close explicit example of a situation from destination
:lhs (and (same ?scene ?x :situationtype)
          (path ?scene ?z :storytype)(is-named ?z literal_example)
          (or (empty-filler ?x :storytype)
              (and (path ?x ?y :storytype)
                    (not (is-named ?y literal_example))))))
:rhs ((example
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" the source story is about "
             (str ?x :situationtype)
             ". The destination story is a good example of the same thing. "))))

```

## Explanation Inferences

### RULE 6: Temporal History & RULE 7: Temporal Results

```

(defrule temporal-history-1 ;; same situation earlier absolute time
:lhs (and (same ?scene ?x :situationtype)
          (path ?scene ?time-r :timeofoccurrence (* :parents))
          (is-named ?time-r absolute_time)
          (path ?x ?time-f :timeofoccurrence (* :parents))
          (is-named ?time-f absolute_time)
          (time-before ?time-f ?time-r))
)
:rhs ((temporal_history
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" the source and destination stories are about "
             (str ?scene :situationtype)
             ". The source story happened at "
             (str ?scene :timeofoccurrence)
             ", while the destination story happened earlier at "
             (str ?x :timeofoccurrence)
             "."))
      (temporal_result

```

```

:from (story-of ?x)
:to (story-of ?scene)
:say (" the source and destination stories are about "
      (str ?x :situationtype)
      ". The source story happened at "
      (str ?x :timeofoccurrence)
      ", while the destination story happened later at "
      (str ?scene :timeofoccurrence)
      "."))))

(defrule temporal-result-1 ;; same situation but later absolute time
:lhs (and (same ?scene ?x :situationtype)
          (path ?scene ?time-r :timeofoccurrence (* :parents))
          (path ?x ?time-f :timeofoccurrence (* :parents))
          (is-named ?time-r absolute_time)
          (is-named ?time-f absolute-time)
          ;; (time-before ?time-r ?time-f)
          )
:rhs ((temporal_result
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" the source and destination stories are about "
             (str ?scene :situationtype)
             ". The source story happened at "
             (str ?scene :timeofoccurrence)
             ", while the destination story happened later at "
             (str ?x :timeofoccurrence)
             ".")))

(temporal_history
 :from (story-of ?x)
 :to (story-of ?scene)
 :say (" the source and destination stories are about "
       (str ?scene :situationtype)
       ". The source story happened at "
       (str ?x :timeofoccurrence)
       ", while the destination story happened earlier at "
       (str ?scene :timeofoccurrence)
       "."))))

```

## **RULE 8: Causal History & RULE 9: Causal Results**

```

(defrule causal-history-1 ;; same action but earlier position in the intentional chain
:lhs (and (same ?scene ?x :intentiontype)
          (path ?scene ?x :intentionlevel (* :children) :used-in)
          (not (same ?scene ?x :intentionlevel)))
:rhs ((causal_history
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" in the source story, the "
             (str ?scene :agentrole) " only "
             (str ?scene :intentionlevel) " "
             (str ?scene :intentiontype)
             ". While in the destination story, the "
             (str ?x :agentrole) " "
             (str ?x :intentionlevel) " "
             (str ?x :intentiontype)

```

```

    "."))
(causal_result
:from (story-of ?x)
:to (story-of ?scene)
:say (" in the source story, the "
      (str ?x :agentrole) " only "
      (str ?x :intentionlevel) " "
      (str ?x :intentiontype)
      ". While in the destination story, the "
      (str ?scene :agentrole) " "
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype)
      "."))))

```

(defrule causal-history-2 ;; same action but later position in the intentional chain

```

:lhs (and (same ?scene ?x :intentiontype)
          (path ?scene ?x :intentionlevel (* :parents) :used-in)
          (not (same ?scene ?x :intentionlevel)))

```

```

:rhs ((causal_result
:from (story-of ?scene)
:to (story-of ?x)
:say (" in the source story, the "
      (str ?scene :agentrole) " "
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype)
      ". While in the destination story, the "
      (str ?x :agentrole) " only "
      (str ?x :intentionlevel) " "
      (str ?x :intentiontype)
      "."))

```

```

(causal_history
:from (story-of ?x)
:to (story-of ?scene)
:say (" in the source story, the "
      (str ?x :agentrole) " "
      (str ?x :intentionlevel) " "
      (str ?x :intentiontype)
      ". While in the destination story, the "
      (str ?scene :agentrole) " only "
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype)
      "."))))

```

## RULE 10: Causal Results

(defrule causal-result-1 ;; Missing outcome supplied by story with similar intentional activity

```

:lhs (and (empty-filler ?scene :outcometypes)
          (same-or-similar ?scene ?x :intentiontype)
          (has-filler ?x :outcometypes))

```

```

:rhs ((causal_result
:from (story-of ?scene)
:to (story-of ?x)
:say (" in the source story the "
      (str ?scene :agentrole) " "
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype)

```

```

" but we do not know the results. In the destination story the "
(str ?x :agentrole) " "
(str ?x :intentionlevel) " "
(same-sim ?scene ?x :intentiontype)
" but with "
(str-path ?x :outcometypes) "results. ")

```

```

(defrule causal-result-2 ;; Missing outcome supplied by story about a similar situation

```

```

:lhs (and (empty-filler ?scene :outcometypes)
          (same-or-similar ?scene ?x :situationtype)
          (has-filler ?x :outcometypes))
:rhs ((causal_result
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" the source story is about " (str ?scene :situationtype)
            ", but we do not know the results. The destination story is about "
            (same-sim ?scene ?x :situationtype) ", but with "
            (str-path ?x :outcometypes) "results. ")

```

```

(defrule causal-result-inverse-1 ;; Missing outcome supplied to story with similar intentional activity

```

```

:lhs (and (has-filler ?scene :outcometypes)
          (same-or-similar ?scene ?x :intentiontype)
          (empty-filler ?x :outcometypes))
:rhs ((causal_result
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" in the source story the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype)
            " but we do not know the results. In the destination story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (same-sim ?x ?scene :intentiontype)
            " but with "
            (str-path ?scene :outcometypes) "results. ")

```

```

(defrule causal-result-inverse-2 ;; Missing outcome supplied to story about a similar situation

```

```

:lhs (and (has-filler ?scene :outcometypes)
          (same-or-similar ?scene ?x :situationtype)
          (empty-filler ?x :outcometypes))
:rhs ((causal_result
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" the source story is about " (str ?x :situationtype)
            ", but we do not know the results. The destination story is about "
            (same-sim ?x ?scene :situationtype) ", but with "
            (str-path ?scene :outcometypes) "results. ")

```

## RULE 11: Reasons

```

(defrule reasons-1 ;; Reason for a situation expressed as a belief

```

```

:lhs (and (empty-filler ?scene :belieftype)
          (same-or-similar ?scene ?x :situationtype)
          (has-filler ?x :belieftype))

```

```

:rhs ((reasons
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" the source story is about " (str ?scene :situationtype)
            ", but we do not know what the " (str ?scene :agentrole)
            " believed. The destination story is about "
            (same-sim ?scene ?x :situationtype) ". In it the "
            (str ?x :agentrole) " believed that "
            (str ?x :belieftype) ". "))))

```

(defrule reasons-3 ;; Reason for agent intentionality expressed as belief

```

:lhs (and (empty-filler ?scene :belieftype)
          (same-or-similar ?scene ?x :intentiontype)
          (has-filler ?x :belieftype))
:rhs ((reasons
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype)
            ", but we don't know what the "
            (str ?scene :agentrole)
            " believed. In the destination story, the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (same-sim ?scene ?x :intentiontype)
            ". In it the " (str ?x :agentrole)
            " believed that " (str ?x :belieftype) ". "))))

```

(defrule reasons-inverse-1 ;; Reason for a situation expressed as a belief

```

:lhs (and (has-filler ?scene :belieftype)
          (same-or-similar ?scene ?x :situationtype)
          (empty-filler ?x :belieftype))
:rhs ((reasons
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" the source story is about " (str ?x :situationtype)
            ", but we do not know what the " (str ?x :agentrole)
            " believed. The destination story is about "
            (same-sim ?x ?scene :situationtype) ". In it the "
            (str ?scene :agentrole) " believed that "
            (str ?scene :belieftype) ". "))))

```

(defrule reasons-inverse-3 ;; Reason for agent intentionality expressed as belief

```

:lhs (and (has-filler ?scene :belieftype)
          (same-or-similar ?scene ?x :intentiontype)
          (empty-filler ?x :belieftype))
:rhs ((reasons
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" in the source story the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype)
            ", but we don't know what the "
            (str ?x :agentrole)

```

```

" believed. In the destination story, the "
(str ?scene :agentrole) " "
(str ?scene :intentionlevel) " "
(same-sim ?x ?scene :intentiontype)
". In it the " (str ?scene :agentrole)
" believed that " (str ?scene :belieftype) ". "))))

```

## RULE 12: Reasons

```

(defrule reasons-2 ;; Reason for a situation expressed as agent intentionality
:lhs (and (empty-filler ?scene :intentiontype)
          (same-or-similar ?scene ?x :situationtype)
          (has-filler ?x :intentiontype))
:rhs ((reasons
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" the source story is about " (str ?scene :situationtype)
           ", but we do not know the activity of the " (str ?scene :agentrole)
           ". The destination story is about "
           (same-sim ?scene ?x :situationtype) ". In it the "
           (str ?x :agentrole) " "
           (str ?x :intentionlevel) " "
           (str ?x :intentiontype) ". "))))

```

```

(defrule reasons-inverse-2 ;; Reason for a situation expressed as agent intentionality
:lhs (and (has-filler ?scene :intentiontype)
          (same-or-similar ?scene ?x :situationtype)
          (empty-filler ?x :intentiontype))
:rhs ((reasons
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" the source story is about " (str ?x :situationtype)
           ", but we do not know the activity of the " (str ?x :agentrole)
           ". The destination story is about "
           (same-sim ?x ?scene :situationtype) ". In it the "
           (str ?scene :agentrole) " "
           (str ?scene :intentionlevel) " "
           (str ?scene :intentiontype) ". "))))

```

## The Comparison Inferences

### RULE 13: Similarities

```

(defrule similarity-1 ;; similar intentional activity of agents
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (or (empty-filler ?scene :situationtype)
              (empty-filler ?x :situationtype)
              (same-or-similar ?scene ?x :situationtype))
          (or (empty-filler ?scene :outcometypes)
              (empty-filler ?x :outcometypes)
              (path ?scene ?x :outcometypes (* :parents) :used-in))
          (or (empty-filler ?scene :intentionlevel)
              (empty-filler ?x :intentionlevel)
              (same ?scene ?x :intentionlevel))

```



```

      (or (empty-filler ?scene :belieftype)
          (empty-filler ?x :belieftype)
          (same ?scene ?x :belieftype)))
:rhs ((similarities
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype) ". In the destination story, the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (same-sim ?scene ?x :intentiontype) ". "))
      (similarities
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" in the source story the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype) ". In the destination story, the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (same-sim ?x ?scene :intentiontype) ". "))))

(defrule similarity-2 ;; similar situations
:lhs (and (same-or-similar ?scene ?x :situationtype)
          (or (empty-filler ?scene :intentiontype)
              (empty-filler ?x :intentiontype)
              (same-or-similar ?scene ?x :intentiontype)))
:rhs ((similarities
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" the source story is about "
            (str ?scene :situationtype) ". The destination story is about "
            (same-sim ?scene ?x :situationtype) ". "))
      (similarities
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" the source story is about "
            (str ?x :situationtype) ". The destination story is about "
            (same-sim ?x ?scene :situationtype) ". "))))

(defrule similarity-3 ;; similar beliefs of agents
:lhs (same-or-similar ?scene ?x :belieftype)
:rhs ((similarities
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " believed "
            (str ?scene :belieftype) ". In the destination story, the "
            (str ?x :agentrole) " believed that "
            (same-sim ?scene ?x :belieftype) ". "))
      (similarities
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" in the source story the "
            (str ?x :agentrole) " believed "

```

```
(str ?x :belieftype) ". In the destination story, the "
(str ?scene :agentrole) " believed that "
(same-sim ?x ?scene :belieftype) ". "))))
```

## RULE 14: Differences

(defrule difference-1 ;; similar intentional activity of agents but different situations

```
:lhs (and (same-or-similar ?scene ?x :intentiontype)
  (has-filler ?scene :situationtype)
  (has-filler ?x :situationtype)
  (not (same-or-similar ?scene ?x :situationtype)))
:rhs ((differences
  :from (story-of ?scene)
  :to (story-of ?x)
  :say (" in the source story the " (str ?scene :agentrole) " "
    (str ?scene :intentionlevel) " "
    (str ?scene :intentiontype) ". In the destination story the "
    (str ?x :agentrole) " "
    (str ?x :intentionlevel) " "
    (same-sim ?scene ?x :intentiontype) ". However, the source story is about "
    (str ?scene :situationtype) ", while the destination story is about "
    (str ?x :situationtype) ". ")))
```

```
(differences
  :from (story-of ?x)
  :to (story-of ?scene)
  :say (" in the source story the " (str ?x :agentrole) " "
    (str ?x :intentionlevel) " "
    (str ?x :intentiontype) ". In the destination story the "
    (str ?scene :agentrole) " "
    (str ?scene :intentionlevel) " "
    (same-sim ?x ?scene :intentiontype) ". However, the source story is about "
    (str ?x :situationtype) ", while the destination story is about "
    (str ?scene :situationtype) ". "))))
```

(defrule difference-2 ;; similar situations but different intentional activity by similar agents  
;; This rule tries to capture a little flavor of structure matching (alignment of scenes) without  
;; actually having rules that can process across scenes to stories

```
:lhs (and (same-or-similar ?scene ?x :situationtype)
  (or (same-or-similar ?scene ?x :agentrole)
    (path ?scene ?x :agentrole (* parents) :used-in))
  (has-filler ?scene :intentiontype)
  (has-filler ?x :intentiontype)
  (not (same-or-similar ?scene ?x :intentiontype)))
:rhs ((differences
  :from (story-of ?scene)
  :to (story-of ?x)
  :say (" the source story is about " (str ?scene :situationtype)
    " and the destination story is about " (same-sim ?scene ?x :situationtype)
    ". However, in the source story the " (str ?scene :agentrole) " "
    (str ?scene :intentionlevel) " "
    (str ?scene :intentiontype) ", while in the destination story, the "
    (str ?x :agentrole) " "
    (str ?x :intentionlevel) " "
    (str ?x :intentiontype) ", which is different. ")))
```

```
(differences
  :from (story-of ?x)
```

```

:to (story-of ?scene)
:say (" the source story is about " (str ?x :situationtype)
      " and the destination story is about " (same-sim ?x ?scene :situationtype)
      ". However, in the source story the " (str ?x :agentrole) " "
      (str ?x :intentionlevel) " "
      (str ?x :intentiontype) ", while in the destination story, the "
      (str ?scene :agentrole) " "
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype) ", which is different. ")))

(defrule difference-3 ;; similar intentional activity of agents but different outcomes
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (or (same-or-similar ?scene ?x :agentrole)
              (path ?scene ?x :agentrole (* parents) :used-in))
          (has-filler ?scene :outcometypes)
          (has-filler ?x :outcometypes)
          (not (path ?scene ?x :outcometypes (* :parents) :used-in))) ;; no parents match either
:rhs ((differences
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype) " with a "
            (str-path ?scene :outcometypes) " result. The destination story differs in that the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (same-sim ?scene ?x :intentiontype) " but with a "
            (str-path ?x :outcometypes) " result. ")))
      (differences
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" in the source story the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype) " with a "
            (str-path ?x :outcometypes) " result. The destination story differs in that the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (same-sim ?x ?scene :intentiontype) " but with a "
            (str-path ?scene :outcometypes) " result. "))))

(defrule difference-4 ;; similar intentional activity of agents but different levels of activity
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (or (same-or-similar ?scene ?x :agentrole)
              (path ?scene ?x :agentrole (* parents) :used-in))
          (has-filler ?scene :intentionlevel)
          (has-filler ?x :intentionlevel)
          (not (same ?scene ?x :intentionlevel)))
:rhs ((differences
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype) ". The destination story differs in that the "
            (str ?x :agentrole) " "

```

```

        (str ?x :intentionlevel) " "
        (same-sim ?scene ?x :intentiontype) " instead. ")
(differences
:from (story-of ?x)
:to (story-of ?scene)
:say (" in the source story the "
      (str ?x :agentrole) " "
      (str ?x :intentionlevel) " "
      (str ?x :intentiontype) ". The destination story differs in that the "
      (str ?scene :agentrole) " "
      (str ?scene :intentionlevel) " "
      (same-sim ?x ?scene :intentiontype) " instead. ")))

(defrule difference-5 ;; similar intentional activity of agents but different beliefs
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (or (same-or-similar ?scene ?x :agentrole)
              (path ?scene ?x :agentrole (* parents) :used-in))
          (has-filler ?scene :belieftype)
          (has-filler ?x :belieftype)
          (not (same ?scene ?x :belieftype)))
:rhs ((differences
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " believed "
            (str ?scene :belieftype) " and "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype) ". The destination story differs in that the "
            (str ?x :agentrole) " believed "
            (str ?x :belieftype) " instead and "
            (str ?x :intentionlevel) " "
            (same-sim ?scene ?x :intentiontype) ". ")
          (differences
            :from (story-of ?x)
            :to (story-of ?scene)
            :say (" in the source story the "
                  (str ?x :agentrole) " believed that "
                  (str ?scene :belieftype) " and "
                  (str ?x :intentionlevel) " "
                  (str ?x :intentiontype) ". The destination story differs in that the "
                  (str ?scene :agentrole) " believed that "
                  (str ?scene :belieftype) " instead and "
                  (str ?scene :intentionlevel) " "
                  (same-sim ?x ?scene :intentiontype) ". "))))

```

## Application Inferences

### RULE 15: Warnings

```

(defrule advice-1 ;; similar intentional activity of agents but destination has a warning
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (path ?x ?y :storytype) (is-named ?y warning))
:rhs ((warnings
      :from (story-of ?scene)
      :to (story-of ?x)

```

```

:say (" in the source story the "
      (str ?scene :agentrole) " "
      (str ?scene :intentionlevel) " "
      (str ?scene :intentiontype) ". The destination story gives a warning about the "
      (str ?x :agentrole) " who "
      (str ?x :intentionlevel) " "
      (same-sim ?scene ?x :intentiontype) ". ")))

(defrule advice-inverse-1 ;; similar intentional activity of agents but source has a warning
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (path ?scene ?y :storytype) (is-named ?y warning))
:rhs ((warnings
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" in the source story the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype) ". The destination story offers a warning about the "
            (str ?scene :agentrole) " who "
            (str ?scene :intentionlevel) " "
            (same-sim ?x ?scene :intentiontype) ". ")))

(defrule advice-2 ;; similar intentional activity of agents but destination has an opportunity
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (path ?x ?y :storytype) (is-named ?y opportunity))
:rhs ((opportunities
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " "
            (str ?scene :intentionlevel) " "
            (str ?scene :intentiontype) ". The destination story offers "
            (prefix-article ?x :storytype) " for the "
            (str ?x :agentrole) " who "
            (str ?x :intentionlevel) " "
            (same-sim ?scene ?x :intentiontype) ". ")))

(defrule advice-inverse-2 ;; similar intentional activity of agents but destination has an opportunity
:lhs (and (same-or-similar ?scene ?x :intentiontype)
          (path ?scene ?y :storytype) (or (is-named ?y opportunity) (is-named ?y lesson)))
:rhs ((opportunities
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" in the source story the "
            (str ?x :agentrole) " "
            (str ?x :intentionlevel) " "
            (str ?x :intentiontype) ". The destination story offers "
            (prefix-article ?scene :storytype) " for the "
            (str ?scene :agentrole) " who "
            (str ?scene :intentionlevel) " "
            (same-sim ?x ?scene :intentiontype) ". ")))

(defrule advice-3 ;; similar situations but destination has a warning
:lhs (and (same-or-similar ?scene ?x :situationtype)
          (path ?x ?y :storytype)(is-named ?y warning))
:rhs ((warning
      :from (story-of ?scene)

```

```

:to (story-of ?x)
:say (" the source story is about "
      (str ?scene :situationtype) ". The destination story offers a warning about "
      (same-sim ?scene ?x :situationtype) ". ")))

(defrule advice-inverse-3 ;; similar situations but source has a warning
:lhs (and (same-or-similar ?scene ?x :situationtype)
          (path ?scene ?y :storytype)(is-named ?y warning))
:rhs ((warning
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" the source story is about "
            (str ?x :situationtype) ". The destination story offers a warning about "
            (same-sim ?x ?scene :situationtype) ". ")))

(defrule advice-5 ;; similar beliefs of agents but destination has a warning
:lhs (and (same-or-similar ?scene ?x :belieftype)
          (path ?x ?y :storytype)(is-named ?y warning))
:rhs ((warnings
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" in the source story the "
            (str ?scene :agentrole) " believed that "
            (str ?scene :belieftype) ". The destination story has a warning for the "
            (str ?x :agentrole) " that believed "
            (same-sim ?scene ?x :belieftype) ". ")))

(defrule advice-inverse-5 ;; similar beliefs of agents but source has a warning
:lhs (and (same-or-similar ?scene ?x :belieftype)
          (path ?scene ?y :storytype)(is-named ?y warning))
:rhs ((warnings
      :from (story-of ?x)
      :to (story-of ?scene)
      :say (" in the source story the "
            (str ?x :agentrole) " believed "
            (str ?x :belieftype) ". In the destination story has a warning for the "
            (str ?scene :agentrole) " that believed "
            (same-sim ?x ?scene :belieftype) ". ")))

```

## RULE 16: Opportunities

```

(defrule advice-4 ;; similar situations but destination has an opportunity
:lhs (and (same-or-similar ?scene ?x :situationtype)
          (path ?x ?y :storytype)(or (is-named ?y opportunity) (is-named ?y lesson))))
:rhs ((opportunities
      :from (story-of ?scene)
      :to (story-of ?x)
      :say (" the source story is about "
            (str ?scene :situationtype) ". The destination story offers "
            (prefix-article ?x :storytype) " about "
            (same-sim ?scene ?x :situationtype) ". ")))

(defrule advice-inverse-4 ;; similar situations but source has an opportunity or lesson
:lhs (and (same-or-similar ?scene ?x :situationtype)
          (path ?scene ?y :storytype) (or (is-named ?y opportunity) (is-named ?y lesson))))
:rhs ((opportunities

```

```

:from (story-of ?x)
:to (story-of ?scene)
:say (" the source story is about "
      (str ?x :situationtype) ". The destination story offers "
      (prefix-article ?scene :storytype) " about "
      (same-sim ?x ?scene :situationtype) ". ")))

```

(defrule advice-6 ;; similar beliefs of agents but destination has an opportunity or lesson

```

:lhs (and (same-or-similar ?scene ?x :belieftype)
          (path ?x ?y :storytype)(or (is-named ?y opportunity) (is-named ?y lesson)))
:rhs ((opportunities
       :from (story-of ?scene)
       :to (story-of ?x)
       :say (" in the source story the "
             (str ?scene :agentrole) " believed that "
             (str ?scene :belieftype) ". The destination story offers "
             (prefix-article ?scene :storytype) " for the "
             (str ?x :agentrole) " that believed "
             (same-sim ?scene ?x :belieftype) ". ")))

```

(defrule advice-inverse-6 ;; similar beliefs of agents but source has an opportunity or lesson

```

:lhs (and (same-or-similar ?scene ?x :belieftype)
          (path ?scene ?y :storytype)(or (is-named ?y opportunity) (is-named ?y lesson)))
:rhs ((opportunities
       :from (story-of ?x)
       :to (story-of ?scene)
       :say (" in the source story the "
             (str ?x :agentrole) " believed "
             (str ?x :belieftype) ". In the destination story offers "
             (prefix-article ?scene :storytype) " for the "
             (str ?scene :agentrole) " that believed "
             (same-sim ?x ?scene :belieftype) ". ")))

```