CHAPTER 9

SUMMARY OF RESEARCH ISSUES

Hypertext systems can be considered to be database applications which provide a unique, non-sequential, and flexible method of accessing information through navigation and exploration. The essential features of hypertext are nodes which contain information and links which connect related nodes. It is the linking capability which makes hypertext more powerful than conventional information systems. There are a number of research issues related to the design, development, and application of hypertext systems. This chapter summarizes all these issues that were explored in detail in the previous chapters. Some approaches to addressing these issues have also been presented. The issues that were addressed during the recently held Hypertext '93 conference are also reported.

The following is the legend for this chapter:

- Items considered research issues.
- Possible solutions/approaches to address the research issues.

1. Implementation Issues

We have not fully understood the cognitive aspects involved in implementing hypertext systems.

- It is very essential to understand reading and writing models in order to understand hypertext. In addition, we need to understand the cognitive processes involved in argumentation and decision making. This needs revisiting some of the cognitive models such as Toulmin and Rittel argumentation schema and Guilford's Structure of Intellect Model.

- Also, existing metaphors such as electronic encyclopedia, notecards, journeys, browsing, windows, paths, guided tours, travel holidays, and survey-type maps are too restrictive and do not fully exploit the true potential of hypertext. The metaphor for hypertext should be based on "the general cognitive model of how individuals think about complex problems." Hypertext systems should try to exploit the basic nature of human cognition which is essentially organized as a semantic network of concepts linked together by associations. This general approach allows any individual to adopt the appropriate mental model by employing self-generated metaphors in the context of a specific application while the implementation itself can be based on a general semantic model [Balasubramanian & Turoff, 1993]. Such an approach provides navigation and analysis of the underlying database independent of the specific application and the different mental models of individuals.

Converting linear text to hypertext has been a classic problem while dealing with large information spaces such as encyclopedias, training manuals and dictionaries. Attempts have been made to convert these printed material both by manual and automatic means.

- Automatic conversion of text to hypertext based on structural features alone is not sufficient.

More work is required in the area of automatic link construction based on lexical and semantic analysis of text. The concepts of shallow apprentice (automatic linking based on lexical analysis) and clever apprentice (based on semantic analysis) must be explored further. The concept of automatic link generation based on the pattern of previously created user-links can be explored. Such an algorithm can use the user's Link Profile [Chang, 1993]. Some researchers have suggested guidelines for both manual and automatic conversion. These guidelines must be applied and evaluated.

Very little work has been done in exploring the use of hypertext templates in areas such as collaborative writing, teaching etc.

- Hypertext templates facilitate the design, organization, and presentation of a collection of knowledge in the form of hypertext. Templates can also be used to capture pre-defined or well-established relationships in organizational tasks. The specifics of the contents within the template can be filled in by the author.

Traditional writing is associated with implicit guidelines backed by thousands of years of linear writing experience. On the other hand, hypertext writing is new to authors and it is easy to produce an incomprehensible hypertext document.

- Researchers have suggested some general guidelines for authoring hypertext documents. These include dividing a hypertext document into three components: the content part, the organizational part, and the presentation part. Experiments must be conducted to assess the effectiveness of such authoring guidelines in developing large-scale hypertext systems.

Information systems such as Decision Support Systems and Expert Systems require a dynamic implementation of hypertext by incorporating virtual structures, computation, and filters.

- The use of bridge laws to generate dynamic structures must be explored further. Tools are also required for developers to define bridge laws easily. Dynamism can also be achieved by employing link-resolving algorithms which generate links to nodes based on user interaction [Tompa et al., 1993]. For example, the user can click on a word and the system can search for the occurrence of the same word or a synonymous word in other documents/nodes and traverse to that node. These can be considered non-authored link markers/links. Links thus become similar to database keys: not only can individual hypertext links be stored as explicit pointers but they can also be resolved "on the fly" through the execution of more complicated algorithms.

Very few attempts have been made to linearize hypertext documents for the purpose of printing.

- A first step towards linearization would be an algorithm to traverse all the nodes visited by the user and produce a linear document. Another method would be for the user to specify the start and end points of linearization so that all interactions between these two points will be linear.

2. Database Issues

Database requirements of hypermedia systems have received very little attention. Relational Data Base Management Systems (RDBMS) cannot fully address the data handling requirements of hypermedia systems.

- Object-Oriented Data Base Management Systems (OODBMS) have been shown to meet the storage requirements of complex systems such as geographical information systems, multimedia systems etc. We need to investigate the use of OODBMS as storage mechanisms for hypermedia applications.

- Object-oriented approaches to hypermedia must be investigated. Many features from the areas of object-oriented analysis, design and programming can be extended to the hypertext model. Integrating an object-oriented data model with hypertext can greatly improve the information retrieval process. This can be accomplished by redirecting hypertext functionality from the application level to the database level using object-oriented database systems.

3. User Interface Issues

Although many designs exist for hypertext navigation, the problems of disorientation and cognitive overhead still persist. In a true hypertext system, users must be able to move freely through the system according to their needs, without getting lost either spatially or cognitively.

- The facilities to navigate through a hypertext database must be at least as rich as those available in books. Many user interface solutions have been developed by different groups of researchers. However, all these designs have been ad hoc approaches to navigation problems. There has been no systematic and comprehensive approach to user interface design for hypertext systems. A set of fourteen user interface design guidelines were presented in this review paper. In addition to following these guidelines, it will be highly beneficial to integrate existing navigational tools and study the effectiveness of such a systematic and comprehensive approach.

- Also, formal methods need to be developed for usability testing and evaluation of hypertext systems. Navigation techniques and evaluation measures must be based on the organizational setting, the targeted task domain, the typical user population, and the desired outcomes of navigation. Experiments must also be conducted to evaluate the effect of deliberately incorporating disorientation and cognitive overhead in learning systems in order to encourage exploration and learning.

4. Information Retrieval Issues

While navigation or browsing is sufficient for small hypertext systems, more powerful information retrieval and indexing techniques are required for large scale hypertext databases.

- A browsing session can take a long time before converging to the required item or may not converge at all. Therefore, browsing mechanisms must be supplemented with querying techniques. In addition to content queries which retrieve the contents of nodes there should be structural queries to retrieve subgraphs of the hypertext network that match a given pattern. Query facilities which incorporate both content search and structure search can act as filters. Also, the implicit structure present in documents in terms of spatial characteristics such as geometry, distance, collocation, recurrence etc., can be analyzed to retrieve templates and document outlines

[Marshall & Shipman III, 1993]. Media-based navigation and picture-index techniques must be explored further to retrieve objects based on shape, color, motion, and auditory features [Hirata et al., 1993].

- Many researchers have investigated the possibilities of separating index information from contents thus forming an index space (or concept network) on top of a content space (or document network). These would not only facilitate IR but also accommodate dynamic linking and independent maintenance of the two networks. Further research is required in the area of aggregating hypertext networks into semantic or hierarchical clusters.

Existing query languages are suitable only for content-based searches.

- Query languages need to be extended to perform structural queries. These extensions include the notions of quantifiers, recursive operators, aggregation, and improved semantics. Visual query languages need to be explored further. Such visual queries should balance expressiveness with ease of use. Users should be able to retrieve information by specifying spatial properties, templates, shapes, color etc. They should also be able to express queries by selecting and manipulating visual representations of hypermedia objects. Such a query language is being developed as part of the Multimedia Object Retrieval Environment [Lucarella et al., 1993]. It will be interesting to see the results of their work. More work is required in the use of belief networks or Bayesian inference networks for hypertext-based IR. The computational complexity of these approaches need further investigation.

Very little work has been done in the area of merging Artificial Intelligence with hypertext.

- A combination of inference-based IR and knowledge-based hypertext could greatly facilitate browsing and searching.

Formal methods and experiments are required to measure the effectiveness of these IR techniques.

5. Integration Issues

In order to make hypertext systems fully open and integrated, the following issues must be addressed: interoperability, programmability, node and link typing, distributed linking, concurrency control for multi-user access in a shared environment, maintaining public and private links, operating systems support, networking, bridge laws, linking protocols, multimedia support, user interface consistency, and version control. Most of these requirements can be addressed using object-oriented techniques.

- Interoperability can be achieved by employing some of the many layered, platform-independent architectures, models or engines, and frameworks that have been proposed and developed by researchers in an effort to make hypertext systems more generic and integrated into the desktop environment. In order to make hypertext systems fully portable, existing document standards such as ODA and SGML must be extended to support unstructured documents and linking. International standards such as HyTime and MHEG are emerging to support hypertext functionality and multimedia information in applications. The applications of these standards to operational and proposed systems must be investigated. A few commercial products such as FrameBuilder from Frame Corporation, DynaText from Electronic Book Technologies, and

PassageWays from Passage Systems provide SGML-based hypertext authoring tools [ComSymHT93, 1993].

- Programmability can be achieved by providing application development toolkits for adding hypertext functionality to existing systems.

- The concept of concurrency control is quite different in a multi-user collaborative environment as opposed to a multi-user environment. Such environments require complex concurrency control mechanisms such as event notification, fine-grained notification, shared locking, fine-grained locking, user-controlled locking, and persistent collaboration information [Wiil & Leggett, 1993]. The requirements suggested by these researchers must be applied to collaborative hypertext systems.

- Linking protocols such as Sun's Link Service, Intermedia's Link Server, Microcosm Link Engine have been developed. Some of these are closed systems. They work with only certain applications on certain hardware platforms/operating systems. The commercial use of these protocols must be explored further.

- Most linking protocols exist as layers above the operating system. Making the link service an integral part of the operating system must be investigated. Such an attempt is being made as part of the Macintosh implementation of the Microcosm Link Engine (called Macrocosm) [Lewis, 1993].

- Only when hypertext functionality becomes an integral part of our computing environment will knowledge workers accept and incorporate hypertext into their daily work process.

6. Applications

Most corporations seem to be interested in the profit-making and entertainment aspects of multimedia rather than intellectual applications of hypermedia such as learning systems, group decision support systems, brainstorming systems etc.

- The hypermedia paradigm can be extended to many traditional information management systems as well as emerging complex information systems. Some of the application areas that can be greatly improved by incorporating hypermedia technology include on-line documentation, electronic encyclopedias, interactive kiosks, learning systems, idea processing environments, decision support systems, collaborative systems, issue based information systems, software engineering, and medical information systems.

- Many corporations suffer from the lack of a comprehensive view of their data/information due to the proliferation of many database applications. These applications were developed over a long period of time, each addressing a specific problem. A hypermedia link engine would be a good mechanism to integrate such heterogeneous database applications providing unique navigation and information retrieval facilities to retrieve large amounts of inter-related information.

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