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Chapter One

Introduction

Thesis Description

This thesis examines the problems involved in navigating hypermedia systems. Chapter One offers a general discussion of hypermedia, comprising of a general definition of Hypermedia, followed by a discussion of the origins of hypertext concepts and systems. Next is a short presentation of a number of common hypermedia systems and some of their characteristics.

In Chapter two, navigation and orientation in hypermedia systems is discussed. Firstly, metaphors in the interface are discussed and then the application of the geographical metaphor to navigating hypertext systems (or information '*space*') is explained through various geographical metaphors used in a number of systems. Then the navigational capabilities of various hypermedia systems are presented at three levels — large scale, medium scale, and small scale — as the tools and techniques that are used in finding information differ at these levels.

Chapter Three breaks down the tools that are used for navigating hypermedia systems into specific discussions of their use and utility, with detailed examples from specific systems being presented. The main tools and techniques discussed are Paths and Tours, Maps, Guides and Agents.

In Chapter Four a trail-blazing facility is presented. It begins with a discussion of navigation in HyperCard and follows with a description of the navigational problems that the trail-blazing facility alleviates. Following this is a description of some of the specific mechanisms that the facility uses to help reduce navigation and orientation problems in large hypermedia systems — or more specifically, in large groups of HyperCard stacks. Lastly, it explains in detail how to use the facility to produce guided paths through HyperCard systems.

Chapter Five presents the implementation details of the trail-blazing facility. It explains the structures used, screen layouts, and problems and limitations of it.

Chapter Six presents the Pilot Study that was used to evaluate the trail-blazing facility. Conclusions and further questions are discussed.

In Chapter Seven some overall conclusions about paths as aids in navigation of hypermedia systems are presented. Then it provides some ideas for future enhancement of the trail-blazing facility, as well as some ideas for further research into this area of navigation in Hypermedia systems.

Lastly, the appendices provide details of the pilot study: the HyperCard stacks used, the test path used, demographic and evaluation questionnaires, a program listing, and finally the references used in this thesis.

Hypertext Definition / Explanation

In this thesis I will not differentiate between hypertext systems and hypermedia systems, although there are, of course, differences between the two. Hypermedia might be thought of as a superset of hypertext because it incorporates more media types. Thus it includes the capabilities and problems that hypertext contains, but it also presents more capabilities and problems due to the inclusion of more media types. Many problems are common to both systems, especially in navigating the information base, so in this thesis I will use the general term hypermedia as this encompasses hypertext as well.

Hypermedia can be defined in many ways. Some previous attempts at definitions include:

> *"a combination of natural language text with the computer's capacity for interactive branching, or dynamic display... of a non-linear text...which cannot be printed conveniently on a conventional page."*
> [T.H. Nelson, cited in Conklin, 1987, p.17];

> *"Hypertext, at its most basic level, is a DBMS that lets you connect screens of information using associative links. At its most sophisticated level, hypertext is a software environment for collaborative work, communication, and knowledge acquisition. Hypertext products mimic the brain's ability to store and retrieve information by referential links for quick and intuitive access."*
> [Fiderio, 1988];

> *"A defining attribute of hypertexts is that they embed textual information in related but non-sequential segments and they provide mechanisms for readers to explore this information flexibly, often on the basis of their personal preferences and needs."*
> [Reinking, 1992, p. 19].

The determining characteristics of hypermedia systems are the existence of chunks of information, called nodes; connections between nodes, called links; and mechanisms for accessing the nodes and for following the links from node to node.

Nodes

Nodes are the information base of a hypermedia system. They are the individual documents that are stored in the system and that are displayed in some manner when accessed. The distinction between hypertext and hypermedia occurs in the content of the nodes. In a hypertext system the nodes will be text documents. In a hypermedia system, the nodes may contain text, graphics, sound, animation, video, some other medium, or a combination of these.

Links

Links are explicit connections between nodes or parts of nodes. A link has meaning. Landow (1987, p.332) says that "*Hypertext links condition the user to expect purposeful, important relationships between linked materials*". This means that links are seen as adding meaning to the documents — they provide the structure for the system.

Access mechanisms

A hypermedia system must provide some means of accessing the documents and the links contained in those documents. These access tools must at least allow a user to follow a link and to backtrack — that is to get back to where they came from. Other access tools should be provided to help the reader avoid the disorientation that can occur in complex systems. Numerous access mechanisms should be available so that different types of users can use a tool that suits their goals, experience, and expectations.

Hypertext Origins

The first hypertexts were paper-based. An early example of paper-based hypertext was the Talmud [Oren, 1987]. This was a document that was annotated by successive generations to form a large body of writing with many inter-connections. The principle current paper-based hypertext system is our library system where most documents contain references to other documents. So a library is really a large interconnected body of writing, on a very large scale, however. It is this idea of inter-connections between documents which forms the basis of hypertext but also provides some of its problems.

Hypertext as originally conceived was to operate in a similar manner to the human brain — by association. It was thought that the idea of accessing ideas or files strictly through indexes was far too limiting and that more flexibility was needed to cope with the ever-increasing amount of knowledge in the world. Thus the idea of instantaneous cross-referencing via machine was envisioned by Vannevar Bush in 1945. He called the machine the memex. He thought that if libraries of information were stored on machine then all that information could be accessed quickly and flexibly. Personal trails could be created through the information and our own thoughts could be annotated over the original material. He thought that the future would bring "*a new profession of trailblazers, those who find delight in the task of establishing useful trails through the enormous mass of the common record*" [Bush, 1945].

Bush introduced the idea of nodes and links although he did not specify nodes as such. He had the notion that an author (or trailblazer) could find materials that were related through the use of indexes and bring those materials into view on the memex. Then they could create links between the related documents or ideas. These documents and their inter-connections would leave a trail for another user to follow. The other users would travel from document to document via the links, perhaps going off on side-tracks, following the authors train of thought. Thus they might learn from the author's trail, or they could add their own comments for other users. Thus a new mechanism for accessing information was proposed — one that was not directly linear — and it was machine-based which would result in benefits of speed, storage and flexibility. It seemed that it might more closely resemble the way the human mind operates — by association.

Ted Nelson, Andy van Dam, and Doug Englebart pioneered the development of hypertext systems and are responsible for much of the developmental work illustrated in today's systems [Nielsen, 1990]. Their systems — Augment/NLS, Xanadu, the Hypertext Editing System, and FRESS — illustrated many of the concepts of current hypertext systems and have spawned many current research areas, of which hypertext, groupware, electronic publishing and multimedia are but a few.

Englebart's NLS (oN Line System) featured a primarily hierarchical structure, but it also allowed any number of non-hierarchical reference links within and between files. The system had three main aspects which are still often used: a database containing all the text, view filters that would filter the text in the database, and views which structured the display of the selected information.

The system provided view filters for the file structure which would enable a user to control the display of items, as well as to write customised filters in a high-level language that displayed only statements containing the specified content. It has evolved over the years and is still marketed today as a commercial network system (called Augment) that supports a wide range of activities, both individual and group communication, document production, information management, and software engineering.

Andy van Dam and Ted Nelson designed the Hypertext Editing System that was used by the Houston Manned Spacecraft Center to produce Apollo documentation. This was followed by the File Retrieval and Editing System (FRESS) that van Dam and several students developed at Brown University.

FRESS featured a dynamic hierarchy, bi-directional reference links and keyworded links and nodes. No limits were placed on the size of nodes, and multiple windows and vector graphics were supported. As the available technology advanced, the next system, the Electronic Document system, made heavy use of colour raster graphics and extra graphical navigational aids. All this development work at Brown is continuing and most recently has resulted in the Intermedia system which has been an exploration into how hypermedia functionality should be handled at the system level with linking available for all applications [Haan et al., 1992]. It will be described later in this thesis.

Lastly, Ted Nelson is credited with coining the term *'hypertext'*. His idea has been to create an environment where all the world's literature would be online. He called this proposed system Xanadu. The system makes heavy use of links, so that only the original documents and changes to them are stored. Any referencing that occurs is through links that point to the appropriate part of the original document. In this way storage space can be reduced and issues such as copyright and royalties can, perhaps, be more readily dealt with. The development of Xanadu is continuing today but it has not yet been widely used so little information about its capabilities exists.

Some Hypertext Systems

In this section some of the common current Hypermedia systems and a summary of their main features are presented. The systems that are discussed are HyperCard, Intermedia, NoteCards, Xanadu, the WorldWideWeb, Wide Area Information Server (WAIS), and finally Gopher.

HyperCard

HyperCard is a product, originally from Apple Computer, Inc., that was bundled with every Macintosh system sold between 1987 and 1991. Because of its widespread distribution, price, and ease of use it has become very popular. Although not originally designed as a hypermedia product, it's ease of use, programmability, and rapid linking capability combined to produce a hypertext-like system that could be used to rapidly prototype new design ideas.

HyperCard uses the metaphor of a stack of cards. Groups of cards are formed into stacks. Multiple stacks of cards may be opened at one time and each appears in its own window. Each card may contain a number of fields that can hold textual information. A card can also contain graphics. Thus each card may be thought of as a hypermedia node. Only one card from a stack appears in each window at a time. However, pop-up fields can simulate the appearance of multiple nodes being open at one time. Another component on a card is a button that usually contains some code or Hypertalk script. Hypertalk is HyperCard's programming language. Hypertalk scripts can perform almost any task because the language is extensible through the use of external commands and functions called XCMDs and XFCNs. These can be written in languages such as Pascal and C and provide a way to access lower level functions within the Macintosh Toolbox.

The provision of an extensible language provides much power to HyperCard, and enables complex links to be set up between different objects such as cards, buttons, fields and text within fields to other objects. This means that very complex documents or groups of documents can be formed. The language and extensions provide access to a range of media including sounds, 2- and 3-dimensional graphics, and video. So it is a potentially very complex system. Usually a HyperCard stack will be on one topic and the amount of information contained within it will be relatively small. However, more complex stacks are being developed, as well as groups of stacks, and these can present navigational problems for some users.

HyperCard provides a number of integral navigational facilities. These are found in the Go menu and are listed in Chapter Four. Two that are significant are the Recent map and the Go Back menu command. The Recent map provides an iconic view of the 42 most recently visited cards. Selecting one of the icons results in a return to that card. The view of the cards is not in strict temporal order, however. If a card is visited more than once, only the occurrence of the first visit to the card is added to the map. The facility that provides a strict temporal history is the Go Back command. This uses a temporal history that can contain up to the last 99 nodes visited, in the order of visitation.

HyperCard is a very useful tool and it's power, as well as many of its problems, stems from its great flexibility. The application of design guidelines as well as the creation of some extra facilities can alleviate many of the problems associated with navigating groups of stacks. However, for it to become a real hypermedia system, operating system-level support is required to provide basic hypermedia services.

InterMedia

Intermedia is a hypermedia system developed by the Institute for Research in Information and Scholarship (IRIS) at Brown University. The intention of IRIS was to "*create a model for how hypermedia functionality should be handled at the system level, where linking would be handled in the same way for all applications*" [Haan et al., 1992]. Intermedia provides a graphical file system browser similar to the Macintosh Finder; a set of direct manipulation editors for text, graphics, timelines, animations, and videodisc data; a set of linguistic tools; and the ability to create and traverse links in any document in the system. The system uses privileges to control access to documents so there is no distinction between authors and readers. If a user has the appropriate privileges then they can edit, explore and annotate as they wish.

All the applications support anchors, anchor extents, and links. The anchor is the link origin, the anchor extent is the block within the document that is linked, and the link connects the block to other blocks. See Figure 1.1 for an example. All links are bi-directional so a user can traverse a link and then easily return to where they came from. All applications support a consistent visual appearance of the link marker which is a small icon positioned to the left of the anchored block. This is an important stylistic convention that immediately conveys the knowledge that it is a link and can be clicked upon. This is very important for small and medium scale navigation as the consistent approach removes some cognitive overheads for the user. That is, you don't have to spend your time searching around for links — you know immediately what is linked and what isn't by the presence of the small link icon and the link icon is the same throughout all Intermedia documents.

The idea of an active anchor was added to provide extra functionality to temporal data such as video and animation [Palaniappan et al., 1990]. An active anchor includes an action flag so that, on following a link, the time-based data (such as video) will run if the flag is set. If the flag is not set then the destination block will be highlighted and can then be viewed manually.

Sets of links are organised into webs that may be browsed using the Web View. The web view facility provides an organised visual map of the network of links and nodes to give the user some sense of context and location within the web. The web and the web view will be described further in Chapter Three — Navigational Aids in Current Systems.

A distinctive feature of Intermedia is that information about the anchors and links is maintained in a database management system separate from the document data [Haan et al., 1992]. Because editing operations may be carried out by anyone with the appropriate privileges it is very important that the system be able to maintain the integrity of the links and their respective anchors. This is necessary to prevent the occurrence of "dangling links" — links that refer to data that has been deleted. The separate DBMS ensures data consistency. All editing operations performed by the applications or by the file system browser pass through the IRIS hypermedia services which coordinate updating. For more information on the specific mechanisms employed see Haan et al. (1992).

Intermedia has been used reasonably widely. Professors in English, Biology, Anthropology, English as a Second Language, and Geology have prepared webs for their students. Other assignments have been for the students to create their own webs through the material and provide commentary and annotation. In addition, some students have been encouraged to link comments on each others' work [Utting and Yankelovich, 1989]. Benefits from using the system seem to be rapid and quantifiable. Students using Context32, a web on English Literature, gave far more detailed and intellectually sophisticated answers in assignments and tests than previous students who had not used it. In addition, inexperienced students made better use of navigational aids, such as introductions, footnotes and glossaries, in books after realising the inter-connectedness of literature and realising the importance of these connections [Landow, 1989].

In summary, the Intermedia system provides a number of tools to support navigation but that these tools primarily deal with medium scale navigation. Large scale navigation and small scale navigation are not particularly supported by the system and are largely left to the user to organise. These might be areas that could be looked at for future implementations. [Note that IRIS is soon to be discontinued due to funding withdrawal so further development of Intermedia seems unlikely unfortunately (Livingston, personal communication).]

NoteCards

NoteCards is a hypermedia system developed at Xerox PARC designed to help people work with ideas. It uses the concept of an electronic notecard — an idea represented on a small card that can be combined with other notecards in various ways to form an orderly and logical argument or presentation. The system provides a variety of tools that enable users to collect, interrelate and communicate ideas and then to display, manipulate and navigate the network of ideas they have created [Halasz, 1988].

A Notecard may contain an arbitrary amount of information such as text, a drawing, or a bitmap image. Each card also has a title. Every card can be edited. There are also different types of notecards depending in part on what they contain, but new types of cards can also be created.

The links that are used to connect these cards are typed — they have additional meaning other than just in connecting two ideas linearly — and directional — the link is from one card to another card and not necessarily both directions. An example of a typed link is a supports link, which is used to connect underlying reasons to a conclusion. This shows that because of the link typing the link is uni-directional. Although, of course, the opposite direction could be said to mean *is supported by*. These links are anchored at a particular location in the source card but point to the whole destination card. The link anchor is represented by a small link icon that can be clicked on to traverse the link.

The two most basic tools to manipulate these notecards and links are specialised types of cards called browsers and fileboxes. A browser is a card that contains a graphical display of the structure of a network of notecards. Cards from the network are represented by their title in a box. Links are represented by lines between the boxed titles. Different line styles represent different link types. The browser enables direct access to any of the cards included in the display through clicking on the card's boxed title, and thus navigate the network. The graphical display is constructed automatically by the system and, once created, can be used to modify the underlying structure of the network of cards.

A filebox is a specialised card that can be used to organise large collections of notecards, mainly designed to help in the management of large networks and to aid storage and retrieval. A filebox is a card in which other cards, including other fileboxes, can be filed. All notecards must belong to one or more fileboxes. Fileboxes were designed to help users manage large networks of interlinked notecards by encouraging them to use an additional hierarchical category structure for storage and retrieval purposes [Halasz, 1987].

To access information, a user primarily navigates by following links from card to card. These links are distinguished from normal text and graphics by surrounding the linked text with a box and emboldening the linked text or by providing a small link icon. This convention is used throughout the NoteCards system to designate a link, and is therefore immediately recognisable and easily used. An alternative method of navigation is by using a browser card to traverse the network directly. All nodes on the browser are links that lead directly to the specified notecard. Here again, the nodes on the browser card are distinguished as links by the convention described previously. NoteCards also provides a limited search facility which will locate all the cards that match some user-specified conditions.

The NoteCards system is quite customisable, but only with some difficulty for many users. It is written in the Xerox Lisp environment and is fully integrated into it. This gives much potential power for extending NoteCards functionality, including being able to integrate it into another Lisp-based system such as an expert system. The system also has many customisation options with which the user can set to tune its exact behaviour (e.g. how links are displayed or the default size of notecards). [Halasz, 1988].

Other types of notecards, such as TableTops and Tours, have been built. These will be discussed in Chapter Three — Navigational Aids in Current Systems.

Xanadu

Xanadu's implementation of a large hypertext system has initially been concerned with the underlying structure and the complexity of the addressing schemes used. The main problem is that the system must keep track of an ever-growing number of items, which means keeping track of many numbers in the form of addresses. The *'docuverse'* might become very large in an unpredictable fashion, so they were concerned with forming an addressing scheme that could deal with this, but also with the idea that it would be concise and clear when used 'in the small' — with individual documents.

Inspiration was taken from the Dewey Decimal System concept of forking numbers that lead to the idea of Humbers or humungous numbers [Nelson, 1988]. They are numbers that can be continually separated to form more numbers. Such an addressing scheme implies a tree or hierarchical structure but this is only on the address space of the system, not on the materials contained within the system. These humbers contain four major fields: Server, User, Document and Contents.

The Server field is the address of the node where the document is stored. The User field is the address of the owner or the document. The Document field is the address of the logical entity in which the material is stored. The Contents field is the address of the actual document contents which can be the actual bytes of material or can be a link to another document depending on the first byte of the address. Protocols have been defined to handle the underlying connections so that the work of an application designer becomes largely a matter of the user interface.

At the moment not enough information is available about proposed access or navigational mechanisms, but with the underlying structure being well defined, it should be less of a problem to provide navigational tools for the system. Some of these tools should be provided as part of the system, in order to present a clear and consistent interface to developers and users of applications that make use of the Xanadu architecture.

World Wide Web Project

The WWW project provides a browser program to access information anywhere in the world [Berners-Lee, 1991]. It uses a simple protocol ("HTTP") but is also available using other existing protocols such as File Transfer Protocol (FTP) and Net News Transfer Protocol (NNTP). It utilises the Standard Generalised Markup Language (SGML) to create webs. These webs can then be accessed using the browser program, either by following a link directly by selecting it, or by searching indexes for keywords. The links are addresses of specific documents, but the documents may be located anywhere in the world — the addressing scheme enables this. The addressing scheme includes information such as the machine address in a certain protocol format, the directory path where the document is located and the document name itself.

Although the scale of the project is large, the structure of the project is conceptually simple. There are, therefore, the very simple navigation tools of a basic index search and linking mechanism provided with the system. This is only a beginning for the system. If this could somehow be integrated with other medium scale systems and the medium-scale tools integrated with these conventions, then a very powerful system would result. At present, it has great potential but is of limited use to anyone except those that are technically oriented already.

Wide Area Information Servers (WAIS)

WAIS is an attempt at a large-scale hypertext system by allowing links to be deduced at run-time and across many databases stored in many places [Kahle, 1989]. Through a simple string pattern-matching query mechanism, servers provide pointers to relevant documents ranked in importance. These document pointers can be thought of as a form of hypertext link — they can be put in another document and retrieved at a later time. By combining many people's groupings, one can navigate through large numbers of documents in potentially interesting ways in a hypertext style.

So this is different style of hypertext linking — it is content- and user-driven rather than having a specific author/reader dichotomy. This would seem to be one of the characteristic features of large scale hypertext systems when compared to the other levels. The large scale systems are aimed at the users forming their own links for their own use. The distinction between author and reader becomes blurred as no special skills are required to create links to other documents. This, of course, does not mean that the quality of the links created are any good, and this is where the value can be added by the information *'trailblazers'*, as Bush (1945) described them.

Gopher

Gopher is another wide area information system based on client/server architecture that began as an attempt at a University campus information system. It consists of an interface to the many pre-existing facilities available on local and global networks. Through the interface, links can be set up to sites or individual files around the world. It hides the complexity of link information behind a graphical interface similar to the Macintosh Hierarchical File System (HFS).

Nodes are currently coarsely grained — they are a geographical site or an individual file. Inter- and intra-document links are not supported at the moment. When the granularity of the system enables these links then the system will be on its way to true hypertext, although much more needs to be done to the system in order to support finer granularity. Additional access and management tools are also needed to provide navigational assistance at many levels. At the moment, navigational management is left up to individual users. The system does not automatically assist management of related materials.

In the near future, the integration of facilities such as Gopher and WAIS will provide a powerful global information system. In their current forms, however, they are not highly usable by unskilled users. They also do not provide support for inter- and intra-document linking which is one of the bases of hypertext. However, tools might be provided that can be combined with these systems to provide the capability for automated or manual linking between nodes. System support of the links is needed, however, in order that the integrity of the links is maintained in the light of deletion and modification of nodes.