Chapter Seven

Conclusions and Future Research

A path mechanism can be a useful aid in navigating hypermedia systems. The effective use of it depends on the task it is used for. Appropriate tasks would seem to be:

- A guided tour as an introduction to a subject area;
- A path reminding aid that can provide assistance in re-finding particular nodes in a system;
- A trail-blazing tool to create personal paths through a complex information space;
- A contextual reminder — the path may provide a sense of past context, by providing an interaction history that can be retraced either manually or automatically.
- A research and teaching tool, because the inherent association ability of hypermedia means that as systems become larger, the number of implicit linkages between nodes becomes greater. A paths facility can enable new trails of thought to be recorded quickly, without necessarily providing new subject matter.
- A structural filtering device. The path is overlaid on top of the system structure so it effectively filters out the information presented to the user, so the system appears much less complex than it actually is.

As a learning aid, a paths mechanism can be used in at least two distinctly different ways. One is as a guided tour through an information base giving an inexperienced student a structured path as a base on which to build. Another way would be to get a more experienced student to create their own path on a topic through an information base. They would need to provide their own annotations

as meta-information to explain the path. This may give a deeper understanding of a subject than the less interactive method of just following the path.

However, assessing the actual effect of a paths mechanism as an aid to learning is complex and probably needs real-life use over a period of time for positive effects to appear. The study at Brown University showed the beneficial effects of using Intermedia in the students' analysis, synthesis, and evaluation skills [Landow, 1989]. The paths facility could be an effective addition to HyperCard and promote exploratory learning by indicating the connectivity between topics, and so promote an investigative frame of mind in students.

As a personal information filtering device and presentation tool, the paths facility can be thought of as an extension to the Personal Browser which would create a node for a card that was visited more than a threshold number of times [Monk, 1989a]. A personal paths stack might contain a number of paths that have been found useful and are saved for later reference and re-use. If so desired, these could be re-used by others, providing they had access to the same information base.

The paths mechanism is useful and could be developed and researched further. From this thesis, it can be seen that a number of enhancements should occur. These are discussed in the next section. The pilot study that was carried out suggested areas for further investigation, as discussed previously. In order to examine more completely how people use a hypermedia system and a paths facility within it, better recording of the user's interaction history should take place.

Collection of Interaction History for Analysis

To provide a better analysis, each user's interaction history should be collected. This should include keystrokes, location of mouse clicks [Salomon, 1990a], cards visited, and length of visit. So a possible structure might be:

Card Identification
Interaction List
{ Keystroke / Mouse click;
location;
time }
Length of visit

This could be kept in the history list with little change to its structure. Only the recording mechanism would need to change, although this may be difficult. When such an interaction history has been recorded, analysis of the number of interactions on each card and the time taken to examine each card may better reveal the positive effects that a path facility combined with meta-information can produce.

Future enhancements

Many future enhancements seem possible for the paths facility. One of the first is to enhance the functions available on the floating palettes to provide better contextual information, as requested by many of the subjects in the study. To give a better understanding of what path a user is on and where the current location within the path is, two additional items of information should be added to the palette — the current path name and the current location within the path. These could easily be added to two fields on the bottom of the palette so the user knows at all times what path they are following, how long the path is, and how far down the path they currently are. So the palettes might then appear something like this:

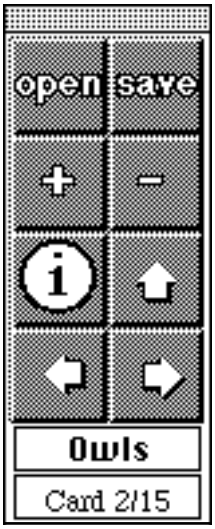

Figure 7.1 *New Author Palette, showing scope information*

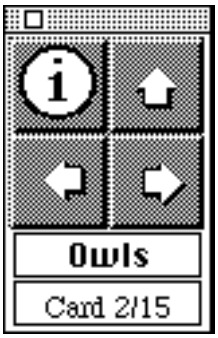

Figure 7.2 *New Student Palette, showing scope information*

The palette should also be altered to indicate what functions are available at any stage. For example, if no path is active, then the meta-information, next

node and previous node buttons should not be active — they should be 'greyed out'. If there is no meta-information for a node, then it should not be selectable. And so on.

Opening Paths from within Paths

At the moment, only one path can be followed at a time. In order to open a new path, a specific path must be selected. To enhance the functionality of the paths mechanism, it might be a good idea to provide the ability to open another path from within a script rather than explicitly having to choose one. This would enable authors to seamlessly integrate the path mechanism into their stacks by opening paths from within scripts according to user actions.

For example, if a user has been making errors in some type of question & answer stack, then a guided tour might be suggested to illustrate the correct way of doing things. Similarly, a manual might have a number of guided tours incorporated within it that give examples of how to do things correctly. Of course, different guided tours may contain common material, but the sequencing of the material may alter the meaning contained in the nodes. The meta-information provided at each node may also serve to reinforce the meanings behind the links.

Structure editor

A graphical browser to display the path through the system would also be a useful addition. Such a browser could perhaps be adapted to provide a graphical path editor so that the path could be easily altered through the direct manipulation of iconic representations of the nodes. To aid this, the meta-information for each node should be stored with the path information, so re-organisation of the path does not require the simultaneous re-organisation of the meta-information structure.

Branching paths

Another facility that may be useful would be the provision of branching paths. This means that from one node there might be a number of destination nodes, and the user would have the choice of which one to follow. This has not been implemented as the present facility was originally designed to be a simple structure designed for novices, and so reducing the navigational decisions at any

point was one of the aims. However, if the paths facility was to be more useful, the ability to provide multiple branches would be seen as desirable as the path-follower may tend to become more involved and this may lead to better understanding. The use of Intermedia at Brown University would tend to support this [Landow, 1989].

Path Preview

The role of path previewing is quite important. Following the HCI guideline of progressive disclosure, a path should be able to be previewed to see whether or not it is relevant to a person's needs. Of course, other tools are also helpful for getting an idea about the contents of a path — such as an introduction or summary. But a path preview is helpful in that it can be self-contained — it is not a separate entity from the path itself — it is just the manner of interaction that changes.

There are various ways one might carry out path previewing, but one of the most promising might be automatic path replay — that is, the linear progression of cards one after another after a specified period of time, just as in a slide show. This would perhaps give the user a relatively quick idea of relevancy as well as a way of assessing subjectively other values, such as presentation.

The history list could also be used to provide context. When a user gets lost or disoriented in a system it is often very helpful to show how they got to the current situation. It is also helpful to review a previous session to quickly gain context. An animation of the most recent steps could be helpful in both of these situations and could be achieved in a variety of ways. One way would be to display, in temporal order, the nodes visited and links selected on each node. Another, perhaps complementary way, would be to animate the path taken through the information space on a graphical browser, so that the nodes and links followed are successively or progressively highlighted. This might be useful in displaying, on a more global browser, the extent of the current area already visited. It would be useful on a large display on which the user might display the node contents and the changes from node to node, as well as the browser window which shows the animated path through the network.

Accessing Nodes Over a Network

An enhancement that would more easily enable paths to be shared is the ability to create paths that access nodes that are physically located elsewhere. The inclusion of relevant location information in the Path data would provide a simple means of access. Ensuring efficient access would perhaps be more difficult. Another positive aspect of paths being created over a network is that, although the information base — the collection of stacks — may not be written to at the same time by multiple users, many users can access the same node at the same time. So many personal paths can be created at the same time through a common information base, and because the meta-information is stored with the path information, annotation and modification to the stored data is controlled.

The addition of these enhancements to the paths facility for HyperCard would provide a much more powerful system. It would enable the ever-growing amount of stacks to be more effectively used as they could be easily linked to present the information in new ways — in ways that may not have been thought of at the time the information was gathered. And the paths facility also provides a simple but effective means of navigating through a complex space. Combining this with a history list that can be used for further path generation, as well as a structure editor for rapid path re-structuring, would provide a much more powerful system that would provide easier access for a wider range of users.

Future Research

Agent Oriented Systems

Alan Kay (in Greenberger, 1990) said that computing in the '90s will not be object-oriented, rather it will be agent-oriented. Our systems may include a number of intelligent agents which communicate with each other. One agent might be a presentation agent that presents our data (perhaps called an interface agent, although presentation is better because interfacing is going to be done between all agents). Another agent might be a personal agent that keeps information about personal preferences and interests. Another agent might be a trail-blazing agent, which might contain knowledge about finding information. These three types of agent could be used in aiding navigation in Hypermedia systems. The trail-blazing agent might find information that is of interest to us, and the presentation agent could present it in a suitable way — perhaps using a path-type structure if personal preferences indicate that we are novices in the subject area.

With an intelligent agent an individual's information space can be personalised so that information of interest to each person is automatically gathered for use as needed. At the MIT Media Lab they have developed the 'personal newspaper' NewsPeek [Brand, 1987] that every day will gather interesting information from various media and present a personalised news service. Thus everyone can have their own personalised news service. What is important to a specific individual will be on the front page, for example personal mail or the cancellation of an important meeting. Less important items, such as world news, might appear later in the news. This is an example of personalised automatic selection and filtering of various media. It is also an example of personalised hypertext — it provides links to information that is important to you. Of course, it adds capabilities that should and will be included in future systems, such as automatic layout, interface elements such as the ageing of articles being indicated through colour changes.

This idea of intelligent agents can be extended from the idea of one personal agent to having a number of agents for different tasks — or perhaps having one controlling agent that can direct others. Thus we could specify that we want to be entertained and the entertainment agent could present our own personal entertainment show. Of course, this can be presented through a

hypertext system — within the entertainment area a number of choices would be available and the creation of a path through that area could take place. This might include comedy, sport, music, adventure, travel, action and so on. Choosing which to follow would depend on our mood at the time, and the agent has selected items within those divisions that are interesting to us. The agent should also provide assistance to us depending on our aims. For example, several levels of interaction exist which affect the style of interaction and the agent should automatically alter the system interface according to the level chosen. Examples of these levels are [Myers, 1988]:

- Tell me — give me the facts
- Inform me — facts plus optional background and points of view
- Guide me — let me browse, but give me extra advice
- Teach me — step by step guidance
- Challenge me — make me find creative connections
- Amuse me — find interesting connections or perspectives

The way navigation takes place and the cues presented change depending on the style of interaction that is chosen, so perhaps an interaction agent that manages the interface aspects is required. The interface agent might also need to distinguish among multiple users to enable varying preferences and styles to be catered for [Laurel, 1990].

The use of software agents is already under investigation. The Object Lens project at MIT enables users to create agents which sort mail, issue reminders, and search databases [Crowston and Malone, 1988]. The utility that such aids can offer seems great, and when combined with a hypertext system the usability of such a system would increase greatly. The agents could do much of the routine tasks of filtering and selection and leave the user to examine the items that were personally relevant. Of course, the user is always able to ignore the agents' choices if they wish to pursue other options or, in keeping with our navigation metaphor, follow other paths. It certainly needs to be explored further.

Animation

Animation could be used to provide a variety of navigational cues. Baecker and Small (1990) state that

"Animation can:
- *Review what has been done*
- *Show what can be done*
- *Show what cannot be done*
- *Guide a user as to what to do*
- *Guide a user as to what not to do"*

They describe eight uses of animation of function at the interface, of which identification, transition, demonstration, explanation, feedback and history could all be used to aid navigation and orientation in hypertext systems.

Animation could be useful in identifying a link destination. For example, if the link points to a video clip or an animation itself, then a short animation used as a preview could be helpful in identifying what it is exactly and help the user in deciding whether to follow it or not.

Transitional animation is useful in hypertext systems in keeping the user aware that a change to the environment is taking place, whether the change is simply going to the next node, or whether it is a jump to another branch, or whether the user has decided to 'go back' to a previous node. Animated transitions can provide feedback as to what sort of change is taking place. These transitional animations are already widely used in the Macintosh interface with the zooming open and close functions when an application starts up and finishes. They also appear in Hypercard stacks with a wipe left or right indicating a page forward or back respectively. A zoom or a dissolve in Hypercard might indicate a jump to another non-sequential node, and an iris close visual effect might indicate a return to a previous location. All these can be useful to reinforce the action taken by the user and to orient the user during the transition from one process to another. They should be used consistently, however, so as not to confuse the user.

Animation as demonstration is related to the idea of identification. With animation the information content of various objects, such as icons, can be improved and consequently clarify their functions. For example, a hypermedia

system contains different node types such as text, video, sound and graphics, and the links used to connect these different node types may be used to indicate what type of node is at the destination. So, as in the identification animation, a link might be represented by an icon that demonstrates, through animation, what is at the destination node. Another use for animated demonstrations would be in combination with a system like NoteCards where a user may have a number of open windows on a card, similar to the TableTop card previously described. An animation could highlight each card in order to demonstrate the order in which they are intended to be read.

Feedback is essential to any interface and animated feedback is very effective in signifying the percentage of process completion [Myers, 1985]. Obviously transitional animation is an example of animated feedback, but there are other examples applicable to navigation and orientation also. A graphical browser that is simultaneously displayed with the nodes and links may give an indication, through animation, of which link is being followed. It may also indicate how much longer it is going to take through progressive highlighting of the link on the browser. This might be applicable in a system that accesses information around the world so that the user can see how close the system is to displaying the selected node.

There are problems with providing animation of course. To be effective, animation requires careful planning and design. It can also require significant processing power, so if the animation degrades the response time of the system, the users will revert to prior, perhaps less effective, methods of information presentation. There are many possibilities to be investigated in the uses of animation at the interface as an aid to navigating hypertext systems, and these methods need greater research.

Colour

Colour can be an effective tool in adding extra information to the interface, and this can be helpful in assisting navigation if used in a consistent and appropriate manner. There are a number of problems with using colour however, and the hypertext designer should be aware of these problems. Several problems are to do with our colour perception. Colours interact with those around them so that the appearance of a colour can change depending on those around it. External conditions such as ambient lighting affect our colour perception.

Computer monitors also vary in their colour calibration so there is no guarantee that a particular colour combination will look the same on two different monitors. Another problem is the individual differences present in the population due to culture, age, occupation, and gender differences — a higher proportion of men have colour deficient vision than women [Salomon, 1990].

In spite of these problems colour can be used to good effect in aiding navigation. It can be used to identify landmarks and to indicate the passage of time, for example. These are two obvious uses for colour that can provide extra information without taking up extra screen space.

Distinguishing landmarks through the appropriate application of colour could be used in many areas and levels of navigation. Landmark nodes could be distinguished by a different background colour. This different colour could also be carried over on to the browser so that landmark nodes are quickly identified through their different colour on the map.

The passage of time could be indicated by altering the colour of a node's representation on the map when it has not been visited for a certain amount of time. A node might fade from yellow to dark brown as it gets 'older', for example. Another example might be to use a certain colour to indicate the nodes that must be visited, as when a teacher supplies a path for a student to follow. The student is free to explore all of the hypertext, but the nodes that have to be visited are highlighted through the use of a distinctive colour.

Colour has been used effectively to indicate both the type and state of nodes in the graphical browser of gIBIS. The type mappings for the most commonly used nodes seemed to be quickly learned so that type identification became a rapid, reflex activity [Begeman & Conklin, 1988]. They say that the use of colour to indicate the node types and links has been a clear success, but that this may be in part due to the limited number of node and link types available.

As Salomon (1990) indicates, some testing is required to discover suitable effective combinations as first ideas are sometimes found to be ineffective. Colour can be used in addition to other attributes such as shape, texture, pattern and location to aid identification when some perception problems might be anticipated. It is a promising area of investigation that needs intelligent guidelines for use, as initial use can result in overuse in a similar manner to the

'fontitis' phenomenon that occurred when people were introduced to the availability of multiple fonts.

Applied to the paths facility, perhaps a colour could be overlaid on top of nodes that were on the path to differentiate them from the surrounding nodes. This would give an immediate indication to the user when they were on or off the path. This could be extended on to the path browser so path nodes would be easily distinguished again. Nodes that had already been visited might change to a different colour to indicate the historical path.

These three areas — agents, animation, and colour — are very powerful and may affect our interactions greatly and positively. They need to be explored further as the importance of effective navigational facilities is increasing because our information systems and hypermedia systems are becoming larger and global in nature.

Overall Summary

When different levels of navigation, the growing complexity of hypermedia systems, and the increasing amount of information available are taken into consideration, a paths facility will be found to be an important navigational aid because it can:

- filter the information presented;
- guide users through unknown areas;
- provide advice, narrative point of view, and contextual information through the use of meta-information;
- provide a simple and consistent interface for novice users; and
- provide a means of saving personal information paths through a complex network for later re-use.

The paths facility in this thesis may be regarded as an attempt at exploring some of the issues involved in navigating large systems and bringing further questions to light. Further research should be carried out in this area as mentioned previously. To be most effective, a paths mechanism should be integrated into a hypermedia system so that it can be used in conjunction with other facilities such as a graphical browser/editor, contextual filters such as webs, existing history facilities, and possibly agents that can filter information in order to create new paths. This would result in more powerful and effective tools for a wider range of users, and the benefits of these systems would be better realised.