User Goals and Web Site Navigation - Implications for the Design of Sitemaps

Chris Pilgrim

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Faculty of Information and Communication Technologies
Swinburne University of Technology
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Abstract

One of the challenges confronting web site developers is to provide effective navigational support. Research in human-computer interaction (HCI) has done much to improve the general area of Web usability and supplemental navigation tools such as sitemaps are frequently included on web sites. However, due to a lack of empirically based guidance for designers, a proliferation of sitemap designs has evolved leaving both designers and users confused about the role and value of these navigation tools. The limited guidelines that do exist are either based on extrapolation of navigation research into pre-Web hypertext systems, or on empirical studies that use methods and measures that may not take into account the particular nature of sitemap tools.

A common assumption in both the application of previous research and recent empirical studies is that sitemaps are selected by users who wish to search for something specific. However, users have a variety of goals, needs and motivations when interacting with web sites. Some users can express exactly what they want; others are vague and unsure of their goal. Goal specificity is an important factor in understanding how users interact with web sites, however it has not been a major consideration in recent research.

This research project investigated the influence of goal specificity on how users navigate through web sites in order to better inform the design of sitemap tools. The thesis commences with the development of a framework describing Human-Web Interaction which provided a structure for the project by clarifying the role of user goals and navigation strategies in the context of previous theory.

Three studies investigated the research problem. The first study involved a number of surveys which explored commercial design practice as well as the expectations of users regarding the purpose and design of supplemental navigation tools. The findings from this study suggested a relationship between certain types of information goals and the selection of search and sitemap tools. In addition, the results provided an insight into the tension between user expectations and current sitemap design practice.

The second study examined the relationship between goal specificity and the use of supplemental navigation tools such as search tools and sitemaps. An experiment tested a hypothesis relating goal types to the use of specific navigation tools. The results suggested that when a user selects a sitemap they are more likely to have a loosely defined goal and are interested in general and meta-information about the web site.

The third study explored the relationship between goal specificity and the strategies that users employ when browsing web sites. The results identified several patterns of behaviour for each goal type, confirming that goal specificity influences user behaviour when browsing web sites.

The thesis concludes with a synthesis of the findings with implications for the design of sitemap interfaces and the design of future empirical studies into web navigation, particularly studies which aim to develop or validate design guidelines for navigation tools.

Keywords:

Web navigation, sitemap design, user goals, human-web interaction

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This thesis contains no material which has been accepted for the award of any other degree or diploma, except where due reference is made in the text of the thesis. To the best of my knowledge, this thesis contains no material previously published or written by another person except where due reference is made in the text of the thesis.

Signed ………………………………

Dated …………………………………

Publications from this research

1. Pilgrim C. J., Lindgaard G. & Leung Y. K. 2005, ‘A Framework for Human-Web Interaction’, *Proceedings of the CHISIG Annual Conference on Human-Computer Interaction: OZCHI 2004,* Ergonomics Society of Australia, Wollongong.

2. Pilgrim C. J., Lindgaard G. & Leung Y. K. 2004, ‘Supplemental Tools for Web Site Navigation – User Expectations vs Current Practice’*, People and Computers XVIII – Design for Life, Proceedings of HCI 2004*, Leeds, UK., pp. 263-276.

3. Pilgrim C. J., Lindgaard G. & Leung Y. K. 2004, ‘An Investigation Into Factors Influencing User Selection of WWW Sitemaps’, *Proceedings of the 6^{h} Asia Pacific Conference on Computer Human Interaction: APCHI 2004*, Rotorua, N.Z. Computer Human Interaction, Lecture Notes in Computer Science, Vol. 3101, Springer, pp. 625-630.

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1 Introduction

> *"The World Wide Web uses relatively simple technologies with sufficient scalability, efficiency and utility that they have resulted in a remarkable information space of interrelated resources, growing across languages, cultures and media."* (W3C, 2004)

These attributes of simplicity and pervasiveness have resulted in an architecture for the World Wide Web that has some entrenched, seemingly irresolvable tensions. On one hand we have a system that needs to be simple to access and contribute to, and on the other it must also contain a vast amount of diverse and rich information. The tension is realised when trying to design appropriate interfaces that allow users to find and use desired information. Shneiderman (1997) has highlighted this problem and comments regularly about "the dilemma of the Web is the difficulty in finding what you need among the abundant sources of information".

As the Web continues to grow in participation and pervasiveness, the provision of appropriate navigational support is critical to its future success. This project contributes to research efforts that attempt to manage the tension between simplicity and size of the World Wide Web by improving support for navigation.

This chapter provides a general introduction to the project, presenting the background to the research problem, the research questions that guide the project and the significance of the topic. The chapter concludes with an overview of the organisation of the thesis.

1.1 Background

Navigation has been acknowledged as one of the major usability problems for the Web since its inception (Xu et al., 2001; GVU, 1994-8). Despite significant research efforts and technological improvements, it is astonishing that the basic methods for locating information on the Web have remained the same over this time. Information retrieval on the Web remains essentially a two-stage process:

(i) finding a web site that relates to an area of interest and (ii) locating the information within the individual web site.

The initial stage of navigation is usually achieved through the use of global search tools. The reliance on search tools for global search has been well documented (Scanlon, 2000; Nielsen 2000a). However, there are several usability problems relating to search tools, particularly the lack of standards, the influence of commercial interests, inconsistent algorithms and interface usability.

Whilst search tools are sufficient for global navigation, they are limited in their use when navigating locally around a site. Instead, in the second stage of information retrieval users usually navigate through individual web sites using a combination of both local search tools and page-to-page browsing (Katz and Byrne, 2003). Browsing involves using information on the pages to trigger decisions to follow particular links of interest, and is an effective strategy for local navigation since it does not require information needs to be fully specified and provides a context in which to understand results (Olsten and Chi, 2003; Teevan et al., 2004).

The 'hit and miss' browsing method of navigation can sometimes result in users feeling lost, confused and overwhelmed (Kim & Hirtle, 1995; McDonald and Stevenson, 1996, 1998a; Otter and Johnson, 2000). This feeling of disorientation is a problem related to hypertext structures (Conklin, 1987; Nielsen, 1990) and exists "where users cannot get an overview, cannot find specific information, stumble over the same information again and again, cannot identify new and outdated information, cannot find out how much information there is on a given topic and how much of it has been seen" (Gershon et al., 1995).

In addition, Web users are impatient, require instant gratification and will leave a site if they cannot immediately figure out how to use it (Nielsen, 2000a). Therefore, it is important that users can quickly appreciate the nature of a site's content, its organization and the methods by which to find particular information as soon as they arrive at the web site.

The standard navigation tools provided by Web browsers are inadequate as they do not provide the facilities to visualise the inter-relationships between pages. This prevents users from answering questions such as 'Where am I?', 'Where can

I go from here?' or 'Which pages point to this page?' (Bieber et al., 1997). A lack of knowledge of the overall structure of a web site can result in confusion and cognitive overload as users jump from one location to another (Mukherjea and Foley, 1995). Nielsen (1998) may not be exaggerating when claiming that users expect failure when they try something new on the Web, and that the total user experience is often miserable.

General hypertext research has raised awareness of the problems of disorientation and cognitive overload and has developed a variety of supplemental navigational tools that can be deployed into web sites (Foss, 1989). Some of these tools provide an alternative view of the topology of the system, claiming that they reduce the complexity of the system to allow the user to employ a larger set of navigational strategies (Shneiderman, 1997). Parallels with physical navigation have also assisted in addressing problems with navigation in virtual environments by drawing on a rich history of the design of topographical maps and city planning (Edwards and Hardman, 1989; Kim and Hirtle, 1995; Darken and Peterson, 2001). Other research into advanced visualisation techniques that provide support for managing large information spaces has proposed a range of technological solutions to overcome disorientation (Bederson and Hollan, 1994; Card et al., 1999; Cockburn and Jones, 1997; Mukherjea and Foley, 1995; Nation et al., 1997; Lamping et al., 1995; Pirolli et al., 2001).

One of the most common navigation aids from pre-Web hypertext research are 'Overview Diagrams'. Overview diagrams provide a visual representation of the hypertext system and are better known as 'sitemaps' in the context of the World Wide Web. Browse around the Web for a few minutes and you will inevitably come across a link called 'Sitemap'. Sitemap tools may be found on approximately 50% of commercial web sites (Bernard, 1999; Nielsen, 2002) which would translate into many millions of dollars of design, development, storage and maintenance costs each year.

It is claimed that sitemaps have a number of benefits, including improving spatial context and reducing disorientation (Bieber et al., 1997; Shneiderman, 1997), providing a sense of the extent of a particular web site without giving detail (Tauscher and Greenberg 1996) and acting as a visual surrogate for the user's short-term memory (Cockburn and Jones 1996). There are, however, some critics of sitemaps who have identified problems relating to speed, complexity and maintenance (Hoffman, 1996), and problems of navigating sitemaps themselves, especially when they are large or complex (Bieber et al., 1997).

Given the pervasive presence of sitemaps on the Web and the associated costs of developing and supporting these tools, it is surprising that there are few empirically based guidelines for the design and development of sitemap interfaces. The guidelines that do exist are either based on pre-Web research, are subjective in nature, or are based on limited or unsuitable usability studies (e.g.: Nielsen, 2002; Stover et al., 2002; Lynch and Horton, 2002).

The Web has transcended all expectations of size and purpose. Pre-Web methods used in studies of information-seeking behaviour, which were developed for the purpose of evaluating traditional systems, are not appropriate when investigating users' interactions on the Web (Martzoukou, 2005). Empirical studies examining information-seeking behaviour on the Web need to recognise the centrality of the user, with consideration given to their particular needs and capacities.

The role of the user has been the focus in a number of recent empirical studies that have resulted in a more comprehensive understanding of how users seek information on the Web. Examples of such studies are those that have examined the cognitive aspects of searching (Navarro-Prieto et al., 1999; Thatcher, 1999; Tevann et al., 2004), browsing behaviour (Byrne et al., 1999; McKenzie and Cockburn, 2001; Choo et al., 2000; Chi et al., 2001; Pirolli et al., 2003; Olsten and Chi, 2003), navigation strategies (Catledge and Pitkow, 1995), revisitation patterns (Tauscher and Greenberg, 1996; Cockburn et al., 2003), individual differences (Chen et al., 2000) and users' schemata of web sites (Farris et al., 2002).

Research specifically into sitemaps has generally been limited to evaluating their effectiveness in reducing disorientation (Bernard, 1999), determining trends in sitemap designs (Russell, 2002), contrasting constantly visible against optional interfaces (Danielson, 2002) or the development of novel interfaces (Mukherjea and Foley, 1995; Nation et al., 1997; Marchionini et al., 1998; Lai and Tanaka, 2000). There is a lack of empirically sound and theoretically based user-focused research into the design and use of sitemaps.

In user-centred research, a significant factor that should be considered in any empirical study is the goals of users. Users have a variety of goals, needs and motivations when interacting with web sites. Some users know exactly what they want, others have only a rough idea of what they are looking for, whilst others only realize they are interested in something when they see it (Lucarella and Zanzi, 1993). Interfaces to support users with less specific information needs are likely to have different requirements than those designed to support a search for something specific. In addition, a common assumption in empirical studies is that sitemaps are selected by users who wish to search for something specific. Such studies use fact-finding tasks with measures of completion times and task success in their experimental design (e.g.: McDonald and Stevenson, 1998b, Hornbæk and Frøkjær, 1999; Bernard and Chaparro, 2000; Danielson, 2002; Yip, 2004). This assumption may be appropriate for evaluating the usability of search tools which are designed for users with a specific information need, however may not be suitable for other types of navigation tools such as sitemaps.

Apart from some research on general contextual aids (Park and Kim, 2000), there has been little specific research into the relationship between user goals and the use of alternative supplemental navigation tools such as sitemaps. Such research is critical to further our understanding of the role of sitemaps in the provision of effective support in navigation through the World Wide Web.

> *"Understanding why different persons search information in different ways is vital before designing information retrieval systems and offering appropriate user support"* (Martzoukou, 2005).

1.2 Problem Statement and Research Questions

The previous section introduced the problem of disorientation when navigating web sites and the use of sitemaps to alleviate disorientation. It is evident that there is a lack of research into sitemaps that is sensitive to the goals of users and subsequently a lack of appropriate empirically-based guidelines for the design of sitemaps.

The background literature and associated research that has led to the research questions is discussed in detail in Chapters 2 and 3. The research questions are developed in Chapter 4, however they are presented here to provide a sense for the overall direction of the research.

The overall focus question was:

> ***Does goal specificity influence the navigational behaviour of users when visiting web sites, particularly in relation to their use of sitemaps, and what are the design implications for sitemaps?***

The specific questions addressed were as follows:

1. What is the current status of sitemap designs and functionality on the World Wide Web?
2. What expectations do users have of the design and functionality of sitemaps?
3. What level of goal specificity do users have when they decide to use a sitemap?
4. What primary navigational strategy should sitemaps support?

1.3 Purpose and Overview of the Project

The purpose of this research project was to investigate the relationship between user goals and the design and use of supplemental navigation tools, particularly sitemaps, in order to provide a theoretical and empirical base for the development of design guidelines for sitemaps. An additional objective was to improve the design of empirical studies into web navigation, particularly those studies which aim to develop or validate design guidelines for navigation tools, by suggesting that the experimental design become more sensitive to user goals.

This project examined the effect of goal specificity on both the strategies users employ when navigating web sites, and their use of site navigation tools.

The project was carried out in four broad phases:

(i) A review of the literature relating to key areas, including;

   a. sitemap tools and current design guidelines;
   b. human-web site interaction and navigation;
   c. the role of goals and strategies in the use of navigation tools.

(ii) A number of surveys to confirm the nature and extent of the usability issues regarding sitemaps.

(iii) Two empirical investigations into the relationship between user goals and their effect on tool choice and navigation strategy.

(iv) A synthesis of the findings resulting in several recommendations for the design of sitemaps and further empirical studies.

1.4 Significance of the Project

Detailed design guidelines can be an effective way of conveying principles of human-computer interaction design (Henninger et al., 1995). Guidelines are particularly valuable for web site developers who may only have limited knowledge of usability, or who may be required to make rapid design decisions and do not have the time to validate decisions by undertaking usability tests. In addition, users also have strong expectations of design of some web page elements, hence adherence to guidelines can result in consistency of experience for users (Nielsen, 2004).

There are a large number of guidelines and heuristic tests available to assist designers, however these largely do not have a strong empirical or theoretical foundation (Ratner et al., 1996). The ongoing problems of navigation in web sites that are being reported by users are further evidence of a need for research to underpin guidelines.

This project adds to an existing body of knowledge regarding guidelines for the design of sitemaps. The project establishes that current sitemap guidelines have been developed without due consideration to user goals, and it is this gap in the existing research that is addressed by this research.

By investigating the research questions identified in Section 1.2, the project contributes to web navigation research in a number of ways. First, the project clarifies the status of current sitemap research and design practice resulting in the identification of several deficiencies, including that of a lack of sensitivity to user goals in relevant guidelines. Second, a framework for web navigation is proposed that provided a structure to facilitate the identification of the areas in which there is a lack of research, and a scaffold in which to undertake such research. Third, the project clarifies the relationship between the goals of users who select sitemaps, and determines their navigational needs. Finally, a number of design guidelines are proposed that are based on the results of empirical studies which are sensitive to the goals of the user.

The outcomes of this project benefit both web developers by providing an empirically-based set of guidelines for the design and use of sitemap interfaces, and researchers who are involved in the design of empirical studies into web navigation, particularly studies which aim to develop or validate design guidelines for navigation tools.

1.5 Organisation of the Thesis

With the current chapter providing an outline of the problem domain and the issues being addressed, the remainder of the thesis is organised as follows:

Chapter 2 contains a review of supplemental navigation tools for web sites, particularly the design and functionality of sitemap tools.

Chapter 3 presents a conceptual framework that provides an understanding of how a number of key issues and concepts relate to the design and use of navigation tools. Issues relating to user goals and navigation strategies are discussed.

Chapter 4 develops the research questions and identifies several hypotheses and issues that are investigated in the subsequent chapters. The chapter also provides an overview of the research methodology and describes how each of the studies address the research questions.

Chapter 5 presents findings from three surveys which reviewed user expectations and commercial design practice. These surveys confirm the nature of the present problem.

Chapter 6 reports the first major study which involved a qualitative experiment to test a hypothesised relationship between user goals and the selection of supplemental navigation tools. The chapter presents the aims, procedure, results and findings from the experiment.

Chapter 7 reports the second major study that explores the relationship between user goals and browsing patterns in order to clarify the navigational needs of users of sitemaps. The chapter presents the aims, procedure, results and an analysis of the findings.

Chapter 8 draws together the major findings of the empirical studies, and presents several design guidelines for sitemaps.

The final chapter summarises the findings of the project, discusses the contribution and significance, and identifies a number of areas for further investigation.

Figure 1.1 presents the structure of the thesis.

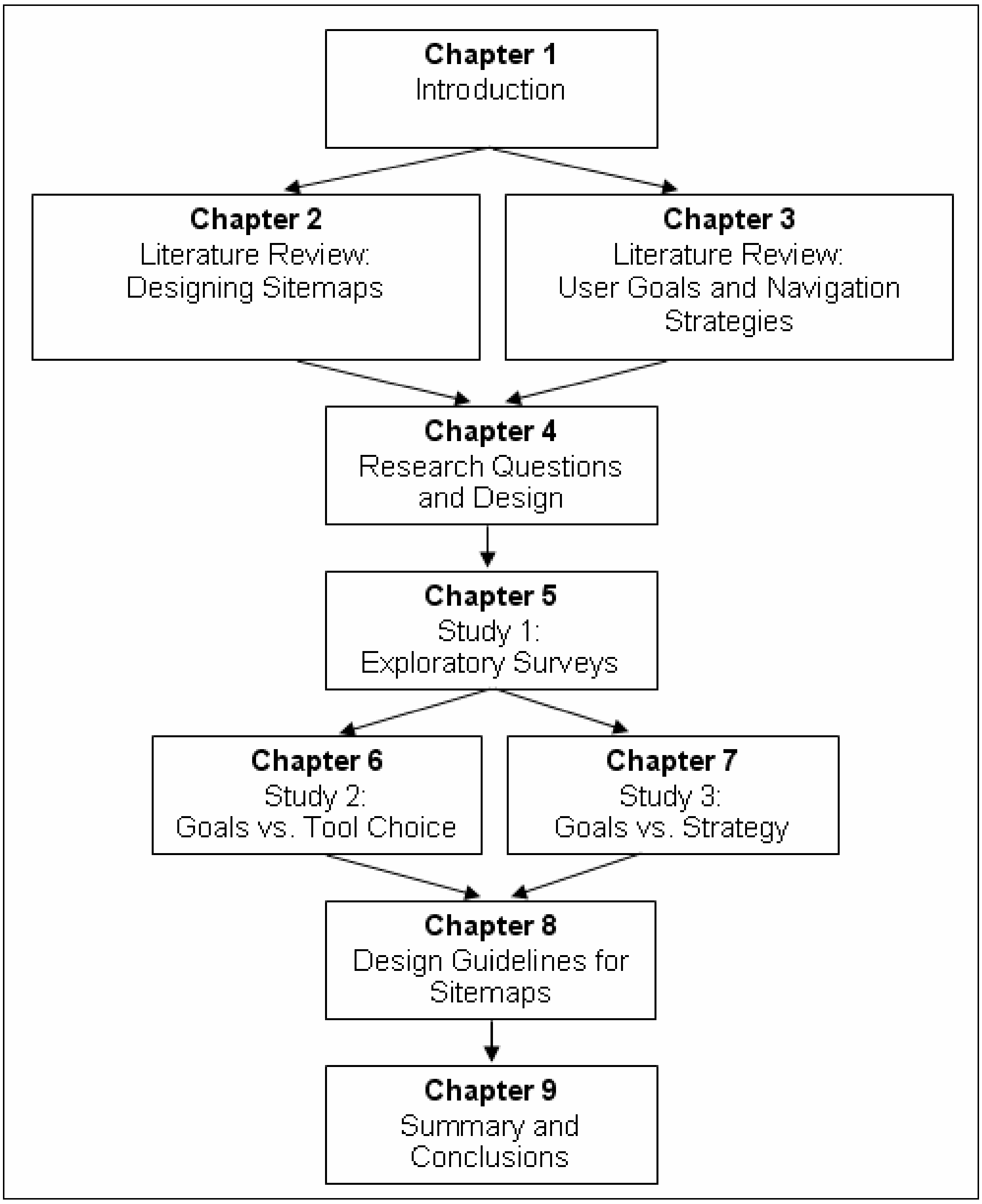


Figure 1.1: Structure of Thesis

2 Designing Sitemaps

2.1 Introduction

Tim Berners-Lee, now Director of the World Wide Web Consortium [W3C], is attributed with inventing the Web. In 1989, Berners-Lee authored a document entitled 'Information Management: A Proposal' that outlined a system which would enable a community of scientists to disseminate and share information. In this document Berners-Lee discussed the problems of loss of information about complex evolving projects in large organisations, and outlined a solution based on a distributed hypertext system. He described an organisation of several thousand creative people working toward common goals and the problems with hierarchical management structures when people communicate across groups, sharing information, equipment and software. He observed that the working structures were a "multiple connected 'web' whose interconnections evolve with time". He proposed a system that would manage information across the organisation in an unconstrained way, allowing the pool of information to grow and evolve with the organisation. In the document Berners-Lee stated that the system would be a "global hypertext system", and as a "web of notes with links between them", would be more useful than a fixed hierarchical system. He concluded by recommending the development of this "universal linked information system, in which generality and portability are more important than fancy graphics techniques and complex extra facilities." (Berners-Lee, 1989)

Whilst there have been many enhancements to the World Wide Web over the past few years, the basic architecture developed in the early 1990's is relatively unchanged (Hill, 1996). The World Wide Web continues to this day to use a hypertext navigation paradigm set in a distributed environment.

In his 1989 proposal, Berners-Lee commented on issues relating to browsing techniques that were being explored by hypermedia researchers at that time. He wrote:

> *"Much of the academic research is into the human interface side of browsing through a complex information space. Problems addressed are those of making navigation easy, and avoiding a feeling of being*

> *'lost in hyperspace'"*. (Berners-Lee, 1989)

It was clear that Berners-Lee was aware of the navigational difficulties inherent in hypertext systems. Subsequently, in further design notes from 1990 that related to navigational techniques and tools, Berners-Lee wrote of the possibility of providing a graphical overview for the then named World Wide Web:

> *"A graphical overview is useful and could be built automatically. Should it be made by the author, server, browser or an independent daemon? Can one provide an overview with less granularity than the basic web by grouping nodes in some way? I think this depends on how long it will take. It might be interesting to experiment with daemons which will independently make and update maps of the web."* (Berners-Lee, 1990)

The questions that Berners-Lee poses regarding the usefulness of graphical overviews, how they should be created and the level of detail that they provide are questions that this project now confronts. This glimpse of the history of the Web describes graphical overviews (i.e. sitemaps) as a tool that alleviates certain navigational problems relating to the Web due to its hypertext structure. This chapter explores these various issues by introducing sitemaps in the context of the Web being a hypertext system.

The first part of the chapter reviews background literature about the architecture of the Web, including a detailed discussion about the nature of hypertext. Then issues relating to the usability of the World Wide Web are discussed, particularly those in relation to navigation, disorientation and cognitive overhead. These issues are discussed with reference to the particular nature of hypertext. This discussion concludes with a summary of the navigational problems relating to the Web.

The second part of the chapter commences with an overview of various supplemental navigational tools used in pre-Web hypertext systems to alleviate navigational problems. The discussion focuses on the evolution of early hypertext concept diagrams into sitemaps for a Web context. A discussion of the applicability of hypertext research to the Web is presented.

The final part of the chapter examines sitemaps in detail, including a review of literature that report benefits and problems. A review of current design guidelines is presented. The chapter concludes with a summary of the issues confronting the design and use of sitemaps in web sites.

2.2 The World Wide Web - A Hypertext Based System

2.2.1 Hypertext – definitions and history

In 15 years the Web has grown to over 300 million hosts in 2005; triple the number that existed in 2000 (ISC, 2005). Supporting this rapid evolution are some fundamental concepts that are sometimes forgotten under the hype and seductiveness of the Web. The concept of 'hypertext', which pre-dates the Web by almost half a century, provides the basic architecture on which the Web is built. The Web as a collaborative, distributed hypertext system is simply a natural extension of earlier hypertext systems (Durand and Kahn, 1998; Sears, 2000). Even hypertext itself is "not so much a new idea as an evolving conception of the possible applications of the computer" (Conklin, 1987).

Nielsen (1990) provides the following classic definition of hypertext:

> *"Hypertext is non-sequential writing: a directed graph, where each node contains some amount of text or other information. The nodes are connected by directed links. In most hypertext systems, a node may have several out-going links, each of which is then associated with some smaller part of the node called an anchor. When users activate an anchor they follow the associated link to its destination node, thus navigating the hypertext network."*

Hypertext is an information management technique that utilises a non-linear structure of 'nodes' and 'links'. Nodes hold information comprising text, graphics, audio, video and other forms of data. Embedded within the information are link anchors that are essentially pointers to other nodes. Users navigate through the hypertext system by activating anchors and following links from node to node (see Figure 1.1). Users may also backtrack by following links they have previously used in the reverse direction. The network of nodes and links are hidden from the user by the fact that the users can, at any one time, only view one node and any links leading out from that node. Conklin (1987) states that the essence of hypertext relates to this linking capability which provides the non-linear organisation of information.

> *"Its chief characteristic is that words, phrases, sentences or other pieces of text may be 'linked' to other passages of text. Rather than text appearing in a purely sequential manner as in conventional text media, hypertext systems store logical relationships between various components. This linking embodies the 'hyper' nature of the way that the data is organised."* (Messing, 1991)

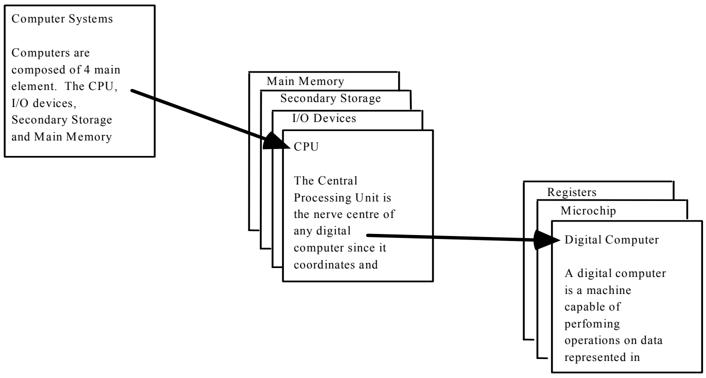


Figure 2.1: Hypertext nodes and links

The word 'Hypertext' has been attributed to Theodore Nelson (Nelson, 1967), although the original concept of the storage of textual information as a network of documents linked together by meaningful pointers was first developed by Vannevar Bush (1945). Bush realised the importance of flexible access to, and control of, information. He devised an information browsing and retrieval system called 'Memex' which would provide an "intimate supplement" to an individual's memory. A user could store books, records and communications through which they could later browse, search for particular information or join items of interest together to create paths through the documents. Bush stated that the "essential feature of Memex was its ability to tie two items together" (Bush, 1945). This concept laid the foundations for later hypertext systems.

The first hypertext systems were concerned mainly about the presentation of text. In systems such as Doug Engelbart's 'oNLine System (NLS)' (1962), documents were broken down into smaller chunks to fit fixed sized nodes known as cards or frames. Links between nodes were embedded in the cards as segments of text and were activated by cursor control. Later systems such as Hyperties in 1983 (Shneiderman et al., 1991), Xerox Parc's NoteCards in 1985 (Halasz, 1988) and Apple's Hypercard in 1987 incorporated developments such as the mouse and windows interfaces to allow users to follow links in the form of buttons or hotspots. Today's hypertext systems vary widely in architecture, but are all essentially based on the concept of information stored in nodes connected through embedded links.

The term 'hypermedia' is used to refer to the fact that hypertext systems may now store and manipulate not only textual information, but information in a variety of media formats such as video, audio and graphics. Research by Jonassen & Grabinger (1990) emphasised the high level of dynamic user control that hypermedia permits by the use of a range of media rather than simply textual transfer of information.

Many researchers have described the place where the hypertext or hypermedia information exists as an 'information space'. This 'space' metaphor has been extended to include references to users travelling or moving through an information space (Hammond and Allinson, 1989) following paths or routes (Canter et al., 1985). The term 'browsing' is frequently used to describe how people interact with hypertext systems. The phrase 'browsing the Web', now achieving a colloquial familiarity, conjures up the impression of people physically moving through an information space at will and with ease similar to the physical experience of browsing through shopping centres.

2.2.2 Benefits of hypertext

There are several significant benefits that hypertext and hypermedia bring to the experience of interacting with an information system.

First, the experience is enriched due to the nature of hypertext which, as Utting and Yankelovich (1989) claim, becomes a complex, richly interconnected and cross-referenced body of multimedia information. Its flexible structure (Otter and

Johnson, 2000) provides users with the freedom to browse and interact with the information in a variety of ways.

Second, hypertext supports and encourages incidental learning by allowing users to browse through links in a serendipitous manner. The Oxford dictionary defines serendipity as the "making of happy discoveries by accident". This effect frequently occurs when searching for something specific on a hypertext system and involves being presented with something else that is unrelated to your current goal, and then diverting your attention to explore the discovery, possibly forgetting about your original goal. Theodore Nelson (1967) wrote "Hypertext is described as non-sequential writing". The non-sequential nature of hypertext frees users from linear structures by allowing them to follow contextual connections. Hence, users are able to access information in the order most appropriate to their own needs (Bieber et al., 1997; Lucarella & Zanzi, 1993; Ekland & Zeiliger, 1996; Simpson, 1990). Hypertext is different from other information retrieval systems which provide a single output set from a query (Carmel et al., 1992), as it provides opportunities for incidental connections by allowing the reader to branch off and inspect related information. Such diversions allow users to find pieces of information which they could never request by a formal query (Brusilovsky, 1996). This effect may be explained by the possible congruence between hypertext representations and human information processing mechanisms where hypertext can aid thinking by encouraging users to follow associative links (Bush, 1945; Frampton, 1992). In addition, Fredin (1997) suggests that humans have positive emotions when exploring and discovering, whilst McDonald and Stevenson (1998a) claim that hypertext aids learning by increasing users control over the sequencing of information.

A third benefit reported in the literature relates to the ability of hypertext users to create, annotate, link and extend structures. Hypertext allows users to "create new references, grow their own networks, or simply annotate someone else's document with a comment" (Conklin, 1987). Technologies such as hypertext are considered inherently participatory, which sees readers also taking on the task of author and collaborator (Huesca and Dervin, 1999). This involvement engages users at a deeper level of involvement by merging the roles of reader and author together. The Web has realised this benefit through the development of innovative collaborative tools such as Wikis and Blogs.

2.2.3 Usability problems with hypertext

The various benefits outlined in the previous section are achieved through the flexibility provided by non-linear, non-sequential or network structures. With these benefits come some trade-offs in usability.

Some researchers contrast the non-linearity of hypertext with the linearity of traditional paper documents (McKnight et al., 1990; Dillon et al., 1993; McDonald and Stevenson, 1996; Shneiderman, 1997; Smith and Weiss, 1988; van Dijck, 2000b). Paper-based documents, books, magazines and newspapers are all familiar to us. The physical aspects of hypertext closely resemble the pages in paper documents, whilst the logical structures relate to chapters and paragraphs (Smith and Weiss, 1988). There is a comforting sequence to books and other paper-based documents: a start, middle, an end, a before and an after. There is a tactile and visual quality about books that provide cues to allow the reader to gauge the extent of the text at a glance (McDonald and Stevenson, 1996; McKnight et al., 1990), and visually place any page somewhere in the sequential organisation. This organisation encourages readers to read them linearly from the beginning to the end.

Almost 500 years of publishing experience has led to a widely adopted system of typographical conventions that provide orientational cues and navigational assistance to readers of paper-based documents. The front cover of a book provides the title, authors and publisher. A table-of-contents provides both a semantic and structural overview of a document. The structural organisation of the document is provided by various chapter headings and subheadings, whilst an overview of the type of information that may be found in the text is provided when reading the chapter headings. Some documents contain an introduction, abstract or summary that provides the reader with a synopsis of the contents. Many documents have an alphabetical index that facilitates a keyword search of the text. Footnotes provide explanatory text and cross-referencing. Page numbers reinforce the sequential model of the text, and allow the reader to use a table-of-contents or index to jump to a particular section.

The book metaphor may be extended to that of a library when global search is considered. Libraries also provide familiar structures having rows of books on shelves with position indicators, labels and a cross-indexed catalogue to assist users in locating particular books (Pejtersen, 1989).

Wide adoption of these conventions in Western society has led to a strong mental model of the organisation and use of textual documents. Readers now expect this type of organisation and their use has become intuitive, predictable and somewhat comforting. The linearity of traditional paper-based documents supports the reader in the task of navigating, reading and comprehending. It is quite difficult to get ‘lost’ in a book.

The non-linearity of hypertext presents readers with a number of usability problems. The orientation cues found in traditional paper-based documents are absent in many hypertext systems. Dillon et al., (1993) suggested that the differences between paper and electronic document such as hypertext can be appreciated by what you can tell about either at first glance. Hypertext documents do not provide the same amount of information when first opened. The opening page of hypertext might provide the document title and possibly some information about the contents and authorship, however there is very little else. There may not be any indication about the size, quality, age or how frequently the document has been used. Books by their nature provide this implicitly by their tactile and visual appearance. When opening a link on a hypertext document, there are no assurances that expectations will be met since hypertext documents vary widely in structure and organisation. McDonald and Stevenson (1998a) reported a study that found that this uncertainty is heightened in users who are unfamiliar with the contents of the hypertext. Other studies also found that hypertext users either underestimate (McDonald and Stevenson, 1996) or overestimate (McKnight et al., 1990) the total size of the hypertext system. Harper et al. (2004), claim that true mobility through hypertext can only be achieved if additional context and preview information is provided within the link description.

Hypertext users may have a model of hypertext use that includes an understanding of links, nodes and non-linear structures, but the use of collaborative, distributed hypertext systems such as the Web will inevitably result in some element of uncertainty about the results of any navigational action. The Web varies somewhat from traditional hypertext systems as it does not have any central control, few standards and distributed authorship. As users move between sites the informational structures and navigational modes will vary, resulting in a greater level of uncertainty about the outcomes of any navigational action.

There has been a significant amount of research that reports navigational and orientation difficulties pertaining to hypertext structures (Woods, 1984; Elm and Woods, 1985; Conklin, 87; Marchionini and Shneiderman, 1988; Edwards and Hardman, 1989; Utting and Yankelovich, 1989; Nielsen, 1990; Carmel, Crawford and Chen, 1992; Kim and Hirtle, 1995; Thuring et al., 1995; Cockburn and Jones, 1996; McDonald and Stevenson, 1996, 1998a, 1998b; Smith et al., 1997; Otter and Johnson, 2000; Park and Kim, 2000). In a widely cited review of hypertext, Conklin (1987) classified the two key problems that limit the usefulness of hypertext systems as disorientation and cognitive overhead. These issues are discussed in the following sections.

2.2.3.1 Disorientation

Conklin (1987) described hypertext disorientation as "the tendency to lose one's sense of location and direction in a non-linear document", and attributes it to the additional freedom provided in hypertext. Woods (1984) called it the "getting lost phenomena" which occurs "when the user does not have a clear conception of relationships within the system, does not know his present location in the system relative to the display structure, and finds it difficult to decide where to look next with the system". Many researchers now refer to this condition using a colloquial title of "Lost in Hyperspace" (Mukherjea and Foley, 1995; Gershon, 1995; Otter and Johnson, 2001) and regard it as one of the most fundamental usability problems which users experience when navigating within hypertext systems (Nielsen, 1990; Kim & Hirtle, 1995; McDonald and Stevenson, 1996, 1998a; Otter and Johnson, 2000).

There are several reported symptoms of disorientation in hypertext structures:

Difficulty in finding information.

> Most hypertext systems are designed to support information retrieval, however users commonly have difficulty in identifying where desired information is and moving to that location (Kerr, 1990). Utting and Yankelovich (1989)

claim that hypertext has the ability to "produce complex disorganised tangles of haphazardly-connected documents that make it very difficult to locate information", whilst McDonald and Stevenson (1996) found that users have difficulty in planning and executing direct routes to desired information.

Difficulty in handling digressions.

Hypertext encourages serendipity, the ability to be diverted away from one goal by something else of interest. McDonald and Stevenson (1998b) claim that digressing or being distracted from the task at hand is a common experience for hypertext users. Otter and Johnson (2000) found that this can result in degradation in performance if it resulted in losing track of tasks, not returning from a side track and forgetting which parts of the hypertext had already been visited. Foss (1989) called this the 'Embedded Digression Problem', which when pursuing multiple paths and digressions, resulted in "losing your place, forgetting to return from digressions and neglecting to pursue digressions you intended to follow."

Feelings of being lost.

Users who are experiencing disorientation may have feelings of bewilderment or confusion (McDonald and Stevenson, 1998b), lose their sense of location and direction (Conklin, 1987; Herder, 2003b), may not be able to decide where they want to go (Kim and Hirtle, 1995), and may become frustrated, lose interest and work less efficiently (Ahuja and Webster, 2001).

There is some empirical evidence in the literature that supports the notion of disorientation as a navigational problem in hypertext. For example, Elm and Woods (1985) in a study where subjects were asked to retrieve information from a hypertext system, found three different forms of lostness: not knowing where to go next; knowing where to go but not knowing how to get there; and not knowing where they were in the overall structure of the document. Edwards and Hardman (1989), in a study examining how readers of hypertext cognitively represent its structure, found that almost half of the subjects reported a form of being lost whilst browsing through the hypertext.

Considering the general acceptance of disorientation as a major usability issue, there is a lack of substantial empirical research addressing this topic, and very few attempts have been made to qualify and measure disorientation (Otter and Johnson, 2000; Ahuja and Webster, 2001). Some related research in this area includes Smith (1996) who proposed an optimal path deviation measure that produced a lostness rating based on various navigational path measures, which examined how efficient users were in finding information in a hypertext system. Ahuja and Webster (2001) used a subjective measure of perceived disorientation based on a survey of feelings of disorientation. Otter and Johnson (2000) recommended the use of a "battery of complementary usability methods" including a link-weighted lostness metric. This metric extended Smith's (1996) measure by taking into account the effect that different types of links might have on lostness, and metric of lostness based on the assumption that if the user has a poor mental model of the hypertext system's structure, then it is likely that they will experience disorientation. Herder (2003b) also proposed a complementary approach to a measure of disorientation in Web systems based on a relationship between users' perceived disorientation and their revisitation behavior.

Disorientation stems from the non-linearity of hypertext structures. This non-linearity is achieved by connecting nodes with links into a network structure. These key elements of hypertext: network, nodes and links; all contribute to the possibility of disorientation occurring:

Network organisation

> Hypertext is essentially a network organisation. Users may encounter multiple paths to the same endpoint (Hedberg & Harper, 1991) which can leave the user with no context as to where they are in the hypertext system. Users without a contextual point of reference will struggle to maintain a sense of orientation and direction. Nielsen (1990) refers to this as the 'Homogeneity Problem' where online text basically looks the same, making it hard for users to distinguish between nodes and recognise whether they have visited them before. The comparison with textual documents in the previous section may be used again to understand the nature of the node homogeneity problem. Books have a number of cues such as chapters, page numbers and paragraphs that assist the reader in distinguishing sections and maintaining orientation. These cues or landmarks assist the reader in building an appropriate mental representation of the structure of the text. Hypertext, by

its very nature as a network structure, does not implicitly contain any standard structural cues that would enable a user to visually differentiate between nodes to establish and maintain their location in the system.

The node

The basic information unit of hypertext is the 'node'. Users can only view one node at a time, hence they cannot see the overall structure or size of the system. They have no sense of what to expect or how to cognitively comprehend the system (Nielsen, 1990), nor can they know which portions of the system have been visited, which have been missed and the general extent of the system (Foss, 1989). Woods (1984) referred to this problem as the 'Keyhole Phenomenon' where the user can only view a small portion of the total information space at one time. Hypertext presents data in a serial form one node at a time, which degrades information extraction compared with a parallel presentation mode where all of the data is displayed simultaneously. Users may miss important nodes, open the same few nodes repeatedly, take additional time to locate information and travel in less-than optimal routes. (McDonald and Stevenson, 1998b). Foss, (1989) refers to an effect caused by the node-centric model of hypertext as the 'Art Museum Phenomenon' where someone who spends a long time in a large art museum gazing at hundreds of paintings may not, at the end of the day, be able to recall any particular painting, or how the various styles have influenced each other. A hypertext user examining many single nodes in a system may become overwhelmed and have difficulty remembering, consolidating and understanding the semantic content of individual nodes.

The link

Conklin (1987) claims that the essence of hypertext is the 'link'. Links connect nodes establishing a semantic network allowing users to follow a train of thought from node to node. Beiber et al. (1997) outline a range of issues regarding the implementation of hypertext links, including typed links, link attributes, private and public links, external link databases and link update mechanisms. The traditional hypertext link has a severe limitation as the user is only presented with a snippet of text or graphic as a cue to what type of content will be presented if the link is chosen. Jul and Furnas (1998) define this as ‘navigational residue’, which is the evidence in a view that leads a user to believe that a particular target node may be reached by following a particular link. Good residue leads the user to the target via the shortest path. Pirolli and his colleagues at Xerox Parc (Pirolli and Card, 1995; Pirolli, 1997; Chi et al., 2001; Pirolli et al., 2001; Pirolli et al., 2003) have developed a theory of ‘information foraging’ that describes user behaviour as they follow hyperlinks from page to page mixing directed searching behaviour with unstructured and opportunistic behaviour. Part of this theory involves the notion of ‘information scent’ which relates to the amount of remote indication a user can derive from the link labels and information structure about the relative location of some target information. “Information scent is the imperfect, subjective perception of the value, cost, or access path of information sources obtained from browsing cues” (Pirolli et al., 2003). Likewise, Danielson (2003) describes the ‘behind-the-door’ problem where the user sometimes is unable to grasp what lies directly behind a hyperlink, let alone what may be accessed further downstream. Smith et al. (1997) suggest that one of the reasons that a user cannot find information in a system is that the cues in the route to the information do not match the user’s expectations. Obviously, the stronger the scent the greater the predictability, and the less lost the user becomes (Larson and Czerwinski, 1998).

Disorientation may be amplified under certain conditions, including those of size, complexity and consistency of a hypertext system, and the goals and experience of users. If the information space is very large and the path network is complex with multiple paths to the same destination, then the probability of users becoming lost in the system is quite high (Elm and Woods, 1985; Conklin, 1987; Halasz, 1988; Hedberg & Harper, 1992; Kim & Hirtle, 1995; Ekland and Zeiliger, 1996). Systems that change their content and structure regularly will cause additional problems for frequent users who may have established a working mental model of the system (Conklin, 1987; Halasz, 1988). Systems that are used by a range of different people with different goals and knowledge can result in “unproductive wandering in the link network” (Eklund and Zeiliger, 1996). Users who are unfamiliar with the subject matter are particularly prone to disorientation as they do not possess a conceptual structure that could guide navigation (Hammond and Allinson, 1989; McDonald and Stevenson, 1998b).

These confounding conditions all relate to the World Wide Web, which is an extremely large hypertext system that changes on a regular basis and is used for different purposes by a range of people, including those who may be unfamiliar with the content of a particular web site. The deficiencies and problems relating to navigation on the Web have been well reported in the literature with Cockburn and Jones (1996, 1997), Shneiderman (1997), Xu et al. (2001) and Nielsen (1996 to 2004) providing good overviews of the issues and challenges relating to navigation on the Web, especially that of disorientation. The literature suggests that the symptoms of disorientation are evident in the Web

> *"One of the big issues in finding information in the Internet is what is known as the 'lost in hyperspace' syndrome: users cannot get an overview, cannot find specific information, stumble over the same information again and again, cannot identify new and outdated information, cannot find out how much information there is on a given topic and how much of it has been seen, etc."* (Gershon, 1995)

The well cited surveys developed by the Graphics, Visualization and Usability Center at the Georgia Institute of Technology (GVU, 1994-1998) found disorientation in the Web existed where users had difficulty in finding pages known to exist, finding a page already visited, and visualising paths taken and paths that could be taken. Lazar et al. (2003) reporting on a study into user frustration in web navigation found that users frequently report having problems finding what they want on the Web. "Users can't find the site that they want, and once on a web site, they can't find the specific content that interests them." Diebold and Kaufmann (2001) suggest that the particular nature of the Web increases disorientation, including a lack of physical context with no sense of a start or a part-to-a-whole relationship of a single page being viewed, the endless possibilities of organisational paradigms for web sites, and a lack of knowledge of site structure preventing the user from building an appropriate mental model of the site.

2.2.3.2 Cognitive overhead

Disorientation is compounded further by the requirement that users perform several tasks simultaneously as they navigate through a hypertext system (Conklin, 1987; Foss, 1989; Park and Kim, 2000). Cognitive overhead is "the additional effort and concentration necessary to maintain several tasks or trails at one time" (Conklin, 1987). The navigational task relating to choosing paths and managing digressions through a hypertext system may be regarded as a meta-task, since it is subordinate to the actual task of reading and understanding the content. This meta-task requires additional cognitive effort above that of simply reading linear text where the sequence of material has been pre-determined by an author. If mental resources are engaged by navigational tasks, and if those same resources are needed for learning, it would be logical that achievement should suffer if navigation is demanding (Tripp and Roby, 1990).

The notion of cognitive overhead in hypertext navigation is related to Sweller's (1988) theory of cognitive load, which claims that requiring learners to mentally integrate disparate sources of information can interfere with learning by misdirecting attention. We know that the human information processing system has a limited capacity (Thüring et al., 1995), and hence any excessive cognitive overhead could lead to cognitive overload deteriorating performance.

Cognitive overhead can change the navigational behaviour of hypertext users. Wright & Lickorish (1994) in a study of memory, memory load and memory aids in menu selection tasks explored the relationship between navigation choices and cognitive demands of the task. Their results suggested that people usually select navigational methods that result in the fewest additional demands on their working memory. Nielsen et al. (1992) also found that experts prefer actions with the least amount of cognitive load in order for them to concentrate on the actual task at hand. These empirical studies have shown that navigational tasks impose an additional cognitive load which can be detrimental to task performance. The cognitive overhead is particularly significant for novices who are not familiar with the domain (Bieber et al., 1997).

Balasubramanian (1994) associates the notion of cognitive overhead to Web navigation by claiming that users of web sites can experience cognitive overhead due to decisions as to which links to follow and which to abandon, given a large number of choices. Similarly, Park and Kim report that Web users.

> *".. have to perform many tasks simultaneously, such as remembering tasks and sequences, searching target items, browsing general topics and related items, surfing items of interest, comparing between items, moving from one item to others and so on. Performing all these tasks simultaneously causes users to experience cognitive overload, which may lead them to get lost in hyperspace."* (Park and Kim, 2000)

2.2.4 The Web – navigation, orientation and usability

Web navigation is a two stage process (i) finding a web site that relates to an area of interest and (ii) locating the information within the individual web site. The initial stage of navigation is usually achieved through the use of search tools (Scanlon, 2000; Nielsen, 2000a), however there is a range of usability problems relating to search tools, particularly regarding a lack of standards, dominating commercial interests, varying algorithms and interface usability when the engine returns lists of thousands of hits. Search engines can also be confusing for users unfamiliar with the information context who may struggle to form appropriate queries (Marchionini, 1995).

Whilst search tools are generally sufficient for global navigation, they are limited in their use when navigating locally around a site. Instead, in the second stage of information retrieval users prefer to navigate through individual web sites using a combination of both local search tools and page-to-page browsing (Katz and Byrne, 2003). Even if a user finds an appropriate web site, they still struggle to find content on the site that they are interested in (Lazar et al., 2003).

During site navigation, the user has limited options. Instone (1996) recognised five types of navigation using the standard Web browser:

1. Browser navigation - back, history, open URL.
2. Content navigation - hypertext links, buttons inserted in the page.
3. Within-page navigation – scrolling and pointing.
4. Multi-browser navigation - using more than one browser at once.
5. Application navigation - switching from a browser to another application.

Xu et al., (2001) identified a similarly limited set of navigational options in browsers, including the back button, the forward button, history mechanisms, bookmarks, the home button, hard-wired page buttons and links, and the URL field. These methods present navigational choices to the user, utilising the self as the frame of reference. This 'inside-out' view of the information space is a result of the Web being a 'page-oriented' hypermedia system. Users navigate from one page to another, utilising visual features to trigger decisions to follow links or to backtrack where they came from. The major commercial browsers provide no feedback about the context of the currently displayed page within the total information space, nor do they provide any alternative views of the site being visited. Users, when lost, will attempt to find their way back to a previously visited page, resulting in inappropriate use of the Back button (Tausher & Greenberg, 1996, 1997; Catledge & Pitkow, 1995; Cockburn et al., 2003) and reluctance to explore further (Ayers & Stasko, 1995). Browser software does not provide the facilities to visualise the inter-relationships between pages, preventing users from answering questions such as 'Where am I?', 'Where can I go from here?' or 'Which pages point to this page?' (Bieber et al., 1997). This lack of knowledge of the overall structure of the site can result in confusion and cognitive overload when users jump from one location to another in the Web (Mukherjea and Foley, 1995), or encounter multiple paths to the same or different endpoints (Hedberg and Harper, 1992). This lack of location information can result in a condition that Jul and Furnas (1998) describe as "desert fog", where a navigator is in a situation where the immediate environment is totally devoid of navigational clues that might be useful to the traveller.

Usability problems relating to the lack of a global navigation structure and inadequate location feedback from browser interfaces are compounded by the limited navigational tools and structures (Gershon, 1995) and the vast amount of information that the Web contains. As a consequence of these factors, users are prone to suffer from disorientation and cognitive overhead whilst navigating through the Web.

2.3 Supplemental Navigation Aids and Sitemaps

Disorientation is a problem that may never be solved, as it is result of a trade-off between greater flexibility in access (Kerr, 1990) and the vast amount of information available through hypertext systems such as the Web. The problem may be managed through the provision of aids and tools that minimise the cognitive load of the task of navigation. Nielsen (1989), in a study using a system called Guide, suggested a connection between poor design of an interface and an experience of disorientation by users. Interfaces and tools that support the navigation through web sites need to be designed with due consideration to the nature of the navigational problems, and supported with a strong theoretical and empirical background. Xu et al. (2001) suggest that Web navigation be regarded as a science or art of helping users find their way. It is only through a considered design process that appropriate navigation aids will be developed which are sensitive to the context of the site, reducing cognitive overhead and disorientation in users (Ahuja and Webster, 2001).

This section examines the literature that relates to hypertext and Web navigation aids, particularly the research that proposes the use of overview tools to support navigation and reduce disorientation and cognitive overhead.

2.3.1 Research into hypertext navigation aids

Considerable research has been undertaken to develop better interface tools and aids with the aim of alleviating the problems of disorientation and cognitive overhead. Research has either focused on the development of technical solutions to the problem through innovative navigational interfaces, or has examined the nature of the disorientation problems by examining factors such as prior experience and human memory.

In her well cited article, Foss (1989) describes the 'Embedded Navigation Problem' and the 'Art Museum Problem' as undesirable consequences, and proposes four history management and annotation tools which help the user see where they have been and record what they were thinking at the time: (i) 'Graphical History Lists' which are temporally ordered list of nodes that the user has visited during the browsing session that supports the user in managing multiple digressions by differentiating between visited and unexplored nodes; (ii)

‘History Trees’ which are hierarchically ordered view of nodes that have been visited provides a personal history of a browsing session; (iii) ‘Summary Boxes’ which are described as a tool to facilitate note taking during a browsing session providing a personal summary of the session; (iv) ‘Summary Trees’ which are graphical representations of a session where users can make arbitrary annotations to the tree, including the addition of links, text and further nodes.

Some research has extended Foss’ history-based tools by focusing on the assumption that users create mental models whilst interacting with system, and suggesting that history-based interfaces might support users in the construction and use of mental models.

For example, Edwards and Hardman (1989) report an experiment that examined how hypertext users cognitively represent its structure. The experiment looked at the effects of different hypertext structures on the user’s memories of the structures of the hypertext. They concluded that users appear to be creating a mental model or cognitive representation of the hypertext structures in the form of a survey-type map or schema, and suggested some implications for the types of navigation tools that could be provided. For example, they proposed that hypertext systems have two types of indexes: a contents style similar to that found in text books, and a spatial representation similar to the ‘minimap’ idea from Foss’ graphical history lists.

A similar examination of the development of mental models whilst reading hypertext was reported by Simpson and McKnight (1990) who reported a series of studies that attempted to determine what a ‘contents page’ for a hypertext system would look like. Using a card sorting technique comparing subject’s perceptions of textual and graphical representations, they discovered that that the optimal representation was an interactive graphical overview, or map, of the structure of the system. The overview provided a record of the nodes that users had just visited, the nodes that they had already seen and the order in which the nodes had been accessed, similar to Foss’ history lists and trees.

Other research has addressed the design of overview maps for hypertext systems by examining issues such as spatial representation, task specificity and the prior experience of the user. For example, the effectiveness of overview maps as a navigational aid was investigated by Webb and Kramer (1990) in a study which compared the use of spatial maps and analogical interfaces. Spatial maps were defined as node-link representations of the structure of the system whilst analogical interfaces provide information within a familiar metaphor such as a shopping mall or a desktop. The results suggest that analogies can be an effective support tool, particularly for users who are new to the content domain. The advantages of the analogical interface over the spatial map increased as the size of the hypertext system increases.

An additional consideration of the specificity of task was included in a study conducted by Lai and Waugh (1995) on the influence hypertext structure (hierarchical versus network) and menu design (explicit versus embedded) on navigational performance. The study found that the referential links provided by embedded menus support tasks which are vague and not fully known. The influence of task specificity on navigation is addressed further in Chapter 3.

McDonald and Stevenson (1996, 1997, 1998, 1999) report a series of studies that examined the effects of different structures of navigational aids and prior knowledge on navigation and learning in hypertext. The 1996 study confirmed the existence of hypertext disorientation by establishing that users had difficulty in planning and executing direct routes through hypertext to reach desired information. The 1997 and 1998 studies examined the effectiveness of two common hypertext navigational aids, spatial maps and textual contents lists, on the navigational performance of subjects with differing levels of prior context knowledge. The 1997 study found that subjects who used a map depicting the conceptual relationships within the hypertext performed better on tests of long-term learning than participants who used a map representing the structural relationships within the text. The 1998 results suggested that the map condition was superior to the textual contents list, which was superior to no navigational aid. They found that disorientation was a problem for hypertext users, especially those without prior knowledge of the subject domain. Less knowledgeable users tended to rely more heavily on the navigational aids than the knowledgeable users, who were found to use their background knowledge of the subject domain to guide their navigational decisions. An interesting finding was that the map condition eliminated differences between the knowledge groups, allowing those new to the domain to perform as well as content experts. They proposed that the major advantage of map interfaces is that they support navigation by presenting the conceptual structure of the hypertext. The 1999 study focused on the effects on learning when using a hypertext system and found that the map interface and the contents list did not differ in their ability to facilitate learning. An interesting result was that the level of learning for subjects who used no navigation aid was better than that of the spatial map subjects. Hence, although spatial maps can improve navigational decisions for users with low domain knowledge (McDonald and Stevenson, 1998b), the 1999 study suggests that long-term learning of the content is improved when users are forced to navigate through the system without the support of a navigational tool.

The research outlined in this section supports the need for additional navigational assistance in hypertext systems in order to minimise the effects of disorientation and cognitive overhead. A variety of tools and techniques have been investigated and issues relating to the experience of users and the types of tasks that they are performing have also been explored. However, there seems to be a general proposition that an alternative representation of the underlying structure of a hypertext system will alleviate navigational problems with particular support for overview diagrams or maps.

2.3.2 The need for an overview

Section 2.2 established that the non-linearity of hypertext is the most direct cause of user disorientation and cognitive overload. The non-linear structure of hypertext and the requirement to view its contents one page at a time reduce the user's ability to maintain context information (Durand and Kahn, 1998; Park and Kim, 2000). Users need cues to (i) identify their current position with respect to the overall structure; (ii) reconstruct the way that led to their current position; and (iii) distinguish among different options for moving on from their current position (Thuring et al., 1995). From this, Thuring et al. (1995) proposed a theory of coherence where users need both local coherence which provides an understanding of the small scale connections between nodes, as well as global coherence which supports an understanding of the large-scale connections. The non-linear structure of hypertext can result in a perception of fragmentation where the system is seen as an aggregation of pieces rather than a coherent whole.

> *"Providing a means for structuring, overview, and reduction of fragmentation will significantly increase the coherence of a hyperdocument. This will facilitate the construction of a mental model in the course of reading and thus lead to better understanding."* (Thuring et al., 1995)

Another theoretical concept relating to overview is that of visual momentum which is the cognitive aspect of maintaining connections between nodes as one moves through a system (Woods, 1984). Visual momentum can be supported by showing detailed views after showing a general view (Hochberg and Brooks, 1978). Woods (1984) proposed that visual momentum in a display system can be established by building an analogical representation or map of the underlying system which can: (i) support the ability to generate specific routes as required by the task; (ii) support the ability to traverse or generate new routes as skilfully as familiar ones; and (iii) provide orientation.

2.3.3 Hypertext overview tools

The concept of overview tools for hypertext was proposed early in the history of hypertext with Nelson (1965) suggesting that hypertext should contain summaries or maps of the contents of hypertext systems and their interrelations. These types of tools provide a representation of the structure of a system which assists users in orienting themselves within the global information space, as well as providing a detailed sense of location within the neighbourhood of the current node (Nielsen, 1990). Overview tools act as an index to an information system by presenting related ideas and topics as nodes in a network, and identify relationships between them (Duncan and McAleese, 1987). An overview representation might support either a temporal or a structural context (Utting and Yankelovich, 1989; Park and Kim, 2000). A temporal display would provide a view of all of the locations that the user has previously visited to reach the current node thus supporting backward navigation. A structural view provides an overview of the entire system, including the user's current location, which would support forward navigation.

The literature contains a substantial support for the use of overview tools to provide navigation and orientation in hypertext systems (Utting and Yankelovich, 1989; Nielsen, 1990; Mukherjea et al., 1994; Stanney and Salvendy, 1995;

McDonald and Stevenson, 1998b; Brunk and Marchionini, 2000; Ahuja and Webster, 2001). Conklin (1987) claimed that overviews can provide “important measures of contextual and spatial cues to supplement the user’s model of which nodes he is viewing, and how they are related to each other and their neighbours in the graph”. Cockburn and Jones (1997) suggest that disorientation is alleviated through the provision of graphical overviews as they not only help users maintain a sense of context within an information space, but also reduce cognitive overhead by providing an external representation of the user’s memory of their navigation session. Brunk and Marchionini (2000) claim that overviews help users find the boundaries of an information space so that they can learn what is available, how the various information in the system relates to one another, and what level of granularity exists in these relationships. Such views allow users to become more comfortable with the information rather than overwhelmed by it. In addition to showing the users the structure of the information system, overview diagrams can also help users establish their location in the system and manage their movement through the system (Nielson, 1989; Mukherjea et al., 1994).

2.3.4 Applying hypertext research to the Web

An instinctive response to the disorientation and cognitive overhead problems relating to Web navigation might be to simply apply the findings of previous hypertext research to this new domain. To some extent, the influence of previous hypertext research can be seen in some of the features of Web browser that support navigation, for instance, support for backtracking, maintenance of bookmarks and various visual hints (Hill, 1996). The application of research outcomes for hypertext systems to the Web needs to be carefully considered.

Since the Web is predominately a hypertext system, it is sensible to examine existing research and determine the degree to which it can be applied to the Web (Smith, 1996). However, this application might not be appropriate if there are important differences between the Web and those hypertext systems that the previous research was based on. Dieberger (1996) suggests that the key difference is due to the relative size of the systems; traditional hypertext systems were relatively small with only up to a few thousand nodes, whilst the Web makes these appear like “tiny toy systems”. He claims that “no other system has the size and navigational problems of the WWW”. A further difference relates to the distributed nature of the Web that allows authors to develop sites and pages with little adherence to standards and with variable quality and inconsistent interfaces. Modern web site development has very few checks and balances and a multitude of practices and approaches. This resulted in Smith et al. (1997) claiming traditional usability theory and practices may not apply because the Web is not a single hypermedia system.

Previous hypertext research into navigation and usability problems might provide a relevant foundation for the development of navigation solutions for the Web. However, due to significant differences in structure and size, and the changes in user knowledge and expectations that have occurred over time, there is a need to revisit usability issues in the context of the Web (Sears, 2000).

2.3.5 Web navigation research

Over the past decade there has been a range of research efforts examining Web navigation issues. One of the earliest focused studies (Cockburn and Jones, 1996) reviewed the usability problems relating to the navigation facilities provided by Web browsers. Through the development of a notation to precisely describe users' navigational behaviour and a heuristic usability analysis of the support for navigation that Web browsers provide, the study identified three major problems: (i) a mismatch between the user and system models of navigational support; (ii) lack of context information for the user; and (iii) memory overload problems. The implications from the study included a suggestion that navigation problems can be ameliorated through user-centred aids for browsing.

One of the most researched issues is how users revisit web pages and the use of the 'Back' button on Web browsers (Catledge and Pitkow, 1995; Tauscher and Greenberg, 1996, 1997; Cockburn et al., 2002; Cockburn et al., 2003; Herder, 2003b). Related to this is research which examined the use of aids to support history lists (Ayers and Stasko,1995; Jones et al., 2001) and the use of bookmarks indicating nodes or pages of interest (Abrams et al., 1998; Kaasten and Greenberg, 2001). This research has continued relevance with Wen (2003) claiming that disorientation on the Web is more frequently caused by users who have difficulty in retrieving pages that they had previously encountered but the location for which they had not previously saved. These issues are similar to those raised by Foss in her 1989 review of hypertext navigation problems and tools to support the management of browsing history.

Other usability research has investigated analyses of logs of user actions whilst undertaking information retrieval tasks (Catledge and Pitkow, 1995; Tauscher and Greenberg, 1997; Cockburn et al., 2003). Log files on web servers record details of requests for pages that allow an analysis of the actual frequency of use of pages on a particular site. More detailed information about how individual users access the web can be obtained using client-side logs, however these are limited to smaller scale controlled experiments.

Some researchers have suggested that navigational support should be personalised depending on the user's goals, preferences, experience and knowledge (Eklund and Zeiliger, 1996; Li et al., 2001; Herder, 2003a). Juvina and van Oostendorp (2004) in an empirical study found that the preferences of users can be estimated from their navigation behaviour. Adaptive navigation systems such as that proposed by Zhu et al. (2004) use a variety of clustering, sorting, hiding and annotation techniques to change the content or appearance of a tool based on these user preferences.

Some of the most recent research has addressed the issue of navigational residue through the development of a theory of 'information scent' (Pirolli and Card, 1995; Larson and Czerwinski, 1998; Pirolli et al., 2001; Chi et al., 2001; Pirolli et al., 2003). Information scent relates to the cues on a web page, such as link names, on which users base their navigational decisions. The theory has implications for the quality of the link names provided on a web page by suggesting that a strong scent provides greater predictability thereby reducing disorientation and cognitive overload.

2.3.6 Web navigation tools

Web navigation tools may be divided into two categories: those provided as functions within the browser software, and those that are incorporated into the web site or webpage by the developer.

Web browsers generally include the following navigation support features: back and forward buttons, history lists allowing access to a list of recently visited pages, a list of bookmarked or favourite web pages, colour coding indicating visited/unvisited links, the home button and the URL field.

Web site navigation tools are features included in web sites by the site developers to assist users in achieving orientation and moving in a web site towards a desired target. The three most common web site navigation tools are search tools, sitemaps and indexes.

Web site search tools are commonly provided to allow users to search the current site for those pages that contain a particular search string.

Sitemaps are essentially a visual representation of the architecture of a web site providing users with either an overview of the major headings of the site content or alternatively a view of the physical structure of the site. Sitemaps may be considered similar to the table of contents of a book by providing a list of the major categories of information (i.e. chapters) and their subsections.

Indexes have long been regarded as the "state of the art in print navigation" (Rosenfeld and Morville, 1998). They are defined as an "alphabetical list with references usually at the end of a book" (Oxford Dictionary). Whilst sitemaps may be considered similar to a table of contents provided at the front of a book, it is generally accepted that an index of a web site would be presented as an alphabetical list of the contents of the site.

2.3.7 Maps – physical and virtual

> *"A map is a graphic representation of a portion of the earth's surface drawn to scale, as seen from above. It uses colours, symbols, and labels to represent features found on the ground"* (Davidson, 2003).

Maps are regarded as the most basic visual orientation tool (Durand and Kahn, 1998) and have been used for centuries to communicate the relationships between places and objects in the physical world. Cartography is now a science which provides a means by which to represent and communicate information about spaces that are too large and complex to be understood directly (Dodge and Kitchin, 2001). Cyber-cartography (Taylor, 2003) is now an emerging field that extends the use of mapping to provide a spatial representation of information which does not have a natural physical structure. Such spatial representations are map-like and exploit the human mind's ability to more readily see relationships and meaning in complex data. Map making may be thought as a process of creating knowledge as well as displaying data (Dodge and Kitchin, 2001). Thorndyke and Hayes-Roth (1982) propose that the advantage of knowledge acquired from maps is the relative ease with which the global relationships can be perceived and learned, whilst Marshall et al. (1987) suggest that recall is better for information that is presented pictorially.

There has been significant research that has examined how humans benefit from information presented in a spatial format with a focus on the analogy between physical navigation and navigation of information spaces. Information spaces such as the Web cannot be directly observed, and therefore need to be given some physical representation which provide dimensions (usually 2-D) and bounds. A physical representation of a space inevitably leads to the use of concepts such as navigation, talk of movement in a way similar to moving through physical environments, and the use of navigation tools such as maps (Dillon et al., 1993).

An often cited paper by Tolman (1948) postulated the existence of an internalised cognitive map which is an analogue of the physical world. This cognitive map is developed through interaction with the environment and indicates routes, paths and relationships. Dillon et al. (1993) proposed the use of schemata as an explanatory theory of the type of knowledge of the environment that aids human in navigation. Schemata are an internalised understanding of the world that provides a basic orienting frame of reference and is acquired through experience and interactions with a physical space. Norman (1988) referred to this internalised understanding as a mental model, and described it as a cognitive mechanism that is dynamically created through experience as people interact with others and their environment, allowing predictions to be made about events before carrying out actions.

Cognitive psychologists Siegel and White (1975) proposed a development sequence of internal representations that, as humans become increasingly familiar with a geographical environment, the nature of their knowledge progresses through three levels of maturity:

(a) The first stage is 'landmark knowledge' where travellers orient themselves exclusively by highly visual landmarks. This knowledge is characterised in terms of actual visual images of landmarks allowing them to be used as “course-maintaining aids” (Cohen & Schuepfer, 1980). Hence, the common practise of placing highly salient landmarks at intermittent locations in the design of cities. This could be extended to include landmarks at regular intervals in a virtual information space such as hypertext or the Web. Landmarks provide the skeletal frame of reference from which the two subsequent phases of learning may be achieved (Anderson, 1980; Dillon et al., 1993).

(b) The second stage is ‘route knowledge’ which is a level of understanding characterised by the ability to navigate from one spot to another, utilising landmarks or other visual features to trigger the decisions to turn left, turn right or go straight at intersections (Wickens, 1992). Route knowledge is essentially sequence knowledge (Siegel & White, 1975) based on the self as the frame of reference. It possesses a degree of spatial awareness but is essentially visual, requiring users to make navigational decisions based upon what they can see from their current position.

(c) The highest level is ‘survey knowledge’ which is characterised as an internalised cognitive map of the structure of the environment. This knowledge provides the user with the ability to describe the relative locations of two landmarks in a city even though they may never have travelled a route connecting them. It is based on a world frame-of-reference independent of current location and view (Wickens, 1992).

Edwards & Hardman (1989) also suggested that whilst navigating, users build cognitive representations of the environment in four stages: landmarks, route maps, mini-maps and survey maps. The higher levels of provide users with the ability to work out shortcuts and recover from navigation errors.

This understanding of the cognitive aspects of how humans interact with maps of physical spaces provides some guidance for information spaces such as hypertext or the Web. The hypertext literature suggests that users build a spatial cognitive representation of the structure of hypertext systems whilst navigating (Canter et al., 1985; Edwards & Hardman, 1989; Kim & Hirtle, 1995), and hence the provision of an overview diagram or map can assist the user in the task of navigating by facilitating the construction of an appropriate mental model or schemata (Simpson, 1990). Marshall et al. (1994) claims that a visual/spatial metaphor for hypertext takes advantage of the ability of humans to navigate in physical space, whilst Dillon el al (1993) proposes that like a map of a physical environment, an overview map shows the user what the overall information space is like, how it is linked together and consequently offers a means of moving from one information node to another.

Given the parallels between physical navigation and navigation of information spaces, it is proposed that sitemaps that provide a representation of the structure or content of a web site would assist the user in gaining high-level survey knowledge and in general navigational tasks.

2.3.8 Web sitemaps

A sitemap is essentially a map, diagram or textual description of the structure or content of a web site that is provided by the web site developer as a supplemental navigational tool. Most sitemaps are usually accessible via a link entitled 'Sitemap', which is commonly located proximate on a Web page to links to other site navigation tools such as 'Search' or 'Index'.

The use of a visual overview as a supplemental navigation tool for a web site is not innovative or experimental, but rather a natural extension of the maps humans have used to navigate across oceans, through cities and even around shopping malls for millennia (Morville, 1996). Even the inventor of the WWW, Tim Bernes-Lee highlighted in an early design document (Berners-Lee, 1989) the need for a graphic overview with "less granularity" than the basic Web to enhance navigation.

There is a variety of claims in the literature regarding the advantages of incorporating a sitemap into a web site. The use of sitemaps has been suggested by many researchers as a technique of alleviating disorientation by providing users with a visual overview (Bieber et al., 1997; Cockburn and Jones, 1996; Mukherjea and Foley, 1995; Shneiderman, 1997; Tauscher & Greenberg, 1996; Diebold and Kaufmann, 2001; Li et al., 2001). Shneiderman suggested that sitemaps improve spatial context, reduce disorientation (Shneiderman, 1997), support users when they are attempting to initially orient themselves in a web site and assist in establishing users' information needs (Shneiderman, 1998). Tauscher & Greenberg (1996) claim that sitemaps provide a sense of the extent of a particular web site, whilst Diebold and Kaufmann (2001) stated that sitemaps provide an alternative view of the locality and allow the user to employ a larger set of navigational strategies. The contextual cues in sitemaps help users understand where they are, where they have been and where they can go (Sears, 2000), and can guide users to the desired page (Sifer and Liechti, 1999).

Despite these claims, there are a number of reported problems associated with sitemaps, especially when applied to large web sites, web sites that frequently change, and when used by non-visually oriented users (Conklin, 1987). Kerr (1990) suggested that few users actually use hypertext navigational aids, preferring instead to construct a personal mental model through browsing. Stanton and Baber (1994) believe that the adoption of a spatial metaphor for hypertext is inappropriate and claim that there is little or no proof to support the notion that users conceive of hypertext spatially. Sullivan (1996) claims that many sitemaps provide no inherent clues to their navigational nature and that they cannot substitute for text-based navigation methods. Similarly, Hornbæk and Frøkjær (1999), in an empirical investigation into the use of thematic maps to support navigation, found that subjects occasionally misinterpreted the structure and content of the map. Hoffman (1996) has identified a number of limitations of the use of sitemaps for navigation, including speed, complexity and maintenance. Bieber et al., (1997) describe the problems of navigating sitemaps themselves, especially when they are large or complex. Finally, Farris et al. (2002) suggest that sitemaps may not be effective if they do not reflect either the user's mental model or the domains conceptual structure.

The optimal design of sitemaps is also a topic that has been reported in the literature. Sitemaps are commonly implemented as a visual representation of either the logical structure or semantic content of the web site. There is a large variation in current sitemap designs and functionality, with sitemaps appearing as graphical maps, hierarchical structures or textual lists of contents (further investigations into sitemap designs is reported in Section 2.4). Rosenfeld and Moville (1998) defined sitemaps as a graphical representation of the architecture of a web site which excludes table-of-contents styled presentations and other formats such as indexes, even if they used graphical elements. They maintained that a real sitemap provides a view of the web site in a way that goes beyond textual representation. On the other hand, Morville (1996) advised designers to consider table-of-contents structures for sitemaps, a design that has now become the most prevalent (Russell, 2002).

The conflicting claims regarding the benefits of sitemaps and the complete lack of standards for the design of sitemaps (Bruck, 1999) have provided the motivation for research into sitemaps, particularly their purpose and design.

2.3.9 Research into Web sitemaps

The literature provides only limited examples of research specifically addressing issues relating to Web sitemaps. A number of empirical studies address some fundamental theoretical questions about the design and use of sitemaps, however the majority of the reported research focuses on new sitemap designs and functionality from a technological innovation perspective. The following sections present some major themes in research into sitemaps:

Technologically inspired research

Examples of technologically inspired research into sitemaps are prevalent in the literature, including the development of systems that generate a graphical history map during a Web browsing session providing a temporal view of the path taken, for example, WebMap (Domel, 1994) and MosaicG (Ayers & Stasko, 1995). Visualisation research has been applied to sitemaps, including the Hyperbolic browser (Lamping et al., 1995) that provided a focus + context view, Fishnet (Baudisch et al., 2004) a fisheye web browser, Pad++ (Bederson and Hollan, 1994) a zooming graphical view of a web site, and Java-based visualisations of web sites such as WebCutter (Maarek and Shaul, 1997), MAPA (Durand and Kahn, 1998) and the bi-focal sitemap by Pilgrim and Leung (1996). Some research has developed software to dynamically map the structure of a web site in order to produce graphical node-link diagrams, for example, Navigational View Builder (Mukherjea and Foley, 1995) and Webstalker (Harwood and Metcalf, 1998). A number of commercial web site mapping tools have been developed and marketed such as ClearWeb, Microsoft WebMapper, and

Apple's HotSauce. Finally, some research has developed automated systems to produce topic-focused sitemaps with hierarchical expand-contract controls to allow users to explore sections of the web site in depth, for example, WebTOC (Nation et al., 1997), SiteTree (Pilgrim and Leung, 1999b) and Multi-Granular Sitemaps (Li et al., 2001). A comprehensive review of sitemap techniques and products may be found in Brunk (1999). This majority of this type of research has been motivated by technological opportunities and generally has not involved empirical testing of hypotheses or the development of underlying principles or theories.

Surveys of sitemap implementations

Russell (2002) carried out a survey of the web sites in 1999 and repeating this in 2002. These surveys established the prevalence of sitemaps and whether sitemap were structured as categorical, hierarchical, graphical or alphabetical. The 1999 survey found that 46% of sites did not have a sitemap of any kind, 86% used a hierarchical textual representation and 11% displayed a graphical depiction of the site. The 2002 survey refined the definitions of structure to include locations of the sitemap link and the presence of search engines. In this second survey it was found that 59% of sites had a sitemap, with a 2 or 3 level categorical view being the most common. Most sitemaps were referenced by a term 'sitemap' however site index, index, site guide and site directory were also used. The survey confirmed a lack of consistency in design and implementation and concluded that further research needs to be undertaken in order to demonstrate the benefits of sitemaps.

Design of sitemaps

One of the earliest focused research projects into design issues for web navigation tools was by Cockburn and Jones (1996, 1997). In the 1996 paper they reported a structured usability investigation into the navigation facilities provided by web browsers and identified a number of usability problems, including incorrect mental models of browsers' behaviour, lack of overall context when browsing, and memory overload for users. The 1997 paper extended the work to consider the design issues in visualisation tools to support navigation on the Web. The research reinforced the value of overview diagrams as a tool that can help overcome the navigational difficulties caused by disorientation and cognitive overload, and then critically reviewed a range of web visualisation tools across three key design issues: the characteristics of the visualisation; the functionality attached to the visualisations; and browser independence. Whilst no fundamental theories or principles of design were generated from this research, it provided a turning point in web navigation research by focusing on the problems encountered by users.

Other research examined issues regarding the optimal design of sitemaps. For example, Bernard (1999) reported a small study that compared the number of pages visited when locating specific information in a web site with and without a sitemap. The study found that sitemaps allow sites to be traversed more quickly, and that subjects favoured the use of sitemaps. In a follow-up study, Bernard and Chaparro (2000) compared the search performance and satisfaction with three different types of sitemap menu structures, including a design that provided an alphabetical index, another design that provided a complete list of contents by categories, and a restricted list of contents by categories. The results showed that performance as measured by task success was the same for all designs, however satisfaction was the highest for the full categorical sitemap.

Danielson (2002) investigated the effects on user behavior of having a constantly visible sitemap implemented as a text-based contents list in a separate frame in the window. The study involved 26 subjects performing fact-finding tasks on five sites under two conditions (constantly visible and standard sitemap link). An analysis of click-stream behaviour, including number of pages visited, revisits, back actions and distal jumps, found that the availability of a constantly visible sitemap resulted in users abandoning fewer information seeking tasks, less use of the browser's Back button, and frequent navigational movements across the site hierarchy. Whilst the study was limited to the use of fact-finding tasks, the conclusion indicated that the methodology could be applied to other types of tasks such as exploratory search and general site understanding tasks. In a subsequent paper, Danielson (2003) again used fact-finding tasks in a study that investigated the nature of disorientation of users as navigational options change as they move through a site (transitional volatility). Three types of sitemap designs were used: full overview, partial overview and local context. The results established a link between the type of sitemap support and the perceived level of disorientation and coherence, providing an understanding of how transitional volatility contributes to disorientation.

Another study that used fact-finding tasks was reported by Padovani and Lansdale (2003), who investigated user performance as measured by search times when using two different types of sitemap designs, spatial and non-spatial. Similar to Danielson's (2002) results, this study found that users perform search tasks quicker when using sitemaps, report less disorientation and that the spatial metaphor resulted in superior performance.

Finally Yip (2004), examined the effects of different types of sitemaps on user's performance in fact-finding tasks. The study involved 42 subjects using five different sitemap conditions which varied on constancy of visibility, incorporation of hyperlinks and a no-sitemap condition. Measures of task success, completion times and numbers of nodes visited provided results that suggested that constantly visible sitemaps increased performance especially for large web sites.

A common feature of the studies by Bernard (1999), Bernard and Chaparro (2000), Danielson (2002, 2003), Padovani and Lansdale (2003) and Yip (2004) was the use of fact-finding tasks in the experimental design, with only Danielson (2002) mentioning the limitation of not including other task types such as exploratory search tasks or general informational tasks.

Research that considers task type as a factor

The literature contains limited examples of hypothesis-driven, empirical studies into the design and use of sitemaps where there is a consideration of task type as a factor. In a study that investigated contextual navigation aids for web sites, Park and Kim (2000) compared the benefits of providing a structural context aid with a temporal context aid. The structural aid was similar to a sitemap, as it provided a view of the site structure that would facilitate forward navigation and allow the user to identify the location of the target item. The temporal aid was a history tool that facilitated backward navigation by providing a view of all locations that the user had visited until the current time. An important feature of the study was that participants were asked to complete two task types: browsing and searching. The search tasks involved the participant completing a defined activity with a known outcome, whilst the browsing task was an activity with an open-ended outcome. The results suggested that regardless of the task, both types of context navigation aids improved performance in terms of reducing the number of pages visited as well as improving participants' subjective evaluation of the navigation process. A finding that is significant for this present study is that the results suggested some differences in navigation behaviour and navigation tool use, for instance, structural navigational aids were more effective for searching tasks. The study noted that other tasks, such as informational or navigational tasks, were not addressed and future studies should be extended to include these.

A study by Hochheiser and Shneiderman (2000) evaluated the benefits of two alternative menu structures in the context of the Web. Whilst not directly related to sitemap tools, the study suggested that when tasks are sufficiently complex then additional navigational support is beneficial. However, they found that for simple tasks the additional navigation aids can actually have a detrimental effect on performance.

Whilst there are other studies that include task type as a factor in studies into menu design and general web navigation, there is a lack of empirical research into the effects of task type on the design of sitemap tools. Park and Kim (2000) found that there were differences in navigational behaviour and tool use for different task types. Given the results of Hochheiser and Shneiderman (2000), research needs to address the design of sitemaps but with due consideration to the amount of support that users really need for the type of task that they are performing. (Chapter 3 of this thesis discusses the issue of task type and complexity in detail.)

2.4 Categorising Sitemap Designs

The Web contains countless types and styles of sitemaps, each utilising particular interface techniques, providing a range of functionality and opportunities for users. There are no commonly agreed standards at all for creating sitemaps (Brunk, 1999) which is a reflection of the open and distributed ownership of the Web. Organisations have different goals, activities and beliefs, hence it is to be expected that no single sitemap design would meet common needs. This section of the study reviews current sitemap designs and proposes a classification scheme that provides the basis for empirical investigations.

The literature contains several classification schemes for sitemaps. Durand and Kahn (1998) recognise that there are a number of visual structures that can be used to create maps of web sites. Their proposed taxonomy had three common forms: graph-based structures, hierarchical structures and spatial structures. Graph-based structures are described as 'raw' hypertext and are usually implemented as a node-link diagram. Hierarchical structures restrict the underlying graph, showing clear superior/inferior relationships. Spatial structures use an explicit coordinate system where navigation points are positioned on some axes according to the relative value of some quantifiable attribute or feature.

Figure 2.2 presents a classification based on the extent of connectivity represented in the sitemaps (Pilgrim and Leung, 1999a). The classification scheme has three levels of connectivity, with 'complete-maps' portraying every node (web page) and every link possible between those nodes, 'partial-maps' which displayed every node but only limited links, and 'overview-maps' which displayed only key nodes and particular links.

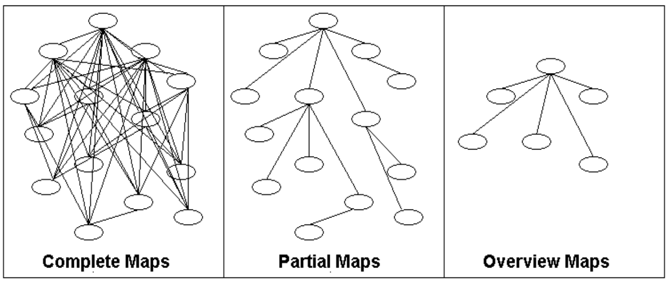


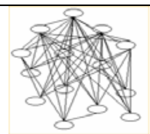
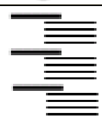
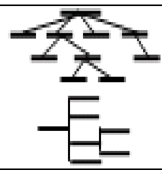
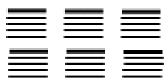
Figure 2.2: Sitemap classification based on connectivity (Pilgrim and Leung, 1999a)

Diebold and Kaufmann (2001) also included the sitemap structure in their classification scheme, however also included factors such as purpose, audience, and preparation method.

Factors that may be considered in any classification scheme include structure, i.e., whether it is based on a hierarchical, categorical or network structure; the level of interactivity, particularly the ability to select and view particular pages; and any visualisation controls that might be available to control the current view. The method of preparation or generation may include manually developed maps, which at the extreme might include hand drawn maps of sites, and automatically generated sitemaps that employ algorithms that scan a site into a database which may then be displayed in a visual format.

Table 2.1 presents a classification scheme based on overall structure, level of connectivity, method of generation, interactivity and visualisation controls. The example designs provide one instance of each classification variant.

Table 2.1: Sitemap Classification Scheme

Structure (2.4.1)	**Connectivity** (2.4.2)	**Generation** (2.4.3)	**Interactivity/ Visualisation** (2.4.4)	**Example Designs**
Network	All Nodes All Links	Manual Automatic	Select Scroll Expand/contract Filter Zoom	
Hierarchical	All Nodes Partial Links	Manual Automatic	Select Scroll Expand/contract Filter Zoom	
	Partial Nodes Partial Links	Manual Automatic	Select Scroll Expand/contract Filter Zoom	
Categorical	All Nodes Partial Links	Manual Automatic	Select Scroll Expand/contract Filter Zoom	
	Partial Nodes Partial Links	Manual Automatic	Select Scroll	

The following sections describe each of the factors used in the classification scheme:

2.4.1 Structure

There are three basic structures employed in sitemaps: network, hierarchical or categorical.

The fundamental approach to the design of sitemaps is to capture the entire site structure, including every page and link, into a single map. For large sites this is usually accomplished through the use of computational techniques that scan the entire site recording all nodes and links in a database that is subsequently used to develop a visual presentation. These approaches result in network representations which produce highly complex structures that are of questionable usability (Bernstein et al., 1991). Durand and Kahn (1998) also claim that these 'raw' networks show too much information for a reader to easily assimilate, lack a meaningful topology, and that the relative position of nodes in the map are too arbitrary.

Hierarchical representations restrict the form of the underlying network structure by removing any links across semantic or structural categories. Navigation is facilitated by imposing a simpler topology onto a complex structure (Parunak, 1989) through a process of link filtering. The advantage of hierarchies is that they support decision making in navigation by reducing the number of alternatives that must be considered at any one time (Norman K., 1991) and are well know from their application in many domains (Durand and Kahn, 1998). Even in the most random topology, users will tend to impose a hierarchical structure to try to make sense of structures (McNamara et al., 1989), suggesting that users are best supported by providing a hierarchical abstraction of either the structure of the site or the major categories of information. Whilst hierarchies aid comprehension, they can limit flexibility (Durand and Kahn, 1998) and might miss representing important relationships between sections of the network.

Categorical sitemaps present a list or group of the major categories of information found in the web site. The categorisation is usually based on semantics rather than any structural factors, hence is similar to information sorting techniques used in concept mapping (Gaines & Shaw, 1995; Ekland & Zeiliger, 1996).

A related consideration in the basic design of the sitemap is whether it is presented as a graphical node/link diagram or a textual list of pages. Research on the issue of superiority of graphical to textual representations of the structure of hypertext-based systems is contentious. Some experimental research asserts that graphical representations provide better navigational support because this type of representation more closely matches a user's internal model of the system (Simpson, 1990). However, other research suggests that hierarchically structured outlines, such as a 'Table of Contents' format, are well-established devices providing a familiar order and functionality (Hoffman, 1996).

2.4.2 Connectivity

One method of classifying sitemaps is to examine the representation of links and nodes and base the classification on the extent of connectivity represented (Pilgrim et al., 1999a). This method of classifying sitemaps yields three main categories as shown in Figure 2.2:

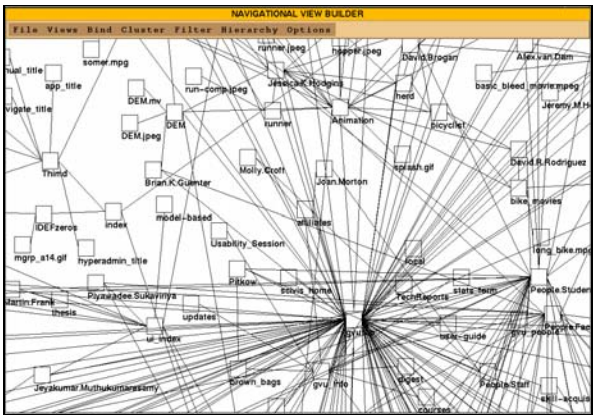


Figure 2.3: Complete sitemap

‘Complete Maps’ (e.g. Figure 2.3) display the complete topology of a web site, usually in a graphical node-link diagram that includes all nodes (web pages) and all links. These maps are usually generated automatically utilising computational techniques that scan sites noting all nodes and links (Mukherjea et al., 1995). Such methods result in network structures of limited usability. For example, large maps require the use of scroll bars to enable the user to change views of the map. Scrolling is an additional activity that may cause the user to perform sub-optimally (Beard and Walker, 1990). These types of sitemaps are also typically too complex for real use (Nielsen, 1990), even with the addition of filtering tools they are difficult for people to gain an appropriate working mental model within short-term memory limitations. Further problems in relation to size, loss of semantic information and manageability have also been identified (Foss, 1989).

'Partial Maps' (e.g. Figure 2.4) present a simplified abstraction of the full detail by removing 'less important' links resulting in a display that includes all nodes but only some links. The mapping tool essentially imposes a simpler topology onto the full map, hence reducing complexity (Parunak, 1989). Applying a hierarchical representation to the network topology of a hypertext system may result in loss of some information. Not all links can be displayed and some semantic connections between sections of the system will be lost.

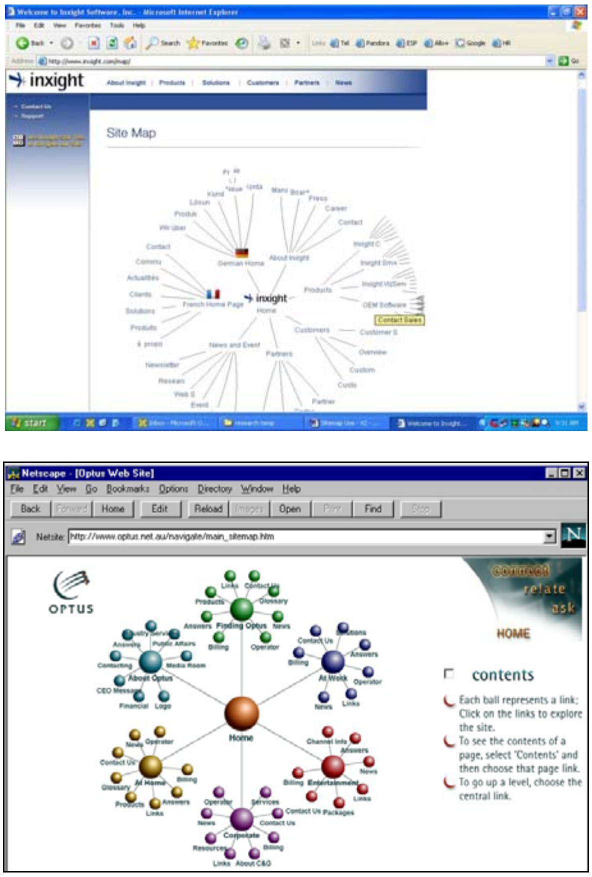


Figure 2.4: Partial sitemaps

'Overview Maps' (e.g. Figure 2.5) display only some nodes and some links. A true 'overview' is presented to the user by removing most of the detail and leaving only a high-level representation of the site structure that allows the user to quickly obtain a sense of the extent and organisation of the hypertext system (McAleese, 1989). This approach is consistent with topographical maps used for physical navigation, which usually show an abstracted version of reality in order to convey the high-level conceptual layout of an area rather than a photo-perfect image of everything.

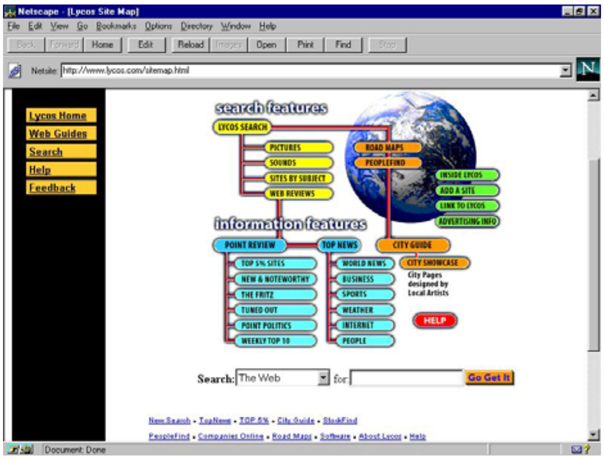


Figure 2.5: Overview sitemap

2.4.3 Generation method

There are two general techniques by which sitemaps may be created: automatic and manual.

Sitemaps may be generated automatically by utilising computational techniques which scan the complete topology of a site, noting all nodes and links (Mukherjea et al., 1994; Diebold and Kaufmann, 2001; Li et al., 2001). This category of overview map tools may present the map to the user either as a static, clickable image map, or as an interactive map with visualisation and manipulation tools. For example, Li et al. (2001) proposed a technique of automatically constructing sitemaps by scanning directory paths, page contents and link structures to produce a representation that prioritises the presentation of page according to an algorithm that calculates level of importance (see Figure 2.6). Other automatically generated sitemap systems include MAPA (Durand and Kahn, 1998), SiteTree (Pilgrim and Leung, 1999b), WebTOC (Nation et al.., 1997), Site Browser (Gibson, 2004) and Mappucino (Maarek and Shaul, 1997).

Manual generation of sitemaps is achieved using text or graphics tools. An example of a manually generated sitemap is shown in Figure 2.7. “Human–constructed maps are considered better than automatically generated maps” (Instone, 1996). Manual methods are very time consuming and do not provide easy method of updating diagrams as systems grow and change.

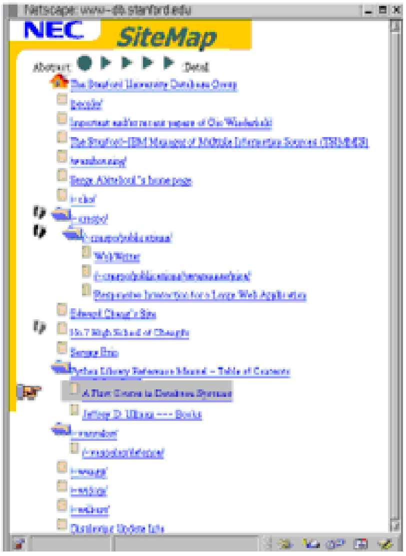


Figure 2.6: Automatically generated sitemap

Figure 2.7: Manually generated sitemap

2.4.4 *Interactivity and visualisations*

There are drawbacks to sitemaps when they are applied to large sites which involve many pages and links. For large sites, it is very difficult to fit the whole information structure onto a single screen (Mukherjea and Foley, 1995). Large sitemaps require the use of scroll bars as the entire map cannot be displayed in its entirety. Researchers (Beard and Walker, 1990) have provided empirical evidence to suggest that users perform sub-optimally with scroll bars in tasks which require navigating a large two-dimensional space. Designers of sitemaps must decide on the level of detail to be provided, with a trade-off between providing a complete view of the entire site contents with the risk that users will get lost in the detail, or providing a narrow view which may limit the opportunity for users to gain detailed information (Danielson, 2002).

Maps of physical space do not attempt to display every feature of the area being mapped true to scale, as this would result in maps that are impossible to read (Davidson, 2003). Hence, mapping is a process of the application of symbols and abstractions in order to control the complexity of the view presented to the user. Mapping virtual spaces such as web sites draws on this experience, and visualisation techniques are commonly applied in order to provide an integrated view of the context and detail in a single view.

Visualisation techniques may be used to control the complexity of the view presented to the user but still allowing exploration of lower levels. There are various techniques that may be applied. Stanton and Baber (1994) proposed that overview diagrams can control the amount of information presented by using either a display providing global and local views, a zoom facility to provide user-controlled levels of overview detail, or a fish-eye view to provide varying levels of detail. Both Spence (1993) and Leung and Apperley (1994) classified the key techniques which can be used to facilitate visualising large information spaces as distortion, encoding and thresholding:

Distortion

> Adequate help must be provided to maintain a user's sense of immediate orientation and to facilitate navigation within the context of the total information space. Hence, there is a need for support for both the local navigation task of moving between pairs of specific nodes as well as the global navigation task which involves movements that span many nodes (Kahn, 1995). Web browsers provide adequate support for navigation at the local level, but lack the contextual overview required for global orientation. Distorted presentations involve a scaling of the data to generate a display consisting of a detail view of a small portion of the data space within a de-magnified global scene. Distortion techniques can provide users with both a local and global view of the information space (Lamping et al., 1995;

Bederson and Hollan, 1994; Pilgrim and Leung, 1996). These techniques may be implemented through the use of zooming, split screens, magnifying glasses, and distortion oriented displays such as fisheye lenses (Furnas, 1986; Sarker and Brown, 1994; Chen and Rada, 1996), continuous zoom (Bartram et al., 1995), hyperbolic browsing (Lamping and Rao, 1996), and bifocal displays (Leung and Apperley, 1994; Pilgrim and Leung, 1996).

The balance between presenting local detail and global structure in maps of information spaces has been a major theme in visualisation research. Hornbæk and Frøkjær (2001), in an experiment comparing three types of interfaces, found that an 'overview+detail' interface supported navigation and helped users to gain an overview of the structure of the document space. Shneiderman (1997) proposed a Visual Information Seeking strategy which involved three steps: overview first, zoom and filter, then details-on-demand. Sifer and Liechti (1999) comment that visualisations of large hierarchies without losing context is a difficult problem and that context can be maintained by providing a distortion or 'focus plus context' view. Pirelli et al. (2003) using an empirical study found that an integrated focus-plus-context view of an information space increased search speeds claiming that the overview provided cues that improved the probability that users would search in the right part of the space.

Encoding

Encoded presentations allow attributes of the data to be displayed in an integrated representation, thus saving valuable screen space. For example, multi-variate visualisation techniques allow users to see and understand basic patterns in data.

The Web may be regarded as a large and complex data set with the basic unit of storage being a page. Each page has a variety of attributes which if summarised into an multi-attribute representation, could provide users with additional insights into the entire site. This information may simply assist the user in the task of browsing by displaying some meta-information associated with the items being browsed (Rada et al., 1993), or by providing the user with higher-level summaries and allowing them to establish relationships between pages.

Researchers have suggested a number of visualisation techniques for the representation of multi-attribute data such as that associated with Web pages. Visualisation techniques, including clustering techniques that organise pages into meaningful groups (Gloor, 1991; Mukherjea and Foley, 1995) and graphical techniques which provide a summary view of multiple attributes such as 'Treemaps' (Johnson and Shneiderman, 1991), 'Cone Trees' (Robertson et al., 1991), 'Perspective Wall' (Mackinlay et al., 1991) and 'Value Bars' (Chimera, 1992). These techniques offer sitemap designers methods for displaying multiple attributes in a single diagram, therefore allowing users to not only locate extreme values and exceptions (Nation et al., 1997), but also allowing them to establish patterns and relationships between groups of nodes.

Thresholding

Thresholding presentations provide a systematic way of suppressing or revealing the information to be presented, reducing screen clutter. Tomek and Maurer (1992) suggest that if the amount of detail on a screen becomes unmanageable, then filtering (eliminating some links not of interest to the user) or ranking (ordering links according to some criteria) may be used to control the complexity. For example, Figure 2.8 shows the 'Sitemapper' system, which includes thresholding functionality to control the number of levels that are visible.

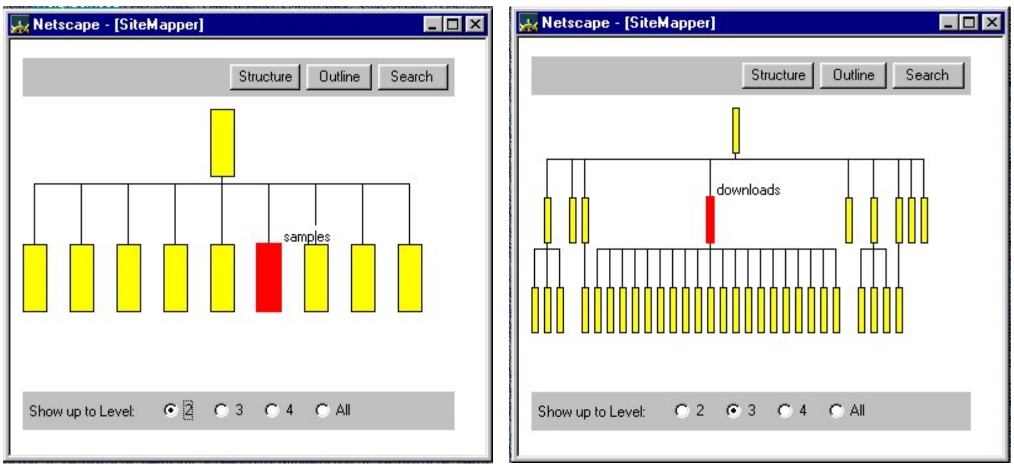


Figure 2.8: Thresholding filtering tools

Other techniques such as hierarchical expand/contract controls can also allow the user to change the level of structure that is displayed, switching between a global overview and a local map. This can improve spatial context and reduce disorientation by allowing the user to obtain a sense of the extent of the hypertext system without detail, or a fine grain picture of a local area.

2.4.5 Examples

The classification scheme presented in Table 2.1 allows most sitemaps to be classified according to the factors of overall structure, level of connectivity, method of generation, and interactivity and visualisation controls. This section provides some examples of actual sitemap systems that implement a range of combinations of the classification factors presented in the previous section.

Structure: hierarchical
Connectivity: partial map
Generation method: automatic
Interactivity: expand/contract tools

Figure 2.9: SiteTree (Pilgrim and Leung, 1999b), a Java applet that displays a hierarchical sitemap generated from a database with filtering tools.

Figure 2.10: WebTOC (Nation et al., 1997) is a hierarchical sitemap of a web site presented in another frame that includes details of media file types and file sizes.

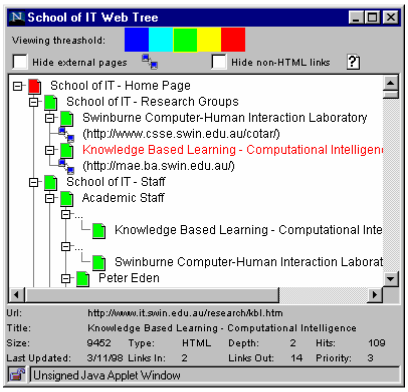


Figure 2.9: SiteTree

Figure 2.10: WebTOC

Structure: hierarchical
Connectivity: overview map
Generation method: automatic
Interactivity: expand/contract tools

Figure 2.11: The SiteMapper applet produces a simple hierarchy that could be filtered according to levels in the site. Initially presents just the first level.

Figure 2.12: The StarTree system (Inxight, 2005) allows users to navigate and explore hierarchical relationships and drill-down to information of interest.

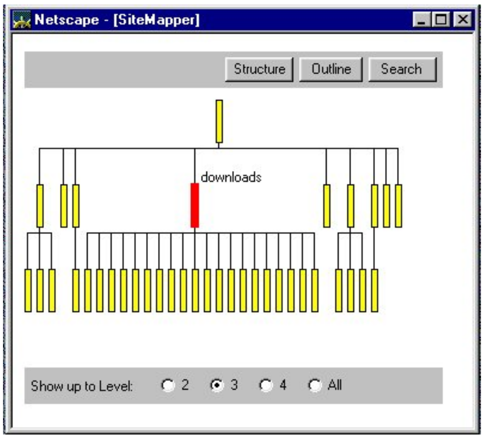


Figure 2.11: SiteMapper

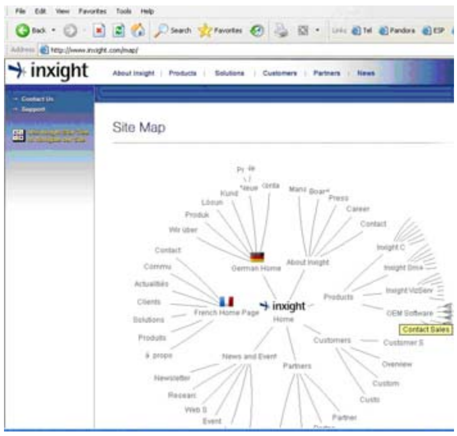


Figure 2.12: StarTree

Structure: hierarchical
Connectivity: overview map
Generation method: manual
Interactivity: zoom, bifocal lens

Figure 2.13: Optus sitemap. A manually developed sitemap that expands lower levels when selected by the user.

Figure 2.14: Bifocal sitemap (Pilgrim and Leung, 1996). A manually developed map that includes a focus+context display. The focused area could be panned around the map whilst retaining contiguous connections over the edge of the focus are.

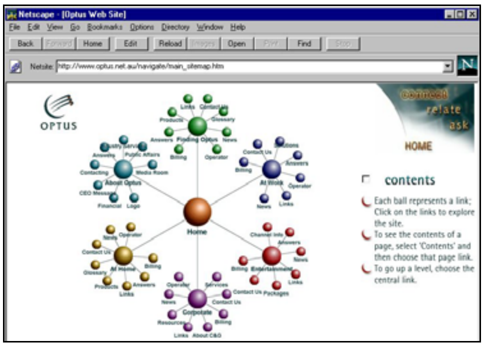


Figure 2.13: Optus sitemap

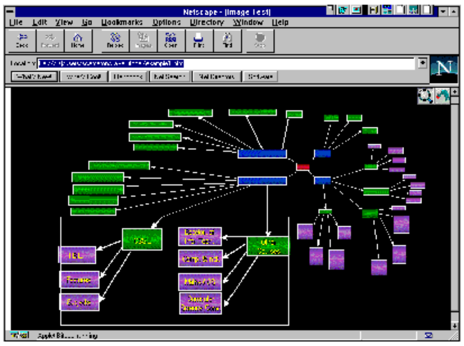


Figure 2.14: Bifocal sitemap

Structure: hierarchical
Connectivity: overview map
Generation method: manual
Interactivity: static

Figure 2.15: Apple sitemap. A manually developed sitemap that provided only a static overview. Users could click sections of the map to open the relevant section.

Figure 2.16: Lycos sitemap. A manually developed sitemap that provided only a static overview. Users could click sections of the map to open the relevant section.

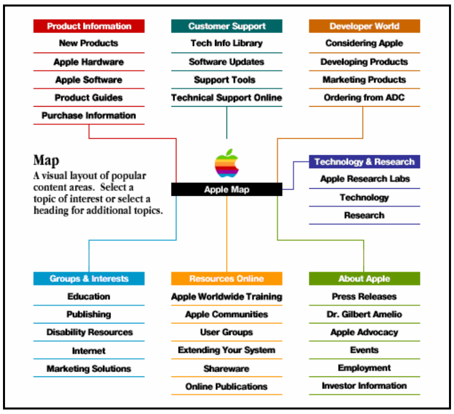


Figure 2.15: Apple sitemap

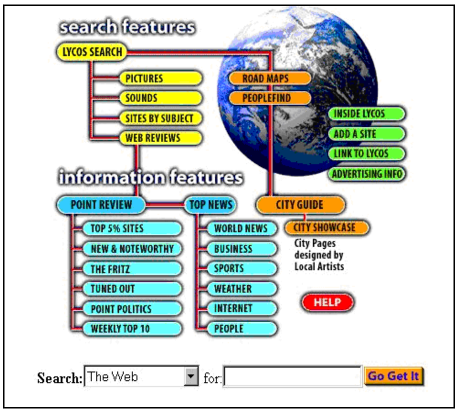


Figure 2.16: Lycos sitemap

Structure: categorical
Connectivity: partial map
Generation method: manual
Interactivity: static

Figure 2.17: Conoco sitemap. A manually developed sitemap presenting 6 categories and 2 levels.

Figure 2.18: Chase sitemap. A manually developed sitemap presenting 4 categories and 2 levels.

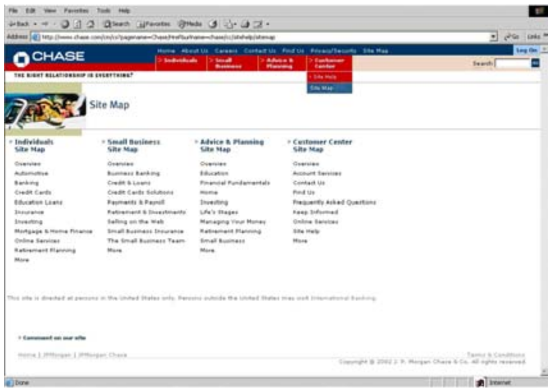


Figure 2.17: Conoco sitemap

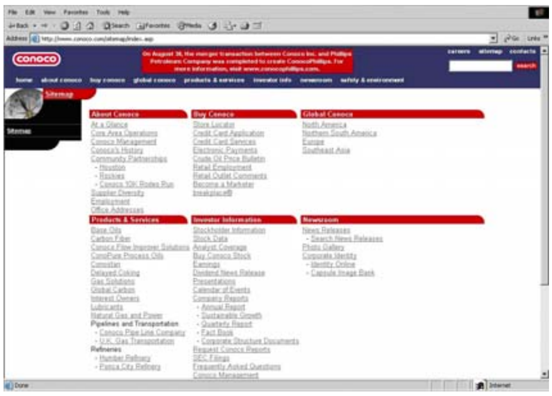


Figure 2.18: Chase sitemap

Structure: network
Connectivity: complete map
Generation method: automatic
Interactivity: scroll and click

Figure 2.19: Navigational View Builder (Mukherjea and Foley, 1995). A complete sitemap of the web site structure which includes all pages and links.

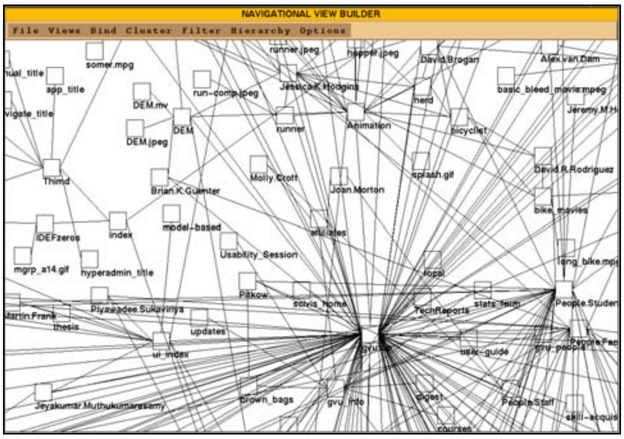


Figure 2.19: Navigational view builder

2.5 Design Guidelines

User interface design practice has been described as more of an art rather than science as it is based more upon individual judgment than systematic application of knowledge (Ramsey and Atwood, 1980). User interface design specialists are experienced in the human engineering of computer systems. Such experts are not always available to guide system development, and hence design guidelines are required to provide expert judgement to designers (Smith and Mosier, 1986).

Design guidelines are principles or rules to assist designers and developers in creating systems that are usable. Design guidelines are an accepted method of systematising knowledge relevant to the design process (Gardiner & Christie, 1987). The IBM Web design guidelines (IBM, 2005) regards guidelines as the "middle level of design guidance in a progression from abstract principles to specific conventions", and defines 'principles' as fundamental ideals and beliefs used to guide decision making and achieve a pervasive or overall result; 'guidelines' as recommended courses of action that are in support of a set of principles and specific to a particular domain such as the Web; and 'conventions' as specific, agreed-to, prescriptive design practices, typically in support of a set of guidelines and principles.

Guidelines provide a framework that guides designers towards making sound decisions (Preece et al., 1994), and hence are useful aids to designers and developers who under the pressure of development budgets and timelines cannot afford to empirically test every design feature of a system. Design guidelines are particularly important in the development of web sites since the nature of the Web means that it can be difficult to access a target user group for usability tests. Further, the absence of any governing rules for designing web sites permits a multitude of design solutions. Hence, the use of guidelines can restrict the scope of the alternatives and inform the designer of the consequences of every design option (Vanderdonckt, 1998).

There are two kinds of guidelines: high-level guiding principles and low-level detailed rules. A common criticism of user interface design guidelines is that the advice that is provided is either too general so that it is difficult to apply to a specific case, or too specific and cannot be widely applied (Beier and Vaughan, 2003). Preece et al. (1994) states that the best user interface guidelines are high-level and widely applicable directing principles which should be interpreted in the context of use. Dillon et al. (1993) also recognise that guidelines are context-sensitive and are usually developed for particular applications, hence can be misused by others who apply them in other contexts. Henninger et al. (1995), classified guidelines into either technology-centric rules about specific interface widgets, or abstract and general purpose principles. They recommended that guidelines be augmented with context-specific examples that highlight the domain of the particular design problem that the guideline addresses. Guidelines may also contain contradictory advice and may have to be traded off against one another when applied in context. The skill in design is selecting the most appropriate design guidelines and applying it appropriately. Poor designs can result when guidelines are not applied appropriately.

Guidelines may be categorised according to their source or basis. Dillon et al. (1993) classified guidelines into three types: common sense guidelines which are usually based on expert opinion; empirically-based guidelines that are derived and proven using experimental methods; and theory-based guidelines that are derived and justified with the help of explanations from psychological theory. Similarly, Preece et al., (1994) suggested that guidelines have two main origins: psychological theory and practical experience. The U.S. National Cancer Institute (NCI, 2005) in their "Research-Based Web Design and Usability Guidelines" rate the sources of the evidence providing three categories of guidelines: Category A:

Experiments (Hypothesis Testing) which consist of published usability-related experiments that allow the strongest inferences to be made; Category B: Studies (Observational Evaluations/Performance-Based Usability Tests) which are usually based on observational studies, including those from performance-based usability tests that occur in usability laboratories and are not generally reported in the open literature; and Category C: Observations (Expert Opinions) which are the opinions of respected authorities based upon their own experiences, or the subjective reports of others, which usually do not have evidence to confirm the recommendations.

Whilst guidelines should be consistent with expert opinion, they should ideally have a firm theoretical foundation and be empirically tested in an appropriate context. There are numerous guidelines for the design of Web pages and sites, but most are based on intuition and common sense with little theoretical or experimental validation (Dalal et al., 2000). Many guidelines for Web development have been derived from hypermedia or database systems development history without any validation when applied in the context of the Web.

2.5.1 Design guidelines for the Web

Design guidelines written to support the design and development of web sites take a number of forms. Some take a broad view by examining the overall structure of a site and how the user navigates through it as the central design element, whilst others focus on the process of creating a usable interface design (Quesenbery, 2001).

For example, the "Web Style Guide" (Lynch and Horton, 2002), originally published on the Web as the "Yale WWW Style Manual", is commonly regarded as the benchmark in the provision of best-practice for the process of design, and detailed advice about site and page design problems. The guide provides interface design hints and also addresses the development process, typography, editorial style, and the use of graphics and multimedia. Similarly, the IBM Web Design Guidelines (IBM, 2005) also focuses on guiding the complete development process, including planning, design, production and maintenance. The IBM guidelines were developed from experience, user studies and published research.

A similar set of guidelines that also address the development process are provided by UsabilityNet (UsabilityNet, 2005), a project funded by the European Union to provide resources for usability practitioners. These Web design guidelines commence with the defining of business objectives, the intended context of use and key scenarios of use. They also address site structure and content, navigation, page design and evaluation methods. The Yale, IBM and UsabilityNet guidelines provide 'best-practice' style advice for Web designers and developers addressing general design issues, but also the design and development process. These guidelines may be regarded as high-level principles that need to be applied in context and with discretion.

There are several examples of design guidelines specific to the development of usable interfaces such as those found in Spool (1997), which provides design tips for web sites based on 50 usability tests on nine different web sites, and Nielsen (2000a) which provides opinion-based guidelines on page design, content design and the design of the overall site architecture. Nielsen also provides further specific web design hints in his on-line Alertbox newsletter (1995 – 2005). Such guidelines tend to be more low-level design hints for common design problems.

A significant set of guidelines are the "Research-Based Web Design and Usability Guidelines" from the U.S. National Cancer Institute (NCI, 2005). Each of the 50 guidelines from N.C.I. have a common structure, including a brief statement of the overarching principle that is the foundation of the guideline, the source of the research and supporting information for the guideline, some examples of the guideline in practice, and a score indicating the "Strength of the Evidence" that supports the guideline. The "Strength of the Evidence" scale is based on the category of the source (Hypothesis Testing, Observational Evaluations or Expert Opinions) providing designers and developers with an indication of how significantly they should consider each guideline. It is noted that the majority of these, and the other guidelines, are largely based on observational evaluations or expert opinion. There is a distinct lack of hypothesis driven, usability-related investigations that inform the development of guidelines for the design and development of web pages and sites.

2.5.2 Design guidelines for sitemaps

Since the inception of the Web there has evolved a large variety of sitemap designs, including textual and graphical representations utilising two or three-dimensions with a variety of visual properties and functional abilities. The initial designs of sitemaps were strongly influenced by the historical use of overview maps in pre-Web hypertext systems, however there is little empirical support for the direct application of theoretical principles for designing hypermedia systems to that of a Web context (Dalal et al., 2000).

The task of designing a sitemap is essentially unbounded. Some sitemaps simply provide a textual list of links to content whilst others are based on a metaphorical representation, including the use of floor plans, maps, shopping centres and book shops (Gershon, 1995). There is no natural topology for information spaces except perhaps that the higher order concepts go on the top or the left (Conklin, 1987), hence the variety of representations is not unexpected.

Consistent with Bruck's (1999) claim that "there are no standards for creating sitemaps" and Xu's et al. (2001) suggestion that "although there are many visualisation and web navigation tools, design guidelines for such navigation visualisation systems are rarely reported", current web design guidelines only provide limited high-level advice regarding the design of sitemaps.

For example, the "Web Style Guide" (Lynch and Horton, 2002), distinguish between table-of-contents pages and sitemaps tools. The guide claims that sitemaps provide the reader with an overview of the site contents and come in two varieties: graphic diagrams that literally use the 'map' metaphor, and structured lists of links to major pages within the site. The guide does not contain any specific design hints or principles, but rather some general comments such as: "Unless your web site deals with information that is inherently spatial, text-based tables-of-contents or indexes will always be more efficient and informative", and "Sitemaps based on carefully organized text links of major menus and submenu pages and major page titles are much more informative than graphic maps and can easily be updated as your site matures."

The IBM Web Design Guidelines (IBM, 2005) does not mention sitemaps at all, whilst the sitemap specific advice from the UsabilityNet (UsabilityNet, 2005) guidelines is limited to the following: “Provide a sitemap or overview - this helps users understand the scope of the site.”

The “Research-Based Web Design and Usability Guidelines” (NCI, 2005) do not have any specific guidelines for sitemaps, however their ‘Usability Glossary’ provides the following definition of a sitemap: “a representation of the organization of a web site, usually including links to all the pages on the web site. Used to help users find and get to pages on the site and help them build a conceptual understanding of the site structure.”

The Australian Government Information Management Office (AGIMO, 2005) provides a range of “Better Practice Checklists” to inform Web design practice for Australian Government web sites. The checklist for Web Site Navigation includes the following advice regarding provision of options for finding information:

> *“Because users approach information on a web site differently, agencies should provide users with a variety of ways to get to information. Examples include: embedded links, a sitemap giving an overall view of the site, A-Z indexes and a search facility.”* (AGIMO, 2005)

The AGIMO site also contains a description of the most common navigation tool types, including “supplemental navigation which comprises additional navigation tools such as sitemaps, indexes and guides.” The site contains some general advice stating that good navigation allows users to easily answer the following questions for every page of the site: “What site am I on?, Where am I in the site?, What can I do here?, Where can I go to from here?, and Where is the information I'm looking for?” Apart from this general advice, there are no specific guidelines or advice regarding the design or development of sitemaps.

There are several examples of recommendations for the design of sitemaps in the research literature. Diebold and Kaufmann (2001), in a study that reports on a usage-based technique for the automatic generation of sitemaps, recommend that sitemaps use an appropriate visual metaphor, provide landmarks as navigational hubs, use a hierarchical abstraction to enable an appropriate mental model, use dynamic filtering and multi-attribute representations to provide user control over complexity, and provide support for local and global views. Morville (1996) produced three rules for the use of sitemaps: don't use them to fix poorly architected sites; consider a Table-of-Contents instead; and maps should be symbolic. Rosenfeld and Morville (1998) proposed one simple guideline for the design of sitemaps: "the higher the level of abstraction, the more intuitive the map", based on the fact that maps of the physical world do not show the exact geography of an area, but rather a number of contextual clues that assist travellers. In all cases these reports did not provide any evidence of empirical or theoretical validation.

The various guidelines and research reports reviewed in this section provide only limited principles for the use of sitemaps and could be categorized using the NCI's (NCI, 2005) "Strength of the Evidence" rating as "Category C: Observations (Expert Opinions)" since they are the "opinions of respected authorities based upon their own experiences".

This current review located only one example of sitemap design guidelines that contain practical guiding principles supported with empirical evidence. Nielsen (2002) provides some advice on "Site Map Usability" which is based on a study of sitemaps on 10 web sites. The report claims that sitemaps in the study were fairly successful at getting users to destinations that were included on the maps, however users were reluctant to use the sitemaps and sometimes had problems finding them. These guidelines were expanded by Stover el at. (2002) which reported a study involving 15 subjects evaluating the navigational support provided by the sitemaps in 10 web sites. The study reported that users go to sitemaps if they are lost, frustrated, or looking for specific details on a crowded site, and that a sitemap's main benefit is to give users an overview of the site in a single glance. The report provided 28 design guidelines for sitemaps, such as:

- Link name and placement ("Site Map," prominent, on every page)
- Navigation (use normal links, avoid extra clicks, be complete)
- Relationship of sitemap to the site (complement main navigation, make hierarchy clear, provide overview not relationships)
- Design (cross-browser, visited colors, minimize graphics/scrolling/load time, make it clean)

- Content (include all areas, including About and Search, clarify links that take user to areas with their own structure)
- Alphabetical Indices (specify what it includes, cross reference, provide context)

The Stover guidelines may be categorised as an example of the NCI (NCI, 2005) 'Category B' guidelines as they are "based on observational studies and usability tests that are generally not reported in the open literature". Whilst findings obtained from observational studies are valuable, in many cases there is a lack of connection with prior research and established theories.

The optimal NCI 'Category A' guidelines are derived from "hypothesis-led usability experiments" which provides the basis to make the strongest inferences to guide design practice. Neerincx et al. (2001), in a study which investigated the fundamental cognitive determinants of navigation performance, suggested that designers should utilise guidelines in order to overcome problems relating to inefficient navigation, disorientation and loss of overview. However, they noted that theory and empirical research to validate the guidelines are lacking. It is apparent that current research into the design of sitemaps suffers from a lack of appropriate connections with previous research and fundamental psychological and cognitive theories. Hence, it may be asserted that there is a lack of design guidelines that are derived from hypothesis-led usability studies.

2.6 Summary

The evolution of the Web draws on a rich history of hypertext research and development. Hypertext defies the traditional linearity of information storage and discovery and provides opportunities for incidental learning and information discovery through serendipitous exploration. The additional flexibility the hypertext offers is traded off against certain aspects of system usability. The non-sequential nature of hypertext structures can result in users getting lost and experiencing difficulties in finding desired information. Such experiences have been classified as disorientation, the symptoms of which are difficulties in finding information, difficulties in handling digressions and a general feeling of being lost. Disorientation is compounded further by the cognitive overhead as users perform several tasks simultaneously as they navigate through a hypertext system.

The World Wide Web Consortium describes the Web as:

> *"the universe of network-accessible information, the embodiment of human knowledge"* (W3C, 2005).

This vision of the Web is contingent on the ability of users to freely access and contribute to the overall system. The freedom of the Web threatens its own future due to the possibility of users being disoriented and cognitively fatigued. Strong support for navigation and orientation is required.

Current web browser software provides only limited support for users navigating through web sites. The page-based view, which is the essence of the hypertext model, does not support users in maintaining context in a web site. A constant theme in the rich history of research into hypertext navigation is the need to provide an overview presentation of a system that supports users in orienting themselves and navigating towards desired information. Hypertext research has influenced the development of supplemental navigation tools for web sites, including the provision of sitemaps. A sitemap is a map, diagram or textual description of the structure or contents of a web site. It is claimed that sitemaps alleviate disorientation, improve spatial context, act as a continuously visual surrogate for the user's short-term memory, provide a sense of the extent of a web site and generally support navigation. Despite these claims there are a number of reported problems associated with sitemaps, especially when applied to large sites, sites that frequently change, and when used by non-visually oriented users. Some research also suggests that users simply don't use sitemaps and that many sitemaps present navigational challenges of their own. There are a multitude of approaches to the design of sitemaps resulting in inconsistent user models. Design guidelines for sitemaps are limited, are generally not substantiated by empirical studies, and lack connections with previous research and fundamental psychological and cognitive theories.

Contemporary research into sitemaps has focused on technological innovation that explores the application of novel visualisation, generation and design techniques, resulting in design practice guided by technical opportunism. There has been little fundamental research that has investigated design issues from the perspective of the user. In particular, the relationship between the type of task that a user is performing and their tendency to select a sitemap has not been systematically investigated. This chapter has established that there is a lack of appropriate empirical research that investigates the influence of the user's task types on the design and functionality of sitemaps. Current research into the design of sitemaps also suffers from a lack of appropriate connections to fundamental psychological and cognitive theories. As a result, current sitemap design guidelines are not sensitive to task type and lack a theoretical basis.

2.7 Conclusion

This chapter has reviewed literature relating to hypertext and web navigation. Problems relating to navigation and disorientation were identified and the use of supplemental navigation tools, particularly sitemaps, were discussed. A scheme that facilitates the classification of sitemap designs and functionality was proposed and examples presented. Current design guidelines for sitemaps were reviewed. The chapter has established current sitemap design guidelines are deficient as they are not sensitive to the informational goals of users when they select to use sitemaps. The lack of connection with previous research and underlying theories was also raised as a concern with current guidelines.

The following chapter reviews the literature relating to the relationships between user goals and navigational strategies and proposes a conceptual framework that clarifies for the purpose of this research project, the relationships between human-web interaction, information retrieval and navigation in the context established theories.

3 User Goals and Navigation Strategies

3.1 Introduction

The previous chapter presented sitemaps as a tool that can assist users in maintaining orientation within a web site, obtaining an overview of the site contents or structure, and navigating towards desired information. The chapter concluded by suggesting that current sitemap design guidelines are deficient for two reasons: first, current guidelines are not sensitive to the informational goals that users might have when they decide to use a sitemap; and second, guidelines have not been based on hypothesis-led empirical studies or research that is grounded in cognitive or psychological theories.

This chapter investigates these reasons by examining the centrality of the user in the navigation process. This chapter commences with the development of a conceptual framework that seeks to explain human-web interaction in the context of previous research and established theories. This framework guides the analysis of the role of user goals and navigation strategies, providing the basis for the identification of several research questions.

3.2 The Role of the User in Web Navigation

The importance of understanding 'who' the end-users are and the activities they engage in has been acknowledged as critical in the design process.

> *"If technology developers start from an understanding of human needs, they are more likely to accelerate evolutionary development of useful technology."* (Shneiderman, 2002a)

The needs and goals of users is highlighted in the International Standards Organization [ISO9241] definition for usability: "the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments". Effectiveness here is defined as the "accuracy and completeness with which specified users can achieve specified goals in particular environments", whilst efficiency is "the resources expended in relation to the accuracy and completeness of goals achieved".

Users vary in many ways having different goals, cognitive styles (characteristic ways of behaving and preferred strategies and tactics when seeking information) and cognitive abilities (spatial, language, logical, intellectual). The individual differences and cognitive abilities of users are important to web navigation, with research investigating issues such as spatial ability (Vincente and Williges, 1988; Stanney and Salvendy, 1995; Farris et al., 2002), preferences for map interfaces (Streeter et al., 1985), individual differences and user interfaces (Chen et al., 2000) and adaptive user interfaces (De Bra et al., 2002; Brusilovsky & Cooper, 2002). The issues of individual differences and cognitive abilities are outside the scope of this project.

This project focuses on the goals and needs of users when using a web site, and the strategies and tactics that they might use to achieve an outcome. The importance of understanding the needs of users was highlighted early in the life of the Web in a well-cited panel discussion at the 1995 WWW conference (Gershon et al., 1995). The introductory remarks acknowledged that “users come in many flavours” and that “we need to understand how the human mind works when searching for unknown and known information”.

In relation to the goals that users have when interacting with the web, Rose and Levinson (2004) found that previous work on understanding the behaviour of users when performing searches on the Web has focused on ‘how’ people search and ‘what’ they are searching for, but not ‘why’ they are searching. They claim that the ‘why’ of user search behaviour is essential to understanding the user’s information needs, and proposed a framework that classified query types by the underlying goals of users. Similarly, in relation to sitemaps, van Dijck (2000a) suggested that designers should consider the kind of experience they want to give the sitemap user by starting with the question “Why do they use a sitemap?” Whilst van Dijck claimed that the goals of users might vary from wishing to find some specific piece of information to simply looking around a site to find what else they might enjoy, he reported no empirical work examining the fundamental question of why users might decide to use a sitemap.

Having established the focus of this study in relation to the role of the user and their informational goals, the following section develops a conceptual framework that clarifies the roles and relationships between the various components in web navigation, including user goals and strategies.

3.3 A Framework for Human-Web Interaction

The previous chapter proposed that one of the central usability problems for the Web relates to the vast amount of information it contains and the limited methods by which a user can appreciate and access this information. As a consequence of these two factors, users are prone to suffer from disorientation whilst navigating through the Web. Despite substantial research as reported in Chapter 2, problems with disorientation and navigation still afflict the Web. There are a number of potential reasons for the lack of significant improvement in web navigation. First, human-web interaction is a complex issue due to the variety of cognitive, affective, social and situational variables involved (Spink, 2000). Interaction in particular, is a "complex, difficult, messy, hard and confusing issue to deal with because humans are involved" (Saracevic, 1997). Consequently, research into web navigation, particularly empirical research, is difficult to conduct. A second reason for a lack of improvement in web navigation is that in many cases new navigation tools have been developed with a focus on what is technologically possible rather than being led by theory or empirical investigation. Design not grounded in theory risks having limited application and is generally not sustainable.

There are a range of components in human-web interaction that need to be organised and investigated. Xu et al. (2001) suggest that web navigation is made up of: the users (humans), web pages (the systems) and web navigation tools (the interaction). Canter et al. (1985) describe the variables in human-computer interaction in the following: "The task the user is performing and the preferred strategies he has at any time for moving around the data will affect his behaviour." The role of the user, their goals, the strategies that they use and the navigation tools and options that are available, and the relationships between these, need to be clarified in order to understand the reasons why users select particular navigation tools.

The literature contains a range of frameworks which seek to explain human-system interaction. These models generally decompose the action process into a number of stages or behaviours with connective relationships and feedback loops. Action models range from theoretical models of interaction to specific frameworks that address particular contexts such as information retrieval or navigation. Frameworks or models can be used to guide the design process, illustrate connections with existing theories and provide a structure in which research can be undertaken.

This section reviews a number of conceptual frameworks and proposes a Human-Web Interaction Framework which seeks to explain the role of goals and navigational strategies when users interact with web sites.

3.3.1 Human-web interaction

The processes that take place when humans interact with an information system such as the Web include the interlaced processes of information retrieval and navigation.

Information retrieval is the process of extracting information from a system according to some perceived need. This process is essentially a cognitive activity consisting of iterations of steps involving: (i) establishing an informational need based on current goals; (ii) choosing an information source; (iii) carrying out an information search (navigation); and (iv) evaluating-judging the relevance and compatibility of retrieved documents with needs (Rasmussen et al., 1994).

The navigation component of information retrieval involves movement through a system, generally but not always, towards some target. There are two concurrent processes that must take place to manage and achieve this movement: wayfinding and motion (Darken and Peterson, 2001). Wayfinding is the cognitive element of navigation, including selection of paths, strategy etc, whilst motion is the actual movement (physical or virtual) through a system to the target information.

This description of human-web interaction recognises both the informational and navigational tasks as described by Conklin (1987) who describes the cognitive overhead problems experienced by users of hypertext systems. Conklin attributes cognitive overhead as a reason that users feel disoriented due to the several tasks that users must perform simultaneously as they interact with a hypertext system (Conklin, 1987; Foss, 1989; Kim and Hirtle, 1995). These tasks include informational tasks involving reading and understanding the contents and relationships between the nodes, and the navigation tasks which involve planning and choosing paths through the system. Oulasvirta (2004) distinguishes these by referring to navigation as the task of finding a particular page from a site, and content-orientation which relates to the task of attending to the textual information on the target page.

The two parties who interact in human-web interaction are the user and the system (the Web interface). The user has a particular information need, a certain level of domain and system experience, and distinguishing behaviours which are all significant factors in human-web interaction (Benyon & Hook, 1997). Their level of familiarity with the task domain, information seeking experience and experience with the interface are directly linked with the user's ability to formulate an information need and translate it into actions at the interface level (Marchionini & Shneiderman, 1988).

The interface to the web site provides a particular view of the organisation and structure of the information system. A variety of types of views may be created, for example, some with the goal of minimising lookup time (Hoffman, 1996), and others focusing on informing the user about the content and structure of the web site. The type of structure of the information within the system and the access interface techniques both affect the retrieval strategies and thus are critical factors in task performance (Marchionini and Shneiderman, 1988).

The various concepts in relation to human-web interaction, information retrieval and navigation described above require an overall framework to understand their particular roles and relationships. The literature contains a number of explanatory theories which are commonly presented as frameworks or models that describe the stages of interactions when humans use systems such as web sites. The following sections define conceptual frameworks, their purpose and reviews several frameworks that have been proposed in the literature.

3.3.2 Conceptual frameworks

A conceptual framework[1] is a way of representing an object, system, process, structure or concept, by first identifying all of the essential elements and then representing their relationships in an organised manner. Frameworks may be regarded as a particular view of an object, and as such, multiple frameworks may exist for the same object. Saracevic (1997) claims that frameworks and models are not verifiable theories. Rather, frameworks and models only assist in explaining the relationships between components in objects in the context of particular theoretical concepts, principles and philosophical assumptions. Similarly, Wilson (1999) suggests that conceptual models guide research, systematise knowledge, and facilitate the identification of relationships that might be fruitful to explore or test. Here Wilson concurs with Saracevic (1997) by stating that a "conceptual model cannot be assessed directly empirically, because it forms the basis of formulating empirically testable research questions and hypotheses."

Frameworks and models that have been developed from HCI research usually have a foundation in psychology or information science. These types of frameworks focus on the interaction process, particularly the cognitive processes and decision points at different levels of the interaction. These interaction frameworks, sometimes known as action models, deconstruct user behaviour and activity to provide an understanding of the elements and their inter-relationships in the context of existing theories.

The development of frameworks and models are important in the context of research activity. A panel at the CHI'2002 conference addressed the issue of the need to deepen the foundations of HCI as an academic discipline through the development of predictive, explanatory and generative theories to support the future innovation and development (Shneiderman et al., 2002b). In this panel, Shneiderman stated that "explanatory models such as Norman's seven stages sharpen our understanding of successful products and can guide future designs".

Furthermore, frameworks can provide orientation and direction to research by

[1] There appears to be no agreed definition of the terms 'conceptual framework' and 'conceptual model' in the literature, hence whilst this thesis refers to a 'conceptual framework', the term 'conceptual model' also applies.

providing a scaffold in which the various variables, research questions and underlying theories can be organised. This allows a program of research to be approached logically and systematically, allowing researchers to decompose research problems into manageable components without losing the overall context.

Finally, frameworks can provide the basis for evaluating the relevance of research outcomes and to facilitate the identification of areas of application and further research.

3.3.3 A comparative analysis of interaction frameworks

Table 3.1 presents a comparative analysis of a number of significant conceptual frameworks of interaction (Hacker, 1985; Neiseer, 1976; Norman, 1988; Guthrie & Mosenthal, 1987; Ellis, 1989; Marchionini, 1995; Juls & Furnas, 1997; Spence, 1999). In the table, each stage of analogous action in the various frameworks is identified, resulting in eleven discrete categories. A number of the stages in particular frameworks span several of the identified categories and in several cases the sequence of the stages is not purely top-to-bottom. Together these categories of action stages encapsulate the essential activities of general human action and interaction. It is interesting to note that apart from Ellis (1989), who focused on information-seeking behaviours, most of the frameworks are quite similar with stages progressing from identification of goals, planning of strategy, performing actions and then perceiving the results of those actions and finally evaluating the outcomes. Each of these steps will be discussed separately in the following sections.

Action Stages / Model	Hacker (1985)	Neiseer (1976)	Norman (1988)	Guthrie & Mosenthal (1987)	Ellis (1989)	Marchionini (1995)	Juls & Furnas (1997)	Spence (1999)	Stages
Set Goals	Set goals		Goals are stated	Form goals		Recognise and accept info problem	1. Form goal		Goals
Form Intention			Intention to do some action			Define and understand the problem			
Locate Source				Inspect appropriate categories of information	Starting – identify sources	Choose search system			Strategy
Plan Strategy	Plan way to accomplish goals	Schema directs exploration	Action sequence formed	Sequence the inspection	Chaining – following and connecting new leads	Formulate query	2. Decide strategy	1. Formulate browsing strategy	
Execute Plan	Physical execution of plan		Execution	Extract details	Extracting – systematically working through sources	Execute a search	3. Acquire data 6. Act (then go to 4.)	2. Browse	Action
Examine Results		Exploration samples Object (available information)	Perception		Monitoring – a particular area for new developments	Examine results Extract information	4. Scan		Perception
Interpretation			Interpretation according to expectations		Browsing – scanning contents for subject affinity			4. Interpret	
Evaluate Results	Evaluation and refinement of methods and actions		Evaluation wrt intentions and goals		Differentiating – assessing sources for usefulness	Reflect /Iterate /Stop	5. Assess		Evaluation
Refine Methods		Object modifies Schema							Cognitive Model
Build Schema /Model			(Implicit)				5.5. Form conceptual model	3. Form model	
Iterate or Stop		(Iterate)		Recycle to obtain solution	(Iterate)		(Iterate)	(Iterate)	Feedback

Table 3.1: Comparative Analysis of Action/Navigation Models

3.3.3.1 Goals

The origin of a model of an interaction process is the concept of a goal or information need (Wilson, 1997). Hacker's Action Theory (Hacker, 1985) which commences with the formation of user goals, seeks to explain goal-directed behaviour by distinguishing four stages of action that deconstruct the process of translating an intention into an action. In this model, goals lead to the selection of methods/tools to achieve those goals and conclude with execution and iterative refinement of the methods and actions. Similarly, Norman's "Seven Stage Action Model" (1988) also commences with a stage of goal formation which expresses the state that is to be achieved.

> *"The basic idea is simple. To get something done, you have to start with some notion of what is wanted – the goal that is to be achieved"* (Norman, 1988).

This initial stage in Norman's model is followed by a stage in which the goal is translated into an intention to do some action. Norman distinguishes these stages by stating that a goal is often a vague statement of something to be achieved, whilst an intention is a specific statement of what is to be done. Marchionini (1995) in his eight-stage framework that models the information-seeking processes when using electronic environments also commences with the recognition and acceptance of a problem. This initial stage is described as the "most basic situational factor that causes the user to act" (Marchionini, 1995).

The complexity of goals makes them very difficult to analyse. Loeber and Cristea (2003) comment on the complexity of goals in their 'needs model' that describes user goals in terms of functional needs, symbolic needs and hedonic needs. They state that goals emerge as the result of various processes relating to cognitive models, including perception, knowledge integration, personal interests and prior experiences which commence with a sensory or mental input that triggers the users' attention. Guthrie and Mosenthal (1987) highlight the complexity of goals in their model of how readers search for information in written documents. Their five stage model commences with the formulation of a goal which may arise externally from questions which are provided to readers, or internally where a specific information need arises whilst undertaking another activity. Such goals might need to be deconstructed into subgoals if they are vague and the information space is large and complex. Marchionini (1995) also recognises that goals vary in source (internally or externally motivated) and characterisation (a gap, visceral need or a defect in one's mental model).

The General Framework for Navigation proposed by Juls and Furnas (1997) articulates clearly the role of goals in models of interaction. This framework was composed during a focused workshop on Navigation in Electronic Worlds (Figure 1), where it was stated that "A navigation task begins with the navigator deciding what the object of the task is to be." Examples of the types of tasks were provided as either trying to find a specific item, a group of items or information about the contents of the space.

Several of the models summarised in Table 3.1 exclude goals entirely. For example, the models proposed by Neiseer (1976) and Spence (1999) highlight the role of the internal schema by attributing it as the source of direction for exploration rather than explicitly referring to goals. The role of internal schema will be discussed later in this section.

3.3.3.2 Strategy

The categories of action stages of 'Locate Source' and 'Plan Strategy' in Table 3.1 describe a range of cognitive planning processes that must occur before any action can take place. All of the models have some type of planning stage in which a strategy is determined. For example, Norman (1988) proposes a single strategy stage which involves the specification of an action sequence in which the intention to act is translated into a set of internal commands described as a mental representation of an action sequence that can be performed to satisfy the intention. Likewise, Hacker (1985) and Juls and Furnas (1997) also include a stage in which a strategy or plan is devised in order to accomplish a task.

A more detailed approach is taken by both Guthrie and Mosenthal (1987) and Marchionini (1995), who each propose a two part strategy stage in which sources or categories of information are initially identified and then the sequencing or actual formation of the query takes place. This multi-part approach allows the format or type of information source to influence the actual query formation which is particularly relevant when considering the context of navigation on the Web. Web navigation involves several different types of strategies for different levels in the navigation process: strategies used to find an appropriate web site, strategies for navigating through a particular web site and finally strategies for locating desired information on a particular web page. Available strategies may vary at the different levels in the navigation process, and may include the use of an index or a table-of-contents (Guthrie & Mosenthal, 1987) or the use of tools such as search engines or maps (Juls and Furnas, 1997). Spence (1999) in particular, highlighted the two determinants of the formation of a browsing strategy as being cognitive and perceptual. Cognitively initiated strategies are usually planned strategies that are determined as a result of an interpretation or idea, whilst perceptually initiated strategies are formulated as a result of what is perceived and tend to be more opportunistic. The frameworks presented in Table 3.1 do not distinguish between different types of strategies and the role of perception prior to choice of strategy.

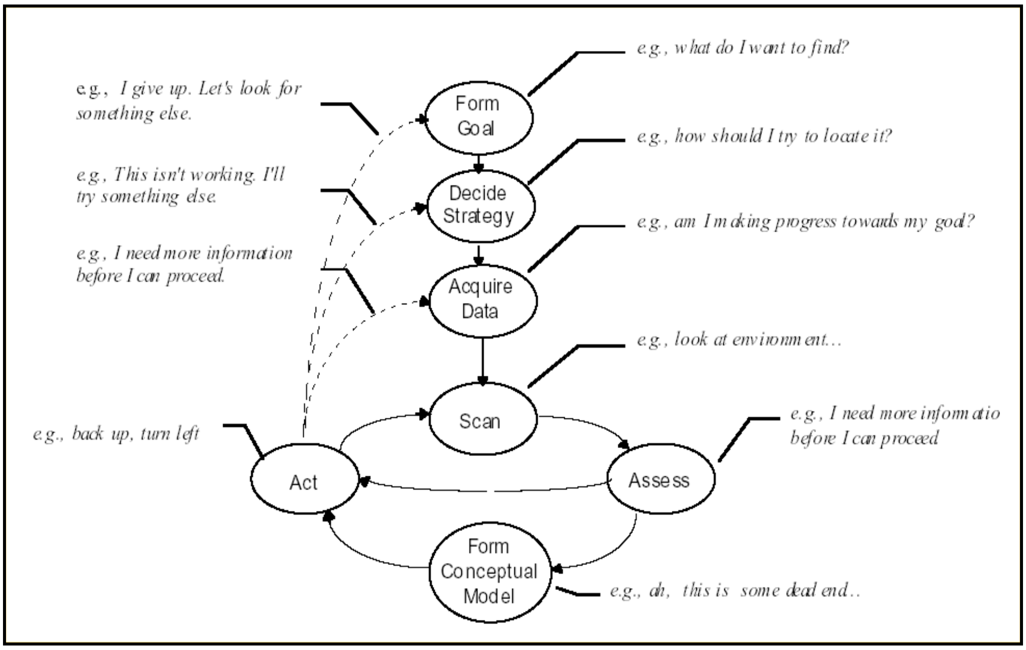


Figure 3.1: General framework for the navigation process (Juls and Furnas, 1997)

Choice of strategy is also related to the specificity of the information goal and the stage of an investigation. For example, Ellis (1989), in an investigation of the information seeking behaviours of engineers and research scientists in industrial environments, identified eight categories of behaviours (surveying, chaining, monitoring, browsing, distinguishing, filtering, extracting and ending). He claimed that researchers become more selective about their behaviours as they progress from preliminary to advanced phases of a project, and as they become more knowledgeable and specific about the problem.

The notion of defined strategies has been suggested by Marchionini (1995) who proposed three types of browsing strategies: directed, semi-directed and undirected. Likewise, Wilson (1997) identified several categories of information seeking: passive attention, passive search, active search and ongoing search. Neiseer's (1976) proposition that mental schema directs exploration and Hacker's (1985) proposal that methods are evaluated and refined after action both suggest that defined strategies might be developed over time and stored for later use.

3.3.3.3 Action

All of the models in Table 3.1 contain a stage in which a plan of action is executed. Norman's model (1988) initially proposed that human action can be divided in stages of execution and evaluation. Execution involves doing something and evaluation is the comparison of what happened in the world with the goal. Norman expanded the stage of execution to provide four levels (Goals, Intention, Actions, Execution) that resemble the first three stages in Hacker's Action Theory, and then expanded the evaluation stage to into three levels (Perception, Interpretation and Evaluation).

There is no mention of how actions are managed with respect to previous and current actions. Conklin's (1987) recognition of the cognitive overhead problems experienced by users of hypertext-based systems as they perform both informational and navigational tasks demonstrates how route management is critical in models of navigation. Users who become overwhelmed by the task of monitoring their navigational path to facilitate path decisions and backtracking at the same time as they attempt to comprehend information on each page may become disoriented, resulting in suboptimal performance.

3.3.3.4 Perception

For the purposes of this analysis, perception is defined to include both the act of viewing an interface and the interpretation of the view. The role of perception in action models needs to be clarified. Some of the models (Spence, 1999; Hacker, 1985; Guthrie & Mosenthal, 1987) do not explicitly contain a stage where the results of the actions are viewed. Many of the other models have a perception stage occurring after execution, whilst the Juls and Furnas model (1997) has a 'Scan' stage occurring after strategy formation. Furthermore, although perception was seen as a contributor to strategy selection in a previous section (Juls & Furnas, 1997; Marchionini,1995; Spence, 1999), these models lack an explicit perception stage prior to formation or choice of strategy.

3.3.3.5 Evaluation

All of the models in Table 3.1 contained an evaluation stage in which the outcome of the actions is considered relative to the intentions and goals. Norman (1988) states that "evaluation begins with perception". In his model he claims that perceptions are interpreted according to expectations and then compared with respect to intentions and goals. Marchionini (1995) notes that evaluation not only relates to how well the extracted information fulfils the goal but also how it relates to accepting the problem and an assessment of the whole information-seeking process. He highlights that the process of monitoring the information-seeking process is crucial to browsing type strategies which are highly interactive and opportunistic. Evaluation generally results in either concluding the process or following various feedback paths to allow refinement and recycling through other stages.

3.3.3.6 Cognitive model

Several of the models reviewed in Table 3.1 (Neiseer, 1976; Guthrie & Mosenthal, 1987; Juls & Furnas, 1997; Spence, 1999) focused on the cognitive elements of the interaction process by including a reference to a schema or cognitive model. The terms 'mental model', 'cognitive model' and 'schema' have been used in many contexts and for many purposes. The theory of mental models was proposed by Kenneth Craik (1943) to provide a general explanation of human thought based on the contention that humans represent the world they interact with through mental models. Johnson-Laird (1983) developed the concept of mental models claiming that individuals develop and use a working internal model of a phenomenon in order to understand it. Mental models are cognitive mechanisms that are dynamically created through experience as people interact with others and their environment (Norman, 1988), allowing predictions to be made about events before carrying out actions. There is evidence to suggest that an appropriate mental model can improve a user's ability to interact with a system

(Rumelhart & Norman, 1981). Cognitive models are used specifically in the context of learning (Rumelhart & Norman, 1981). Cognitive models may have new knowledge added to them through reflection, perception or experience, new models may be created by modelling it on an existing schema and then modified based on new experiences, and existing models may be tuned through practice. Similar to cognitive models are schema, which usually refer to organised structures in memory that contain our knowledge of the world.

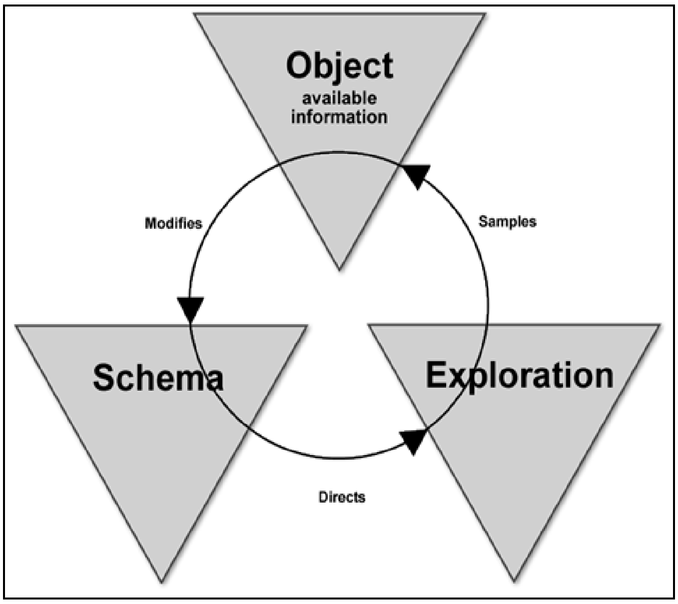


Figure 3.2: Neisser's perceptual cycle (1976)

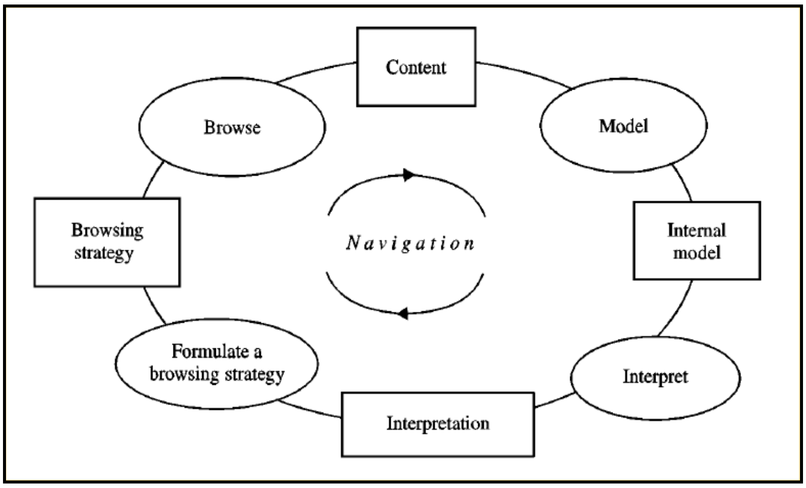


Figure 3.3: Spence's extended framework for navigation (1999)

The frameworks proposed by Neiseer (1976) (Figure 3.2), Guthrie and Mosenthal (1987), Juls & Furnas (1997) and Spence (1999) (Figure 3.3), include a reference to a schema or cognitive model. Neisser's Perceptual Cycle, in particular, emphasises the role of stored mental schema on exploratory behaviour and the perception of external context. Neisser was one of the first researchers who attempted to integrate learning, perception and activity (Rauterberg, 1995). He proposed a cycle (Figure 3.2) in which perception modifies stored mental schema, the schema directs exploration, and to complete the loop, the exploration samples the available information. This cycle stresses the role of cognitive models in web navigation by proposing that knowledge of particular subject matter through a schema will help readers anticipate, find and organise information (Neisser 1976). Knowledge provided through a schema may include knowledge of the particular subject matter, as well as knowledge of the structure of the information space (Winn, 1993) and any navigational features (index, table-of-contents, etc) and how to use them.

The framework proposed by Juls and Furnas (1997) (Figure 3.1) includes the development of a cognitive model after an assessment phase. This cycle of 'Scan, Assess, Form Model and Act' parallels Neisser's Perceptual Cycle by relating perception and action through a cognitive model.

Spence (1999), a contributor to the framework described by Juls and Furnas (1997), proposed an extended framework that clarifies the role of the cognitive model (Figure 3). The extended framework included four cognitive activities, each with their results: browsing, formation of an internal model, interpretation of internal model and displayed data, and formulation of browsing strategy. Whilst this framework excludes references to goal formation and perceptual processes, it does seek to explain the processes by which internal models are created and interpreted.

3.3.3.7 Feedback

Most of the models reviewed in Table 3.1 contained a variety of feedback paths, implying that results would be fed from the last stage back to the first stage. For example, the General Framework for the Navigation Process proposed by Juls and Furnas (1997) contains several feedback loops, allowing the results of actions to refine goals, strategies and the decision whether to continue the process. Hacker (1985) also proposed a feedback loop, allowing refinement of methods and tuning of strategies after the evaluation stage. The models emphasising the cognitive elements of the interaction process (Neiseer, 1976; Guthrie & Mosenthal, 1987; Juls & Furnas, 1997; Spence, 1999) all contain feedback paths that allow the refined schema to influence subsequent goal formation. Feedback paths between other stages are also proposed in other models which highlights the importance and complexity of feedback routes in information retrieval models (Saracevic, 1997; Spink 2000).

Of course, models do not necessarily operate in a one-directional step-by-step manner. Norman (1988) notes that models are 'approximate' since the individual stages are not discrete entities, not all are completed and a continual feedback loop operates. Marchionini (1995), in his eight stage framework, comments that whilst there is a sequence of sub-processes, there is a recognition that they develop in parallel and may recursively call each other.

3.3.4 A proposed human-web interaction framework

The comparative analysis of action/navigation models in the previous section identified six major stages which might be considered in a framework of interaction: formation of goals, strategy, action, perception, evaluation and the development of a cognitive model. These stages may be linked through a variety of sequence and feedback paths.

The roles of, and relationships between, goals, perception and the process of choosing interaction strategies in human-web interaction, are important issues that should be considered in any explanatory framework.

An initial consideration is that there are two different stages of interaction when using the Web. The first stage involves locating a particular or relevant web site. The second stage of interaction involves using the chosen web site in order to achieve some goal. A user may swap between stages at any time. The range of navigation strategies for each stage will be different and may be defined as either 'intra-site' or 'inter-site' navigation strategies. Inter-site navigation strategies refer to global navigation of the Web during which the user will use strategies and tools including those provided by browser tools, global search engines, favourites lists, portal sites, and explicit URLs, to locate a particular or relevant web site. These are different from the strategies and tools available when performing intra-site navigation, which involves navigating within the bounds of a particular web site. Intra-site navigation is achieved either by free browsing between pages, or by using site navigation tools provided by the site designer such as site-search, sitemaps, indexes and navigation bars. Other site navigation aids such as bread-crumbs, home page buttons, landmark pages and the use of consistent page templates may also aid intra-site navigation. A human-web interaction framework should differentiate between 'intra-site' and 'inter-site' navigation strategies.

A second consideration is clarifying the relationship between viewing the web interface (perception) and the process of choosing an interaction strategy. This link between perception and choice of strategy in a Web context is not explicitly addressed in any of the models reviewed in Table 3.1. Web site interfaces vary in the level and type of navigation support they provide. Some sites only provide basic links to areas of content, whilst others provide additional navigational support through search tools, navigation bars, breadcrumbs and sitemaps. The choice of strategy for interacting with a web site is influenced by not only the goals of the user and their preferred strategies, but also by the opportunities provided by the interface such as the available links and navigation tools. According to Marchionini (1995), the process of information seeking is both systematic and opportunistic. Hence, it is only via a visual scan of the interface that opportunities for alternative strategies will be identified. For example, if the user sees a link to a sitemap, then they may use this tool to support an intra-site navigation strategy. A human-web interaction framework should include perception as a specific activity that influences choice of strategy.

A proposed Human-Web Interaction Framework is presented in Figure 3.4. This framework comprises the six major elements identified in the previous section, including a perception stage prior to strategy selection and recognition of the two modes of web interaction.

The proposed framework clarifies the role of perception. Although perception has been listed as a sub-process that occurs between each of the stages, it is recognised that perception is an ongoing activity that parallels the whole interaction process. It occurs before, during and after each of the processes. The role of perception prior to strategy selection is particularly important in relation to the choice of strategy as it allows the identification of opportunities from the interface. Perception is also utilised when considering how to implement actions and evaluate outcomes.

The framework identifies two classes of strategies that exist in human-web interaction. Users will employ inter-site strategies during global web navigation between sites and intra-site strategies when navigating inside a web site. Users may switch between these modes of use as the move between and within web sites.

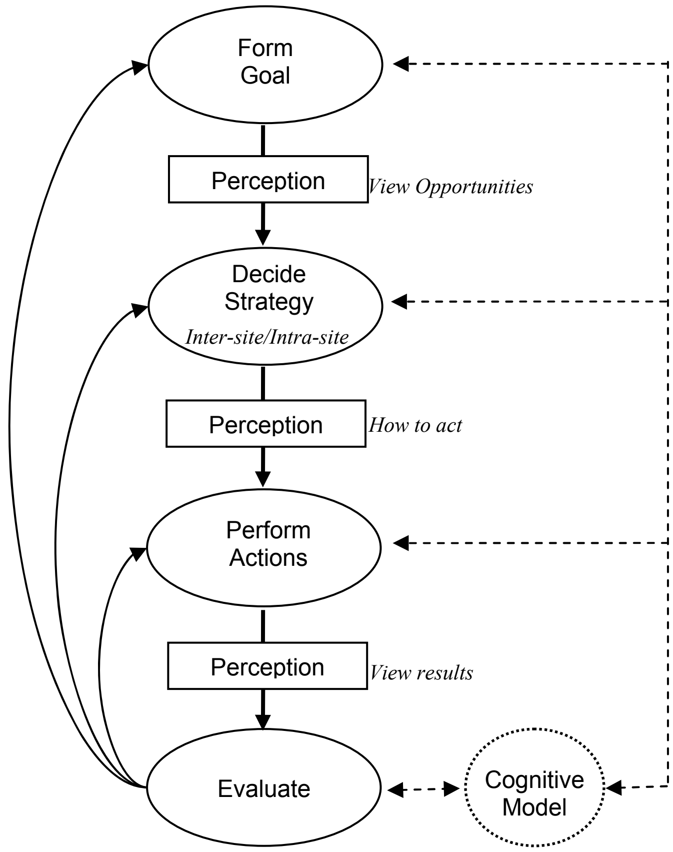


Figure 3.4: Proposed Human-Web Interaction Framework

Each of the processes in the framework are in a constant state of development and therefore neither static nor discrete. For example, goals may switch at any time through incoming perceptions. Strategies are continually being evaluated according to their suitability and are influenced by the cognitive model (previous experiences). The cognitive model is built dynamically as a result of ongoing evaluation of all of the stages and will influence goal formation, strategy selection and implementation of actions.

3.3.5 Using frameworks to support research

Problems relating to web navigation will continue to be one of the major issues confronting HCI researchers and web designers. Nielsen (2000a) claims that web users are impatient, require instant gratification and will leave a site if they cannot immediately figure out how to find what they want. Conceptual frameworks can provide guidance for researchers and designers who wish to alleviate such problems by providing a structure to facilitate the identification of the areas in which there is a lack of research and a scaffold in which to undertake appropriate research. A framework enables a program of research to be approached logically and systematically, allowing researchers to decompose research problems into manageable components without losing the overall context. Frameworks provide a structure in which causal relationships might be proposed. For example, conceptual frameworks operate at the theory formation stage by providing “the conceptual and methodological tools for formulating hypotheses and theories” (Wilson, 1999). Furthermore, frameworks can provide the basis for evaluating the relevance of research outcomes and to facilitate the identification of areas of application and further research. For instance, a researcher who is planning to investigate the relationship between goal types and the selection of navigation strategies may focus their attention on either intra-site or inter-site navigation strategies. Interface designers may also benefit from frameworks by being provided with an insight into the various components and concepts in relation to navigation.

3.4 Framing this Project

The framework proposed in the previous section was used to guide and structure this present project. The project focused on the interaction between the user’s goals and intra-site navigational strategies when navigating a web site. Figure 3.5 shows the relevant sections of the proposed framework which were addressed.

The project did not address the complex goal formation processes and was not immediately concerned with the execution of actions, evaluation of outcomes or development of cognitive models.

The project was primarily concerned with how the goals of users influence intra-site navigation strategies, and the nature and outcomes (in terms of actions) of intra-site navigation strategies. The next two sections explore the nature of user goals and intra-site navigation strategies in order to refine the researchable issues.

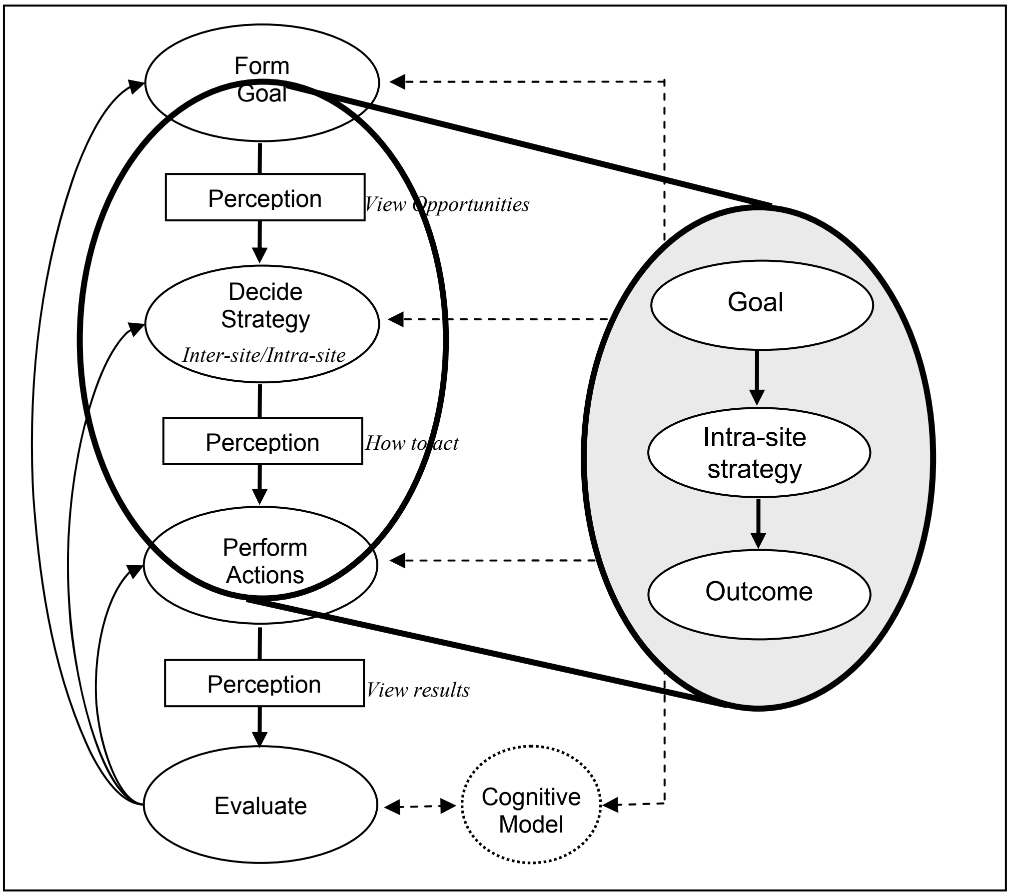


Figure 3.5: Focus of this research project

3.5 User Goals and Goal Types

Preece (1994, p411) defines goals as “the state of a system that the user wishes to achieve” and distinguishes these from tasks which are defined as “the activities required, used or believed necessary to achieve a goal using a particular device”. Whilst goals are usually described at a particular level of abstraction, such as ‘find out the football scores', tasks are a structured set of activities which the user has to do to accomplish a goal.

Goals are formed according to the interests, motivations and prior experiences of the individual and vary in a number of ways. Belkin et al. (1982) proposed in their Anomalous States of Knowledge (ASK) framework that an information need arises from an anomaly in the user's state of knowledge concerning some topic and that the user might not be able to specify precisely how to resolve the anomaly. They suggest that in such cases it is not appropriate to ask the user to specify their need as a request to the system, but rather alternative modes of determining and meeting the needs are required. This raises the question of whether there are particular types of goals and whether goal types require different methods of interacting with a system in order to achieve the desired outcome.

In the context of Web interaction, users' goals will vary widely. For example, a goal might be finding a specific piece of information, purchasing some goods or services, or communicating with another person.

The literature[2] contains several examples of research that has investigated and categorised goal types, some of which comes out of the information and library science community where there is a history of studies into information seeking behaviour. Armbruster and Armstrong (1993) proposed that goals may be categorized according to their source (external or internal), time of formation (before or during) and specificity (very specific to very general). Byrne et al. (1999) used task analysis and video protocols to investigate the types of general tasks that users engaged during uninstructed browsing activities, and the time spent on each of these tasks. They developed a taxonomy of six general classes of web tasks: Use Information, Locate on Page, Go To Page, Provide Information, Configure Browser, and React to Environment, and found that most of the time was spend on the first three tasks types. Järvelin and Wilson (2003) proposed five categories of tasks ranging from automatic information processing tasks to

[2] Note that in the literature there appears some inconsistencies between the definition of a goal and a task. The listed examples maintain the term that was used in the reference however this thesis relies on the definition of each term as described at the commencement of Section 3.5.

genuine decision tasks. This classification was based on how well defined the structure of task is, and includes a consideration of task difficulty and complexity.

Other research has addressed the information needs of users who perform web searches using search engines. Broder's 'Taxonomy of Web Search' (Broader, 2002) proposed three search types based on the information need of the user: 'Navigational' where the immediate intent is to reach a particular site; 'Informational' where the intent is to acquire some information assumed to be present on one or more web pages; and 'Transactional' where the intent is to perform some web-mediated activity. A similar classification was suggested by Rose and Levinson (2004), who also focused on the goals that users have when they undertake web searches. Using an analysis of samples of queries from the AltaVista search engine, they developed three general goal categories for web searches: a 'Navigational Goal' that involves visiting a specific web site; an 'Information Goal' includes all open and closed ended questions and requests for advice and undirected requests to learn more about a topic; and 'Resource Queries' that involve obtaining something other than information, e.g obtain, download, entertain, interact. The outcomes of this analysis highlighted that the design of search engines and interfaces should be sensitive to user behaviour, particularly the reasons why users perform searches. This concern is echoed in this present research project but in the context of the reasons why users choose sitemaps.

Two common attributes identified in these previous studies are the specificity and complexity of goals. Specificity refers to the fact that sometimes a user can express exactly what they want, whilst at other times they are vague and unsure of their goal (Canter et al., 1985; McAleese, 1989). Norman (1988) comments on these less-specific goals as, "everyday tasks, goals and intentions are often ill-formed and vague and many are opportunistic rather than planned". Task complexity refers to the perceived or intrinsic difficulty of a task. Different users will have different perceptions of the difficulty of the same task due to their previous system or contextual experiences. Additionally, some tasks are, by their nature, complex due to the number of variables or outcomes that are possible. The literature as reported by Byström and Järvelin (1995), suggests many different characteristics that contribute to the complexity of tasks:

> *"Repetitivity, analyzability, apriori determinability, the number of alternative paths of task performance, outcome novelty, number of goals and conflicting dependencies among them, uncertainties between performance and goals, number of inputs, cognitive and skill requirements, as well as the time-varying conditions of task performance"*. (Byström and Järvelin, 1995)

Previous hypertext research has used the level of specificity to develop classifications of goal types. Duncan & McAlyeese (1987) discriminate between users who know what they want and are able to express their need in a precise way and those users who are unsure of what they want, who think they have a gap or discontinuity in understanding, and who cannot express this need formally because of a lack of domain expertise. Lucarella and Zanzi (1993), in an empirical study, established the following states of a hypertext user as: (i) when a user knows exactly what they want, (ii) when a user only has a rough idea of what they are looking for, and (iii) when a user only realises that they are interested in something when they see it. Sellen et al. (2002) used a similar method in their classification of the activities that knowledge worker perform on the Web. Using retrospective interviews about pages in history lists over a two day period, they proposed six categories of activity: finding, information gathering, browsing, transacting, communicating and housekeeping. The first three categories differed on goal specificity with 'finding' defined as an activity that was goal-oriented with focused questions, whilst 'information gathering' was less specific such as comparing items or building up information over a time period. Here, 'browsing' was defined as an activity that was not goal driven.

Recognizing the indeterminate nature of such classifications, it is proposed that goal types may be regarded as lying along a continuum based on the level of 'goal specificity' and ranging from tightly defined closed goals to ill-defined open goals. 'Closed Goals' have a discrete answer or set of answers and once achieved will result in closure of the need. This is similar to the classification of closed goals by Rose and Levinson (2004), where the user needs an answer to a question that has a single unambiguous answer. At the other end of the continuum are 'Open Goals' which do not have a finite answer, and hence will not have a specific point of closure where the information need is satisfied. Rose and

Levinson (2004) describe open goals as relating to open-ended questions with unconstrained depth.

The complexity of closed goals may also vary. Shneiderman (1997), in a review of web site design issues, proposed four categories of users' tasks: specific fact-finding, extended fact-finding, open-ended browsing and exploration of availability. In the classification proposed in Figure 3.6, closed goals are divided into two types: specific fact-finding and extended fact-finding. Specific fact-finding may be regarded as goals where the outcome can be achieved by visiting a single node in the information space. This is distinguished from extended-fact finding in which several nodes would need to be visited in order to achieve an outcome. This outcome would typically be an aggregate or a comparison of the information across multiple nodes.

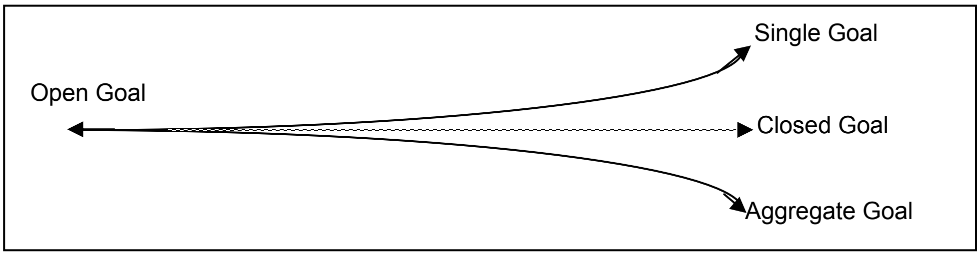


Figure 3.6: Continuum of goal-specificity

Hence the continuum of goal-specificity (Figure 3.6) would include one axis ranging from ill-defined, open goals to tightly defined closed goals which require either a single or an aggregate answer. This goal-specificity continuum can be used as a basis for a broad classification of user goals:

Open Goals

Open goals have a low level of goal-specificity. Whilst such users may not have an immediate information need, users may serendipitously switch or develop more specific goals as something of interest appears or as their domain knowledge increases allowing them to express a need more formally. Success of this type of task is difficult to quantify due to a lack of a distinct objective. Examples of open goals would include achieving a general overview of the site's purpose and contents, or an understanding of meta-information about the site such as its general size and structure. It is possible that first-time visitors to a web site may have goals of lower specificity in order to allow them to determine the suitability of the particular site to their interests.

Closed Goals

Closed goals are characterised by a very specific information need resulting in a discrete outcome. Success of a closed task would be determined simply by whether the target information was located.

Investigative Goals

Investigative goals could be defined as those where the outcome is the result of an aggregation or a comparison of information across several locations. For example, comparing a particular feature of different brands of an item or collecting the names of items that have a particular feature. The distinctive feature of these tasks is that users are required to visit and revisit multiple pages in the site to compile an outcome. The major difference between this type of task and a closed task is that success of this task type can only be measured by how comprehensive the outcome is as opposed to having a single defined target.

Examples of instantiations of each goal types as actual questions might yield the following:

1. Open –
    a. Overview – e.g. "What is this site generally about?"
    b. Meta-informational – e.g. "How large is this site?"
    c. History – e.g. "Where have I come from?"
    d. Current Location – e.g. "Where am I now?"
2. Closed – "Where is ….?" "What is ……?"
3. Investigative –
    a. Comparison – e.g. "What is related to…..?"
    b. Aggregation – e.g. "How many …..?"

If the design of sitemap systems is to improve, then they need to take into account the behaviour and needs of the users who choose to use such systems. This requires an understanding of how people use sitemaps as well as of why they use them. Goal-sensitivity is one of the crucial factors in the design of user interfaces (Rose and Levinson, 2004). This section has presented various goal-type classification schemes from the hypertext and Web literature, and has proposed a continuum of goal types based on the specificity and complexity of goals. The next section will examine the other primary issue in this study which is the navigational strategies that users employ when interacting with a web site.

3.6 Navigation Strategies

Having examined the goals that users have when they interact with a web site, this section explores the strategies that may be employed to achieve goals. A strategy is "a careful plan or method; a clever stratagem; the art of devising or employing plans or stratagems toward a goal" (Merriam-Webster Online Dictionary). There are two classes of Web navigation strategies: inter-site and intra-site, as defined in Section 3.3.4. As previously stated, the focus of this project is limited to intra-site navigation and sets aside issues relating to the task of finding, selecting and moving between web sites.

Most web navigation behaviours can be attributed to some strategy. Some navigation strategies might be strongly-defined with evidence of practiced or planned behaviour, whilst other strategies are less defined relying on opportunistic or serendipitous behaviour. It would be unusual for a user to make navigational decisions in a completely random manner without any thought given to consequences of actions. Use of strategies change over time with users switching between an array of strategies in response to the availability of navigation aids and other features provided on web sites (Danielson, 2002).

It is acknowledged that individual differences play a role in navigation behaviours. Research suggests that users with different cognitive styles develop different strategies and tactics when seeking information on the Web (Martzoukou, 2005). Cognitive style refers to a person's "habitual and preferred way of doing a cognitive task" (Wang et al., 2000). Whilst individuals might have a preferred pattern of undertaking certain tasks, common strategies might be able to be generalised and classified.

One method of understanding the strategy that a user might employ to achieve some goal is to examine the sequence of actions that a user performs when visiting a web site. For example, one strategy might be to browse by selecting each of the main links from the current page and then returning to the previous page by selecting the 'Back' button. Another strategy might be to enter a keyword into a site search tool and then exploring each of the results from the search in turn.

Users have three basic navigational options when they arrive at a specific page in a web site.

(i) They can click on the 'Back' button to return to the previous page or site.
(ii) They can select a supplemental navigation tool e.g. search, index, sitemap.
(iii) They can use embedded links or menu options to browse from page-to-page.

A navigational strategy can be considered to be comprised of one, or a sequence of, these navigational options.

There has been a substantial amount of empirical research on the use of the browser's 'Back' button and page revisitation behaviour of users. Studies such as Catledge and Pitkow (1995) and Tauscher and Greenberg (1997) used client-side logging of user actions when using the Web. Catledge and Pitkow found that dominant navigation choices were embedded links (52%) and the Back button (41%). Tauscher and Greenberg found that link selection contributed approximately 50% of navigation acts, whilst the 'Back' button was used for approximately 40% of user actions. Similar client-side logging studies (McKenzie and Cockburn, 2001; Cockburn et al., 2003) found that web page revisitation is extremely prevalent with approx 81% of pages being previously visited by the user, and that users generally spend a very short period of time at most pages. Whilst these logging studies have provided some valuable perspectives on browsing behaviour, they provide very little information about the task contexts or the reasons why certain actions were performed.

This present study is concerned primarily with the goals of users and the relationship to the navigational actions and strategies that users undertake, hence the use of the 'Back' button is not to be investigated, apart from the use of this button as part of an overall browsing strategy.

The next two sections discuss the other navigational options available when users arrive at a web site. Specifically, the reasons why users might decide to use a supplemental navigation tool such as a sitemap, and the nature of the strategies utilised when users browse between pages in a site.

3.6.1 Using navigation tools

Web site designers use a variety of methods to provide navigation support for users. Neerincx et al. (2001) classified support functions into four categories: task related (FAQ, search, index), overviews (sitemaps, table-of-contents, guided tours, history lists), contextual cues (landmarks, current directories) and personalising (highlighting, agents, visited pages, chosen routes). Upon entering a particular page in a web site, a user has the option of selecting functions such as these, if they are available, as an alternative to browsing through the menus or embedded links that are provided. Such an action can be regarded as a strategy or a component of a strategy.

The most common supplemental navigational tools that are deployed into web sites are search tools, sitemaps and site indexes:

Search Tools

> Search tools may be provided by the web site developer to allow users to search the current site for a particular search string. Halasz (1988) and Conklin (1987) both suggested the need for query based search access to complement browsing modes of information retrieval in hypertext systems, especially when the system is large. Whilst search tool use is commonly regarded as the tool of choice for inter-site navigation, Teevan et al. (2004) in a study of the search behaviour of computer science students, found that keyword search was not heavily relied upon for directed searches within web sites. Participants in this study were found to browse in small, local steps towards target information, thus allowing users to specify less of their information need and providing a context in which to understand their results.

Sitemaps

> Sitemaps are a representation of a web site considered similar to the table of contents of a book, providing a list of the major categories of information (i.e. chapters) and their subsections. An extensive discussion relating to the design and use of sitemaps was presented in Chapter 2.

Site Indexes

> Indexes are usually considered to be an "alphabetical list with references, usually at the end of a book" (Oxford Dictionary). Hence, whilst sitemaps may be considered similar to a table-of-contents provided at the front of a book, it may be assumed that an index of a web site would be presented as an alphabetical list of the contents of the web site.

These support tools may either be incorporated into the design of the home page, or alternatively links to each may be provided in the general template of the web site. Generally, users are presented with a graphical or textual label, providing a link to each tool, i.e. Search, Sitemap and Index. The decision to select a particular tool is therefore based on an association the user makes between the information on the link label and their prior experience.

There are two ways in which a user may use these types of supplemental navigation tools. A user might click on the link to the tool immediately upon entering the homepage of a web site. Alternatively, a user might browse around the web site for a period of time and then select a link to a navigation tool, either from the home page or another page in the site. It may be argued that immediate use of a particular tool is a stronger indication that the visitor has been influenced to choose the tool by their current task. Alternatively, it must be recognized that some users might browse through the site in response to the task and possibly choose to use a tool after finding that they cannot achieve the task by browsing only. Other reasons for deferred use of navigation tools are that the user might only notice the tool links at a later stage, or possibly they have chosen to use a tool because of disorientation and frustration. Both overall use and immediate use of sitemap and search tools should be considered in any empirical study.

This section has discussed the option of using a supplemental navigation tool as the foundation of a navigation strategy. The focus of this project is primarily on the navigational options that are available and the reasons why users select a particular option, rather than how they use the tool. The following section discusses browsing as the third and final basic navigational option.

3.6.2 Browsing

3.6.2.1 Defining browsing

The previous section described the use of supplemental navigation tools as an option for navigating a web site. Browsing is an alternative mode of navigation if support tools are not provided. This section defines browsing, distinguishes it from searching and discusses how browsing strategies might be characterised.

The term 'browsing' is frequently used to describe how people interact with the Web, however it is often misused and misunderstood with the current literature providing numerous and often conflicting definitions. Many researchers agree that the term browsing is hard to define, describing it as terribly vague and fuzzy (Buckinham-Shum, 1996), an activity that is not clearly defined (Carmel et al., 1992) and due to its serendipitous nature, very difficult to quantify (Smith et al., 1997). The term browsing is derived from the "eating behaviour of deer when selecting fresh young shoots" (Cove and Walsh, 1988), implying the task of selecting material that is worthwhile and interesting to a particular person at a particular time. The phrase 'browsing the web' has now achieved a colloquial status, which conjures up the impression of people physically moving through an information space at will and with ease similar to the physical experience of browsing through shopping centres.

Browsing is a visual, direct access method of navigating hypertext structures where users view pages one at a time and navigate between them by activating hyperlinks (Cove & Walsh 1988; Balasubraminian, 1994; Olsten and Chi, 2003). Hildreth (1982) claimed that browsing is not a set of random actions but rather a "purposeful activity occasioned by a felt information need or interest". It is a method of navigation that suits ill-defined problems and new task domains (Marchionini & Shneiderman, 1988), as it allows users to apply recognition skills to find target items rather than having to recalling specific items to use as a search string (Korn, 1996).

Browsing offers incidental learning and promotes discovery through serendipity. Users may follow a train of thought using the links provided where one element of information triggers an association with another element (McAleese, 1989). This can result in users travelling an indirect path to a desired item, however it does provide an opportunity for users to see incidental but related information, to get an idea of the organisation of the information space and a sense of how other concepts are related to the target information (Foss, 1989). McAleese (1989) uses the example of a library where a reader who cannot find a specific book will scan along shelves, examining the table of contents and indexes of books near the target books location to find related information. Knowledge of the structure of the information space can influence less-specific information strategies such as deciding what next to browse, or what might be interesting (Padovani and Lansdale, 2003).

Olsten and Chi (2003) highlight a number of problems in relation to browsing, including poor link labelling and the possible dilution of link visibility due to a large amount of information on a page. Both problems can result in content in a site not being reachable through browsing. Section 2.2.3.1 of this thesis reviewed research into the issues of navigational residue and information scent (Pirolli and Card, 1995; Larson and Czerwinski, 1998; Chi et al., 2001; Pirolli et al., 2003). Information scent relates to the cues on a web page, such as link names and image links, on which users base their navigational decisions. The theory has implications for the quality of the link names provided on a web page by suggesting that a strong scent provides greater predictability and reduces disorientation and cognitive overload. Jul and Furnas (1998) define this as 'navigational residue' which is the evidence in a view that leads a user to believe that a particular target node may be reached by following a particular link. Good residue is that which correctly leads the navigator to believe that a shortest path to a node goes through a particular link.

3.6.2.2 Browsing and searching

Browsing can be clearly distinguished from the use of a search tool. Whilst browsing is the process of viewing pages one at a time and navigating between them using hyperlinks, searching is the process of entering a search query into a search engine, which produces a ranked list of links to pages that match the query (Olsten and Chi, 2003).

Frisse (1988) distinguishes browsing and searching as being two possible strategies of information retrieval. Search strategies are characterised by node retrieval by query formation and rely on systems which emphasise the relative autonomy of nodes with tools for retrieving nodes as answers to user requests whilst browsing strategies are characterised by node retrieval by link navigation and relies on a semantic link structure with tools for traversal and presentation. Lucarella (1990) clearly discriminates the two strategies with search techniques as supporting the "what to where" (we know what we want, but wish to find out where it is), whilst browsing techniques supporting the "where to what" (we know where we are, but we want to know what is there.)

From a cognitive perspective, the user effort differs between browse and search methods. Marchionini (1995) believes that search strategies require planning, greater cognitive overhead and have a higher degree of goal directness. Query-based interfaces rely on the formation of search strings with Boolean connectives and scope limits and require a prior knowledge of keywords and an understanding of special terms (Cove and Walsh, 1988; Marchionini & Shneiderman, 1988). The generation of search queries for complex problems in particular can result in a high cognitive load on short-term and working memory (Berndt et al., 1997). Search methods can facilitate rapid access to target information, however the additional cognitive load may increase the chance of errors. Although search techniques require a high cognitive effort, search tools are essential in large information spaces where it would be impractical to follow links to target information (Balasubramanian, 1994; Conkin, 1987).

Marchionini (1995) states that browsing strategies are more heuristic, interactive, data-driven and opportunistic. Cove and Walsh (1988) make the pertinent point that recognition is easier than recall. As a result, browsing demands a lower cognitive load as it only requires the user to select a single item on the current page. Browsing is also facilitated by rapid response times (Marchionini & Shneiderman, 1988; Berndt et al., 1997), and hence reduces the pressure on users to identify the 'most correct' link, consequently encouraging a discovery-based approach to information retrieval. On the other hand, browsing can result in intellectual and physical fatigue from the effort required in scanning lists of links (Liebscher & Marchionini, 1988) and following sometimes irrelevant links. Also, link selection is based on the user's subject domain knowledge for identifying the most appropriate link, hence experience is a success factor. Furthermore, browsing can promote 'cognitive laziness' as it is easier to browse than search (Carmel et al., 1992).

Browsing and searching techniques can mutually support each other. Searching can return inappropriate results and users can lose context (Olsten and Chi, 2003), hence browsing can supplement searching by allowing users to discover cues that can be useful for the formation of successful queries (Lucarella & Zanzi, 1993; Balasubramanian, 1994). An example of combining the power of search with the flexibility of browsing is a tool proposed by Olsten and Chi (2003) that combines the searching and browsing modalities in a unified interface where directed search results are returned with additional cues that provide hints to the related content in the proximity of each search result.

Page-to-page browsing is the fundamental navigation technique associated with hypertext structures. Browsing offers advantages to the users who may be unfamiliar with the context of a web site, can assist with learning the structure of an information space, provide incidental learning, and can augment other navigation tools. The applications of browsing range from targeted use involving practiced or planned behaviours, through to opportunistic behaviours with serendipitous outcomes. This suggests the existence of particular browsing strategies or tactics that might be used under different circumstances. The next section examines the strategies that might potentially be employed when browsing.

3.6.2.3 Categorising browsing strategies

The literature reports many different methods of analysing and classifying the different strategies that may be employed when browsing hypertext structures such as the Web.

One common approach is to distinguish strategies on the basis of user goal types. Cove and Walsh (1988) propose three categories of browsing: (i) *search browsing* which is a closely directed and structured activity where the desired product or goal is known; (ii) *general purpose browsing* which is an activity where the user consults specified sources that might contain items of interest; and (iii) *serendipitous browsing* which is a purely random, unstructured and undirected activity. Marchionini (1995) also based a similar classification on goal specificity and suggested three browsing strategies: (i) *directed browsing* which occurs when browsing is systematic, focused and directed by a specific target; (ii) *semi-directed browsing* which occurs when browsing is predictive or generally purposeful but the target is less definite and browsing is less systematic; and (iii) *undirected browsing* which is when there is no real goal and very little focus.

Choo et al. (2000) reported a study which used interviews and log files to investigate the information seeking behaviour of knowledge workers resulting in four categories of browsing strategies which differ on the focus of the search. Using the term ‘viewing’ in place of ‘browsing’ the four categories are: (i) *undirected viewing* where the user is exposed to information with no specific informational need in mind; (ii) *conditioned viewing* where the user directs the viewing to information about selected topics to assess the general nature of the information; (iii) *informal search* where the user actively looks for information to deepen their knowledge of a particular issue; and (iv) *formal search* where the user makes a deliberate or planned effort using some established methodology to obtain specific information about an issue. Danielson (2002) distinguishes between (i) *general-purpose browsing* where the user consults sources with items of interest; (ii) *subject-based exploration* in which the user attempts to gain a basic understanding of a specific subject area, and (iii) *fact-finding missions* where the users looks for a specific piece of information.

There is some consistency in these classifications, however most have been developed in the context of hypertext systems and few are empirically based.

> *“Few researchers have explored users' navigational strategies for exploring individual web sites”* (Zimmerman and Walls, 2000).

This section has reviewed several techniques for categorising browsing strategies, including the use of goal types and the focus of the search. An alternative approach is to draw on the history of physical navigation where the paths that navigators took when traversing physical environments provided an understanding of their navigation strategy. This approach is discussed and applied to the Web in the following section.

3.6.2.4 Using browse path patterns to categorise strategies

Many researchers draw parallels between navigating physical environments and the task of navigating through virtual information spaces such as the World Wide Web (Cunliffe et al., 1997; Benyon & Hook, 1997). It is common to find web site interfaces that employ analogical references to directions, paths, maps, footsteps and landmarks, all of which are familiar in physical environments. Some web sites heighten the level of the metaphorical experience by embedding the user in a 'virtual worlds', for example, a library, shopping mall or museum (Kim & Hirtle, 1995). Darken and Siebert (1996) refers to the process of 'wayfinding' as people find their way to a location in the physical world and relates this to the process of navigating virtual spaces.

One key characteristic of physical navigation the actual path that a traveller takes. Paths can take a variety of routes between a start and end point. Commonly travelled paths in physical environments wear a pattern in the ground that can be clearly identified. A pattern is a "frequent or widespread incidence; a reliable sample of traits, acts, tendencies, or other observable characteristics of a person, group, or institution" (Merriam-Webster Online Dictionary). A browse path pattern may be defined as a commonly used sequence of pages through a web site. Huberman et al. (1998) established that Web users have regular patterns of movement through web sites and verified these claims through the development of a mathematical model of browsing that determines the probability distribution of the depth and number of pages that users might visit in a web site.

It is in the context of considering the task of navigating the Web being similar to navigating a physical environment that some previous research has developed an understanding of the strategies the users employ when browsing information spaces by analysing the patterns that their paths take through the system. Canter et al. (1985) in a study of the way that users navigated through a database system identified several strategies that users were found to employ based on the number and order of nodes visited during a given search, as well as recognisable patterns such as sequential paths, rings, loops and spikes. This research identified five discernible search strategies: *scanning*, *browsing*, *searching*, *exploring* and *wandering*, as well as a number of factors such as individual preferences, experience, task and interface that have the potential to influence strategy. Parunak (1989) compared navigation in physical spaces with that of hypertext using a graph theory perspective yielding five basic strategies: *identifier* strategy, *path* strategy, *direction* strategy, *distance* strategy and *address* strategy. Carmel et al. (1992) approached the analysis of browsing patterns more formally by employing GOMS analyses of the decisions that users make at each junction to define three browsing patterns: *scan-browse* – scanning to evaluate information for interestingness; *review-browse* – reviewing to integrate information into the users' mental model; and *search-oriented browse* – search for relevant information then review it to integrate it. Tauscher and Greenberg (1997) in a study of users' revisitation patterns to web pages determined seven common browsing patterns: *first-time visits* to a cluster of pages; *revisits to pages*; *authoring of pages* where pages were reloaded to view the modified page; *regular use of web-based applications*; *hub-and-spoke visits* where users navigate to the pages linked from a central page and back again; a *guided tour* where links guide navigation through the web pages; and a *depth-first search* where users follow links deeply before returning to a central page. Navarro-Prieto et al. (1999) report a study into searching behaviour on the Web which identified strategies that support both fact-finding and exploratory tasks. Using observational techniques they identified three general patterns of searching: (i) *top-down* where users search in a general area and then narrow down their search from the links provided until they find what they are looking for; (ii) *bottom-up*, where users enter specific keywords in a search engine and then systematically go through the results; and (iii) *mixed* strategy, which uses both of the above strategies in parallel, searching for required information at the same time in multiple windows. Rouet (2003) differentiates tasks into specific questions and general questions and claims there is evidence that each triggers different search strategies in hypertext systems. Specific questions result in a *locate-and-memorise* pattern where the subjects quickly skim the contents and then pause for some time on the target. When answering general or high-level questions, subjects use a *revise-and-integrate* pattern where they go back and forth between several sections of the content apparently trying to establish connections between the ideas in the text.

All of these studies approach the identification of the strategies that users employ when browsing hypertext structures such as the Web by examining the common paths that are followed. A common feature of these studies is that subjects were typically asked to find a discrete piece of information in a hypertext system or web site. The measures commonly utilised were reliant on the total number of nodes or pages accessed, the number of different nodes or pages accessed, time taken to reach the target, and task success. Whilst such measures allow an analysis of closed, fact-finding tasks, they do not investigate possible strategies utilised for other goal types such as the investigative or open goals that were described in Section 3.5. Instead, these goals require measures that provide an understanding of more general attributes of navigation paths such as the extent of the site visited and the patterns of the paths that are followed.

3.6.2.5 Browse path measures

Having determined that the paths users take through an information space such as the Web can provide the basis for the identification of common navigational strategies, a method of quantifying the navigation paths is required.

Whilst task time and task success have been used frequently in empirical studies of navigation tasks and tools, the literature contains several examples of alternative metrics that have been used to document and analyse navigation paths. Smith (1996) identified a set of metrics based on 'path measures' to assess usability of hypertext systems in terms of the efficiency with which users find information, the degree to which users become lost through an examination of degradation of performance, and how confident the users are in their ability to find relevant information. The path measures in this study were derived from indicators such as the total number of nodes accessed, the number of different nodes accessed and the number of nodes which need to be visited to complete a task. The path measures were verified in a usability study using video and verbal protocols. Otter and Johnson (2000) extended Smith's metrics with the aim of attempting to measure lostness. The approach defined lostness in terms of degradation of performance and introduced the metrics of weighted links which based on their likelihood of inducing lostness, and a measurement of the accuracy of the users' mental model which assumes that the more accurate the model, the less likelihood of lostness.

This section has suggested that the total number of pages accessed, the number of different pages accessed and ratios of pages accessed to total possible pages in the site provide the basis for the development of a comprehensive understanding of the navigational experience of users. Further alternative metrics for documenting and analysing navigational paths include the following:

Breadth and Depth

The scope of the browse path, which could be defined in terms of breadth and depth, indicates the extent of the web site visited. The *breadth* of a browse path may indicate the range of topics or different sections visited, whilst the average *depth* of a browse path may indicate the level of detail of the information visited during the browse session. Measures of browse breadth and depth provide an indication of the focus of the browse path. A subject may have a highly focused browse path that would be characterized by high depth and low breadth (Figure 3.7). Alternatively a subject that who has a low focus would have a high breadth and low depth.

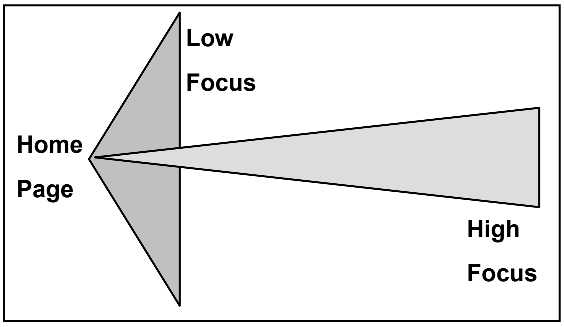


Figure 3.7: Browse focus

Hub-and-Spoke Patterns

A possible measure in understanding how users explore web sites is based on how users explore sub-structures in web sites. Catledge and Pitkow (1995) in an analysis of client-side log files of Web users found that many users operated in a pattern resembling a *hub-and-spoke* structure (Figure 3.8). The hub-and-spoke pattern involves "starting at a relative top-level node (or hub), digging along some path from that hub (creating a spoke), and then returning to the hub to create another spoke" (Danielson, 2002). A hub-and-spoke pattern is formed from frequent use of backtracking where the user has multiple explorations out from a page returning to the page via the same route using the Back button. Tauscher and Greenberg (1997) confirmed the nature of this pattern in a study of users' revisitation patterns to web pages, which resulted in the identification of seven common browsing patterns, including hub-and-spoke visits. The use of hub-and-spoke patterns may be considered an indicator of the level of sophistication of the browsing strategy as it demonstrates a structured and systematic approach to browsing in comparison to the user who haphazardly explores and who might revisit many pages multiple times due to lack of planning.

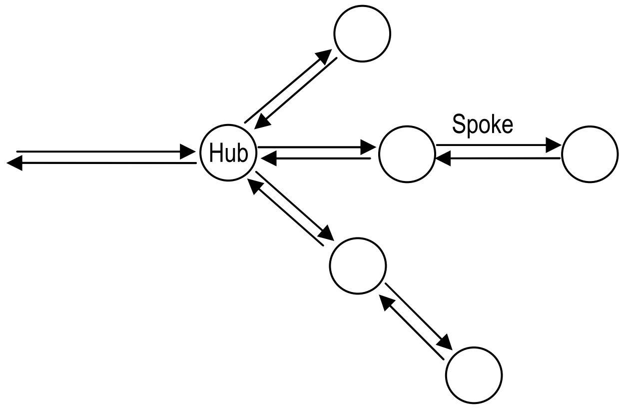


Figure 3.8: Hub-and-Spoke pattern

Landmarks and Homepage Revisits

A further set of more general measures may include the number of *landmarks* established and the number of *homepage revisits*. Previous research (Edwards & Hardman, 1989; Kim & Hirtle, 1995) linked browsing information spaces with the psychology of physical navigation, including the importance of landmarks to navigation. Landmark knowledge is the base form of knowledge for travellers who typically orient themselves exclusively by highly visual points of interest when confronted with a new city. Landmarks are used as "course-maintaining aids" (Cohen & Schuepfer, 1980), hence the common practice of placing highly salient landmarks at intermittent locations in the design of cities to assist first time visitors. Once landmark knowledge is established, more sophisticated structures are developed, including route and survey knowledge (Siegel and White, 1975). This could be extended to include the placement of landmarks at regular intervals in a hypertext system since they provide the skeletal frame of reference from which the two subsequent phases of learning may be achieved (Anderson, 1980). There are several obvious advantages to the identification of landmarks in web sites. Users, when disoriented or who fail to find a target item, tend to return to a focal point in a system (Norman, K., 1991; Shneiderman, 1997). Landmarks can help users recognise their presence in a certain part of a web site and prevent them from getting lost (Neerincx et al., 2001) The *homepage* of a web site is typically the major landmark in the system, hence when users get lost, they typically reposition to this page. The homepage is regarded as a safety node that is revisited whenever the user reaches a point in the browse path where they do not know where to go next or have lost track of where they are in the site. However, returning to the root node in a system can result in inefficient and unproductive navigation paths (Norman, K., 1991). Browsing efficiency is improved when users develop landmark nodes elsewhere in the site enabling them to reposition to these pages rather than the homepage when disorientation occurs. Hence, the number of homepage revisits may indicate a level of disorientation in the user who has to reposition to this node in order to gain a sense of position. The number of landmark pages established may also be used in any analysis of browse paths. Such landmarks may be recognised as pages that which are frequently accessed and are transition points where fundamental turns are taken (Norman, K., 1991; Tomek and Maurer, 1992).

This section has proposed some general navigation path metrics that would provide the basis for the identification of common navigation patterns and particular strategies.

3.6.2.6 Browsing performance and user experience

A significant amount of research has investigated the behavioural differences between experts and novices when using hypertext systems or the Web. Much of the research suggests that changes in information seeking behaviour occur as a result of increased experience of using the Web (Martzoukou, 2005).

Nielson (1993) differentiates between system and domain experience with the following classification of users: "users with minimal computer experience and users with extensive computer experience for the dimension of knowledge about computers in general; novice users and expert users for the dimension of expertise in using the specific system; and user ignorant about the domain and users knowledgeable about the domain for the dimension of understanding of the task domain." Likewise, Marchionini and Shneiderman (1988) distinguished users according to frequency of use, complexity of application, and the general range of computer experience. They argued that low-frequency users need additional assistance, whilst frequent users prefer direct commands. Nielsen (2000b) commented that with the pervasiveness of the Web, systems of the future would only need to focus on domain expertise.

Research examining both system and domain expertise in the use of hypertext systems found significant differences in strategies selected by experienced and inexperienced users (Canter et al., 1985; Rada and Murphy, 1992; Wright and Lickorish, 1994). In particular, McDonald and Stevenson (1998b) in a study exploring the effectiveness of map and text based interfaces for hypertext systems on navigational performance found that domain novices relied more heavily on navigational aides than domain experts, and Carmel et al. (1992) in a study of the cognitive processes associated with browsing hypertext discovered that experts used their knowledge to focus their browsing paths and used additional tools, whilst novices relied more on the links provided and spent additional time on trying to understand the basic structure of the content.

Some Web related studies have found that experience with the Web in general, or with the particular content, have both been found to be factors in navigation. For example, Navarro-Prieto et al. (1999) in an investigation of the cognitive strategies of users when searching the web found that subjects with less Web searching experience did not plan searches and were more influenced by the interface representation. Lazonder et al. (2000) found that experienced users were more proficient in the use of search engines. Saito & Miwa (2001) found significant differences in browsing behaviour for experienced users when performing information seeking tasks. Jenkins et al. (2003) examined the pattern of information seeking of Web users with different combinations of domain expertise and Web expertise and found distinct differences in searching patterns related to expertise. They found that domain and Web novices searched breadth-first, whilst those who were experts in both the Web and the domain carried out depth-first searches. Finally, Rouet (2003) undertook an empirical study that investigated influence of task specificity and prior knowledge on users' search strategies and incidental learning of a hypertext system. The study used fact-finding tasks with specificity manipulated by setting single vs. multiple target questions. Search time and search patterns showed a limited influence of discipline expertise on users' search strategies.

There appears overwhelming evidence in the literature that experienced users exhibit different behaviour when interacting with hypertext or Web systems, and that in general, users who have a high level of both domain and system experience utilise more efficient, sophisticated and systematic information seeking strategies. Consequently, the browsing paths and patterns of users with greater domain and system experience may enhance the understanding of the navigational needs of users.

3.7 Summary

The centrality of the user in design process is now recognised as a vital consideration in the design of interactive systems. The importance of understanding the needs and goals of users is critical to the success of any system, and therefore has been adopted as the primary consideration in the approach to this project. Consequently, this chapter commenced with the development of a conceptual framework that sought to explain human-web interaction in the context of previous research and established theories. Conceptual frameworks represent systems, processes, or structures by identifying the necessary elements and their relationships. In the context of web navigation, a framework can present an explanation of the various cognitive processes, decision points and options that users are confronted by, and the key elements that should be considered in any research into such interactions. The framework proposed in this project facilitated a focused analysis of the goals of users and the strategies that they might use to achieve an outcome.

The goals of web users vary widely, more so that most other interactive computer systems. As such, the task of understanding user goals and applying such knowledge into the design process is extremely difficult. One possible approach to gaining an appreciation of user goals is to develop a classification of goal types. The literature recognises the related factors of specificity and complexity as being major distinguishing characteristics of goal types. These factors have provided the basis for various classifications and taxonomies. For the purposes of this project, goal types may be regarded as lying along a continuum based on the level of ‘goal specificity’ ranging from tightly-defined closed goals to ill-defined open goals. The proposed continuum of goal-specificity (Figure 3.6) includes one axis extending from Open Goals to tightly-defined goals which require either a single (Closed Goals) or an aggregate answer (Investigative Goals).

A web user who arrives at a particular page in a web site has a number of navigational options: they can return back to the previous page or site via the Back button; they can browse the web site using menu options or embedded links; or they can choose to use supplemental navigation tools such as search, sitemap and index. Most web navigation behaviours can be attributed to some strategy which might vary from practiced or planned behaviours through to less-defined serendipitous or opportunistic behaviours. The use of either page-to-page browsing or supplemental navigation tools to achieve a goal are indicators of particular strategies. Furthermore, the actual type of navigation tool used, or alternatively, the browsing path that a user takes through a web site, adds to an understanding of the strategy that is currently being used.

It is these navigational options and user behaviours that expose some fundamental issues. The first issue relates to the impact that the users’ goal type has on a decision to use a particular a web site navigation tool. From the earlier discussion, it is clear that each of the reviewed tools have particular benefits that they offer users and as such, the relationship between the users’ goal type and the selection of a web site navigation tool must be understood if the design of navigation tools is to be truly informed by user needs.

The second issue concerns the impact of the users’ goal type on the strategy that they employ when undertaking page-to-page browsing. It has been proposed that browsing strategies can be understood by examining commonly used patterns that users take through web sites. Several navigation path measures were suggested which provide the basis for the identification of common navigation patterns and related strategies. An understanding of the navigational strategies that are commonly employed by users, particularly experienced users, will assist in the identification of the navigational needs of users with different goals. This knowledge can inform the design of navigational tools that support particular goal types.

3.8 Conclusion

This chapter has examined the role of the user in web navigation. A conceptual framework was developed that clarified for the purpose of this study, human-web interaction, information retrieval and navigation in the context established theories. Literature relating to user goals and navigational strategies was also examined resulting in the identification of two issues: the impact that the users' goal type has on a decision to select a particular web site navigation tool, and the impact of the users' goal type on the strategy that they employ when undertaking page-to-page browsing.

The next chapter explores these two issues and identifies several research questions for investigation.

4 Research Questions and Design

4.1 Introduction

The purpose of this project was to investigate the relationship between user goals and the use of web site navigation tools, particularly sitemaps, in order to provide a theoretical and empirical base for the development of design guidelines for sitemaps.

Chapter 2 reviewed historical and contemporary literature relating to hypertext and web navigation and identified several problems concerning navigation and disorientation. The use of web site navigation tools, particularly sitemaps, was discussed in terms of their ability to support navigation and alleviate disorientation. Design guidelines for sitemaps were reviewed and it was established that current design guidelines are deficient as they lack an appropriate foundation and are not sensitive to the informational goals of users. The lack of appropriate design guidelines for sitemap tools was identified for investigation.

Chapter 3 examined the centrality of the user in the navigation process. The chapter commenced with the development of a conceptual framework that explains human-web interaction in the context of previous research and established theories. This framework guided a discussion of user goals, goal types and navigation strategies resulting in the identification of two further issues: (i) the relationship between the goal specificity of users and their use of web site navigation tools; and (ii) the relationship between the goal specificity of users and their browsing behaviour.

This chapter extends these three issues into formal research questions. The chapter commences with a detailed discussion of each of the key issues resulting in an overall focus question for the project. Next, several targeted research questions are developed. The chapter provides a description of the overall research methodology as well as a brief overview of the purpose and methods used in each of the experimental studies.

4.2 Issues for Research

4.2.1 Design guidelines

Design guidelines are an accepted method of systematising knowledge relevant to the design process and are frequently used by interface designers to develop systems that are usable. Guidelines that are based on hypothesis-led usability studies are regarded as the most reliable and having the strongest validity. The review of the literature presented in Chapter 2.5 ascertained that there are few design guidelines for sitemaps, and these are based largely on expert opinion or observational evaluations. Furthermore, many previous empirical studies examining the use or design of navigational tools such as sitemaps or search tools did not considered goal specificity as a factor. Instead, these previous studies used search-oriented tasks in their experimental design and restricted data collection to measures of completion times and task success. Whilst such measures support the analysis of fact-finding tasks, they do not appropriately investigate possible strategies utilised for other goal types such as the investigative or open goals that were described in Section 3.5. Instead, these less-defined goals require measures that provide an understanding of the general attributes of navigation paths such as the extent of the site visited and the patterns of the paths that are followed.

A necessary prelude to the empirical stages of this project was the development of a base-line understanding of current sitemap design practice to ensure the relevance of any proposed design guidelines. Therefore, the status of sitemap designs and functionality, and the expectations that users have regarding the design and functionality of sitemaps, were identified for investigation through targeted research questions (**Q1** and **Q2**).

4.2.2 User goals and web site navigation tools

The project proposed a conceptual framework of human-web interaction in Chapter 3. A conceptual framework is a way of representing an object, system, process, structure or concept, by first identifying all of the essential elements and then representing their relationships in an organised manner. Whilst frameworks can be used in a range of ways, the emphasis on the development and use of a conceptual model in this project was to afford orientation and direction to the research by providing a structure in which the various variables, research questions and underlying theories were organised. This project does not attempt to validate the framework itself but rather uses the framework in the manner that Wilson (1999) suggests: "A conceptual model cannot be assessed directly empirically, because it forms the basis of formulating empirically testable research questions and hypotheses."

The proposed conceptual framework comprised four stages with a concurrent perception process and an interlinked cognitive model. Three of the stages were relevant to this study: goals, strategies and outcomes (Figure 4.1).

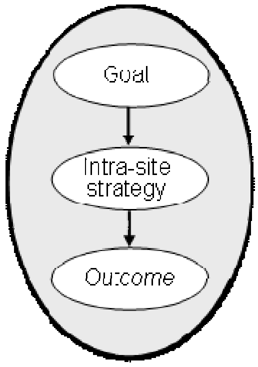


Figure 4.1: Relevant stages of Human-Web Interaction framework

The conceptual framework identified the issue of user goals and their relationship to web site navigation tools for investigation. Section 3.5 proposed a classification of goal types as lying along a continuum based on the level of 'goal specificity' ranging from tightly-defined closed goals to ill-defined open goals. Closed goals have a discrete answer, or set of answers, and once achieved will result in closure of the need. At the other end of the continuum are open goals which do not have a finite answer, and hence will not have a specific point of closure where the information need is satisfied.

Section 2.3 presented sitemaps as tools that provide a representation of a web site's content or structure that can assist users in orienting themselves within the web site, as well as providing users with an overview of the site's content and general purpose. These uses would tend towards the ill-defined end of the goal specificity continuum, hence a potential relationship between the use of sitemaps and low goal specificity is identified for investigation. Liekwise, search tools provide users with the ability to locate an individual page in a web site that contains a match to specific text query, hence are potentially tools that support goals of high specificity. Finally, site indexes which present an alphabetical list of keywords might provide a way for users who have a defined information need to jump between sections of a web site. This suggests that index tools might provide support for investigative goals that involve aggregation or comparison of content across multiple sections of a web site.

Whilst there appears to be a potential relationship between the level of goal specificity of users and their tendency to select particular navigation tools, this present project is primarily concerned about the relationship between the goals of users who select sitemap tools and as such a targeted research question was identified for this issue (**Q3**).

4.2.3 User goals and browsing strategies

The selected components of the proposed conceptual framework as shown in Figure 4.1 indicated that browsing strategies, particularly those intra-site strategies that are used when browsing a web site, were relevant for investigation. Users who arrive at a particular page in a web site have the option to backtrack, to use a web site navigation tool (as discussed in the previous section), or to browse from page-to-page to achieve their goal. This third option of browsing is examined here.

The relationship between browsing strategies and goal types was discussed in Section 3.5 where it was proposed that browsing strategies might be understood by examining the patterns of browsing paths. A number of path measures were identified that facilitate the identification and analysis of common navigation patterns, including: the number of pages visited, the number of unique pages visited, the breadth of path, the average depth of path, the use of hub-and-spoke patterns, home page revisits and the use of landmarks deeper in the web site.

An understanding of the navigation patterns that are commonly employed by users, particularly experienced users, may provide an insight into the navigational needs of users with different goals. Such insights can inform the design of navigational tools that support particular goal types. Hence, issues regarding navigation strategies and patterns, particularly those in relation to the use of sitemaps, were identified for investigation through a targeted research question (**Q4**).

4.3 Research Questions

From the earlier discussion it is clear that the relationship between goal specificity and the navigational behaviour of web site users must be thoroughly understood if web site navigation tools such as sitemaps are to be appropriately designed. This leads to the following overall focus question for this project:

> ***Does goal specificity influence the navigational behaviour of web site users, particularly in relation to their use of sitemaps, and what are the design implications for sitemaps?***

Four issues were identified in the previous section for further investigation. These issues provide the following targeted research questions that will address the focus question:

> **Q1:** What is the current status of sitemap designs and functionality on the World Wide Web?
>
> **Q2:** What expectations do users have of the design and functionality of sitemaps?
>
> **Q3:** What level of goal specificity do users have when they decide to use a sitemap?
>
> **Q4:** What primary navigational strategy should sitemaps support?

4.4 Methodology

This section describes the overall research methodology used in this research project commencing with a review of the major research traditions. A discussion of the methods and techniques that are suitable for HCI and information seeking research problems leads to the identification of particular research methods for each of the targeted research questions.

4.4.1 Research traditions

It is commonly accepted that there are three basic research paradigms, positivism, interpretivism and critical science (Sarantakos, 1996), that may be used as a starting point for the selection of appropriate research methods. Paradigms are based on fundamental belief systems about how scientific research is conducted and how knowledge claims gain credibility (Khazanchi & Munkvold, 2003). "A scientist will normally work within a theoretical framework - a paradigm - that determines the problems that are regarded as crucial, the ways these problems are to be conceptualized, the appropriate methods of inquiry, the relevant standards of judgment" (Philips 1987).

Positivism refers to a theory of knowledge that may be traced back to Auguste Comte (1798-1857) and which was extended by Francis Bacon, John Locke and Isaac Newton. Comte claimed that "positivism is an approach to improving the world through science" (Wikipedia, 2006). It is a paradigm that is based on a belief in objective data gained through direct, systematic observation. Positivists believe that there are basic laws and relationships that govern phenomena in world and that knowledge about these laws can be investigated and verified by objectively observing and measuring behaviour. Quantitative approaches are generally used for this paradigm, including the use of research instruments such as controlled experiments and surveys.

Interpretivists on the other hand, believe that reality and the individual who observes it cannot be separated (Weber, 2004). This paradigm questions the ideal of objectivity believing that prior assumptions, beliefs, values, and interests of the researcher influence investigations (Khazanchi & Munkvold, 2003). Interpretivism is particularly relevant when investigating human social phenomena where an investigation might deal with values, feelings and ideas. In these cases the reality is always relative to the observer and the data needs to be interpreted rather than measured in order to create knowledge about the phenomena. The interpretivist paradigm generally uses qualitative approaches to research which do not predefine dependent and independent variables, but rather focus on "the full complexity of human sense making as the situation emerges" (Myers, 1997). The main types of qualitative research methods include case studies, grounded theory, phenomenology and ethnography.

The critical approach, or 'Critical Theory', is a theory that has its origins in Marxism where there is a belief that reality is controlled by a dominant few who influence and manipulate the perceptions of the population. The critical theory research paradigm suggests that "objective observation is impossible and that all knowledge is generated or justified in the context of the researcher's framework and assumptions" (Khazanchi & Munkvold, 2003). Knowledge is generated and justified by a critical evaluation of social systems in relation to the perspective adopted by the researcher. This research paradigm is usually adopted for investigations into how people understand and improve social systems. The role of the researcher is more active and transformative and includes qualitative methods such as action research.

Whilst much has been written about the differences between the various research paradigms, Weber (2004) argues that there are few substantive differences at a "metatheoretical level" relating to ontology, validity, reliability, etc, but rather the differences relate simply to the choice of research methods. Researchers who are labelled as positivists tend to use experiments, surveys, and field studies, whilst interpretivists use case studies and ethnographic studies. Hence, whilst the distinctions between paradigms are interesting, it is can be suggested that the selection of methods and techniques relative to the actual research problem is more critical.

Each research method has intrinsic strengths and weaknesses. McGrath (1994) explains how each method has potential opportunities not available by other means, but also each has their own inherent limitations. For example, laboratory experiments permit precise measurement of effects resulting from manipulation of variables, however researchers using laboratory experiments sometimes narrow the scope of the problem too much which can result in situations that are artificial. Similarly, whilst qualitative methods such as case studies retain authenticity, they can suffer from a lack of validity and reliability of outcomes.

4.4.2 HCI and information seeking research

The broad focus question for this project relates to users, their tasks, how they navigate a system to complete those tasks, and the design of tools to assist in navigation. These issues draw on the related research areas of human-computer interaction and information retrieval.

> *"Human-computer interaction (HCI) research is performed to provide and promote a scientific understanding of the interaction*

> *between humans and computer technology and tools that we use".* (Giacoppo, 2001)
>
> Information seeking research aims to *"understand the complex process that involves and requires a number of information-related activities",* including *"human information seeking and retrieving behaviours"* and *"the means of searching and retrieval by users and the systems and techniques to accomplish all of these".* (Spink, 2000)

HCI has its foundation in psychology and software engineering with a particular emphasis on design of usable systems. HCI also draws on a range of disciplines such as cognitive science, sociology, computer science, artificial intelligence, linguistics, behavioural sciences and design. HCI has historically relied on the scientific approach with the use of techniques such as task analysis, controlled experiments, surveys, logging and heuristic evaluations. However, various qualitative methods such as case studies, action research and ethnographic methods of contextual inquiries and field studies are now regarded as valid HCI methods.

The intersection with research into information seeking behaviour in this project provides a useful parallel. Information science in general is concerned with how humans create, seek, retrieve and use information from systems such as digital libraries and the Web (Spink, 2000). Issues such as searching behaviour, knowledge of the particular domain, prior experiences and task complexity all contribute to a complex interaction of cognitive and situational variables. Whilst quantitative surveys based on structured questionnaires and interviews have been the most common data collection methods in information seeking research (Byström and Järvelin, 1995), qualitative methods, including case studies, ethnography and grounded theory, are sometimes considered more appropriate where an in-depth understanding of human actions is the primary focus (Martzoukou, 2005).

4.4.3 Research approach

Accepting the validity and equality of both qualitative and quantitative methods for each of HCI and information seeking research, the approach taken in this project was that the general types of each of the targeted research questions were used as the basis for the selection of appropriate methods. Particular types of research questions lend themselves to specific research methods. For example, the following table extends a proposal from Cresswell (2005) by suggesting relationships between types of research questions, research methods and their related paradigm.

Table 4.1: Mapping of Research Question to Methods

Research Question	Method	Paradigm
Explaining whether an intervention influences and outcome for one group as opposed to another group	Experimental Research	Quantitative
Associating or relating variables in a predictable pattern for one group of individuals	Correlational Research	
Describing trends for a population of people	Survey Research	
Exploring common experiences of people to develop a theory	Grounded Theory Research	Qualitative
Exploring the shared culture of a group of people	Ethnographic Research	
Exploring individual stories to describe the lives of people	Narrative Research	

Using the mapping of general question types to research methods as proposed in Table 4.1, the Table 4.2 assigns each of the four targeted research questions with a particular research method and an appropriate approach to data analysis.

Table 4.2: Appropriate Research Methods

Research Question	Method	Analysis
Q1: What is the current status of sitemap designs and functionality on the World Wide Web?	Survey	Categorisation of findings
Q2: What expectations do users have of the design and functionality of sitemaps?	Survey	Categorisation of responses Descriptive statistics
Q3: What level of goal specificity do users have when they decide to use a sitemap?	Experimental	ANOVA
Q4: What primary navigational strategy should sitemaps support?	Experimental	ANOVA

4.5 Empirical Studies

The overall project investigated issues relating to user goals and their relationship to browsing strategies and the use of supplemental navigation tools, in particular sitemaps. The literature review has suggested that goals vary in levels of specificity. It is postulated that goal specificity impacts user behaviour in two ways:

(i) goal specificity is a factor in the choice of navigational tool employed by users;

(ii) goal specificity is a factor in the navigation strategy employed by users.

Four targeted research questions were developed to explore the nature of the problems and the postulated relationships. Three empirical studies were undertaken to investigate the targeted research questions.

The first study addressed the first two research questions. The study involved three survey activities which explored the nature of the issues associated with sitemaps including examining the relationship between user goals and tool choice. Also investigated were user expectations regarding the design and operation of sitemaps, indexes and search. These expectations were compared with design practices in commercial web sites.

Study 2 addressed the third research question through an empirical study that examined the effect of goal specificity on the selection of supplemental navigation tools. A repeated measures analysis experiment was used in this study to test the hypotheses that was generated from the findings of the first study.

Study 3 addressed the fourth research question by establishing how goal specificity impacts the navigational behaviour of web site users. The experiment identified a number of general navigational strategies employed by users when undertaking a several tasks of different levels of goal specificity. This was achieved by analysing the navigation patterns when undertaking page-by-page browsing. This study provided an understanding of the general strategy that users employ for different levels of goal specificity. An experiment utilising a between-subjects design was undertaken in order to investigate the relationships between goal specificity and browsing behaviour.

4.6 Summary

This chapter synthesised the issues identified in the review of the literature into an overall focus question for the project. Four targeted research questions were developed to guide the empirical stage of the project. The chapter described the approach taken in the selection of general research methods and provided an overview of the three studies that were undertaken in the project. The next three chapters present the details of the each of the empirical studies including specific aims, procedures and relevant findings.

5 Study 1 – Exploratory Surveys

5.1 Introduction

The review of the literature in Chapters 2 and 3 identified several issues concerning the design and use of supplemental navigation tools, particularly sitemaps, which resulted in a number of targeted research questions as presented in Chapter 4. This initial study investigated the first two targeted research questions:

Q1: What is the current status of sitemap designs and functionality on the World Wide Web?

Q2: What expectations do users have of the design and functionality of sitemaps?

The study also provided a preliminary investigation into the third targeted research question:

Q3: What level of goal specificity do users have when they decide to use a sitemap?

The first survey involved a review of 300 major commercial web sites to determine contemporary design practice for each navigation tool. The second survey evaluated user expectations regarding the design and operation of sitemaps, indexes and search tools. The final survey investigated user expectations regarding the purpose, with respect to user goals, of the same navigation tools.

The three surveys in this study provided a snapshot of the utilisation of navigation tools in commercial web sites along with an understanding of expectations that users have of the design and purpose of navigation tools. These findings provided an initial point of reference which directed the design and scope of the other empirical studies in this project.

5.2 Exploratory Survey 1

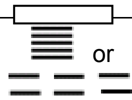
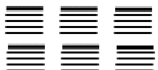
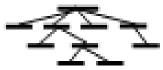
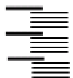
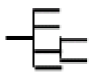
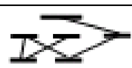
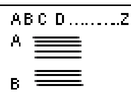
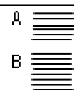
5.2.1 *Introduction*

A survey of major commercial web sites is reported which provides an overview of the range of designs and functions of supplemental navigation tools such as search tools, sitemaps and site indexes. The results yielded several categories of each tool.

5.2.2 *Method*

A Survey Checklist (Appendix 1.6) was developed in order to systematically examine the design of supplemental navigation tools (Search, Sitemap and Index) in each web site. In addition to the presence of each tool, the tools were classified according to the classification scheme shown in Table 5.1 that includes an evaluation of structure, level of interactivity, number of initial visible levels and additional features such as filters or advanced search functions.

Table 5.1: Classification Scheme for Supplemental Navigation Tools

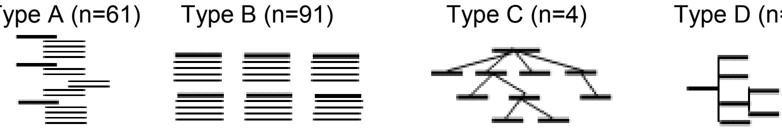
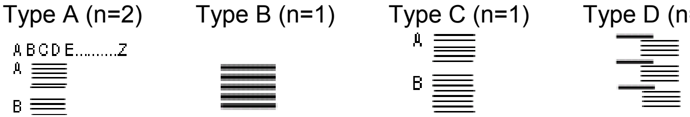
Structure			**Design**
Text field			
Categorical	Flat		
	Hierarchical	Horizontal Textual	
		Horizontal Graphical	
		Vertical Textual	
		Vertical Graphical	
	Network		
Alphabetical	One page	Indexed	
		No Index	
	Multiple pages		

The survey was conducted in late 2002 and reviewed the top 300 companies from the Fortune 500 list all representing major commercial sites. Further surveys would be required to establish supplemental tool use in other types of sites such as educational, entertainment and personal sites.

5.2.3 Results

The survey results are shown in Table 5.2. The ‘N’ column shows the number and relative percentage of responses in each category.

Table 5.2 : Survey 1 Results

Search Tools		**N (%)**
Presence	Search is present	206 (68.7)
Location	Link to search	66 (32.0)
	Integrated into template	140 (68.0)
Sitemap Tools		
Presence	Sitemap is present	158 (52.7)
Categorisation	Alphabetical	0 (0)
	Categorical	158 (100)
Structure	Hierarchical	158 (100)
	Network or other	0 (0)
Levels	Number of initial levels 1 level -26, 2 levels -75, 3 levels -52, 4 levels -4, 6 levels -1	
Interactivity	Expand/Contract or other	2 (1.2)
Size	Scrolling required (1024x768)	114 (72.2)
Design: Type A (n=61) Type B (n=91) Type C (n=4) Type D (n=2) 		
Index Tools		
Presence	Index is present	22 (7.3)
Categorisation	Alphabetical	3 (13.6)
	Categorical	19 (86.4)
Interactivity	Expand/Contract or other	0 (0)
Size	Scrolling required (1024x768)	18 (81.8)
Design: Type A (n=2) Type B (n=1) Type C (n=1) Type D (n=18) 		

The survey found that only 69% of the sites provided a search tool with the majority of the search tool interfaces (68% of those with search tools) embedded into the general site template rather than having a link to a dedicated search page. All sites without a local search tool had either a sitemap or an index tool available for supplemental navigation support.

Some 158 (53%) of the sites surveyed provided a sitemap, usually implemented as a link in the basic page template. All sitemaps presented a hierarchical view of the site based on a list of the major categories within the content. Sitemaps were categorized into four basic designs depending on the way the levels in the hierarchy were presented and connected. Only six of the sitemaps were graphical with a drawn line linking the levels in the hierarchy (C and D in Table 5.2). More commonly, the sitemaps were presented as a list of textual links using either indenting (A in Table 5.2 with n=61; 38%) or columns (B in Table 5.2 with n=91; 57%) to visually distinguish the levels in the hierarchy. An example of hierarchy distinguished by indenting is provided in Figure 5.1. Figure 5.2 presents an example of hierarchy organised using columns and headings to distinguish the sections. Almost all sitemaps allowed the user to click through to an area of interest with only two sites having additional interactivity such as controls to expand or contract the hierarchy. All sitemaps were presented on a single web page with most (n=114; 72%) requiring some scrolling to view the entire sitemap on a standard resolution.

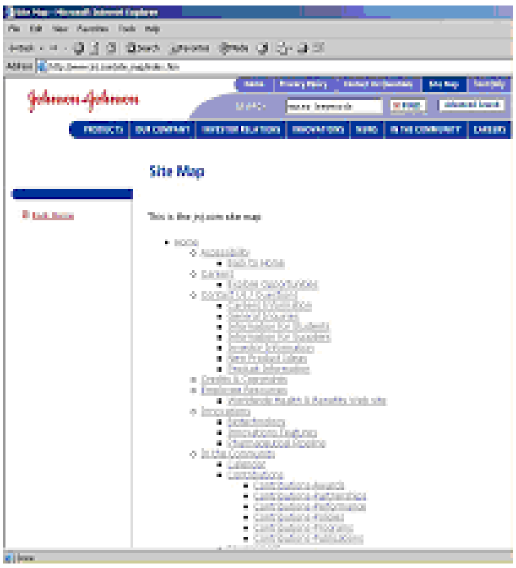


Figure 5.1: Sitemap with indenting

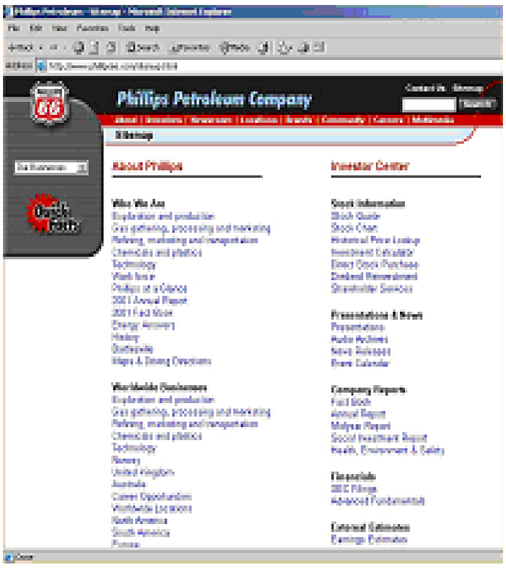


Figure 5.2: Sitemap with columns

Only 22 (7%) sites provided a site index usually with the link and page heading stating ‘Index’ or ‘Site Index’. Of these, only three sites presented the index structured as an alphabetical list of the site contents. This appears to be inconsistent with the accepted typographical convention in books where indexes are organised alphabetically. The most common design (n=18, 81%) of an index actually presented a tool that resembled a sitemap in the sense that they presented a categorical hierarchy of the content. Figure 5.3 shows two examples of sites with Site Index tools using a categorical organisation. None of sites surveyed offered both a sitemap and an index.

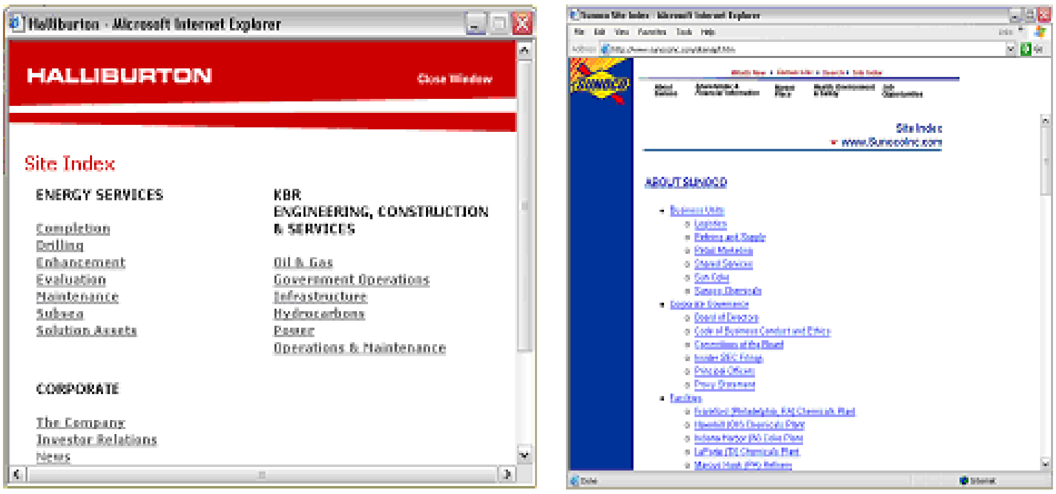


Figure 5.3: Categorical site indexes

5.3 Exploratory Survey 2

5.3.1 Introduction

The aim of the second survey was to investigate user expectations regarding the design and operation of search tools, sitemaps and indexes.

5.3.2 Participants

Eighteen participants took part. All were required to have a minimal level of system experience using the World Wide Web and domain experience using university web sites. All participants were surveyed individually in sessions that took approximately 45 minutes and were paid a fee of $10.

Approval to use students as experimental subjects was gained from the Swinburne University School of Information Technology Ethics Committee. All participants completed and signed an informed consent form.

5.3.3 Setting

All sessions were conducted in the Swinburne Human-Computer Interaction Laboratory (SCHIL) usability laboratory using the same system procedure.

5.3.4 Method

Participants read information explaining the purpose and nature of the survey and asked any questions. The informed consent form was signed. All materials may be found in Appendix 1.

Participants completed a questionnaire examining prior Web experience. Those with less than one year total or one hour/week of web use were excluded.

Participants read the written instructions explaining the procedure for survey and were given the opportunity to ask any questions. The survey involved three sketching activities. Participants were provided with coloured pens, pencils, erasers and three task sheets, each containing written instructions and a blank web page template. The instructions asked the participants to imagine visiting a university web site that contained a link called Search (task sheet 1), Sitemap (task sheet 2) and Index (task sheet 3). Presentation of the task sheets was counterbalanced. The instructions directed them to sketch the visual appearance of the way they would expect the tool to look. A video camera suspended from the ceiling above the desk recorded video of the sketch. Participants were allowed five minutes on each of the three sketching activities. The investigator informed the participant of the time remaining after four minutes had elapsed.

After all three sketches were completed, the investigator asked the participants to explain the operation and functionality of each of the navigation tool interfaces that were sketched. The video camera recorded the explanation, including audio of the participant's verbal description of the functionality.

5.3.5 Results

The sketch and associated explanation of each navigation tool were classified using the following criteria:

(i) Structure (using the classification from Table 5.1)

(ii) Interactivity controls (from participant's explanation)

(iii) Number of levels displayed.

Figures 5.4 to 5.6 show samples of participants' sketches of each of the navigation tools. Most sketches had clearly defined designs which facilitated the classification process.

Figure 5.4: Sample sketch of search page

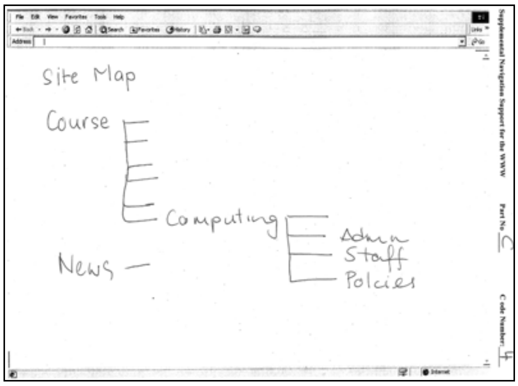


Figure 5.5: Sample sketch of sitemap page

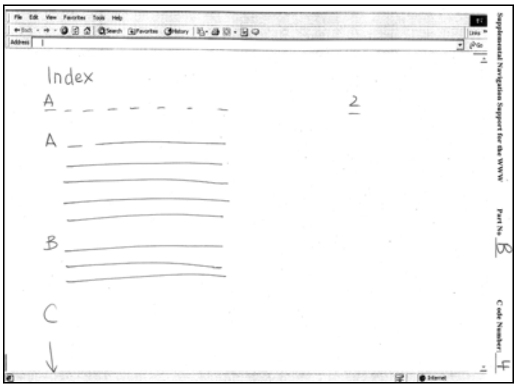


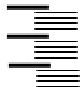
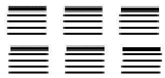
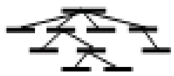
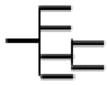
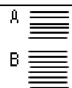
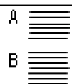
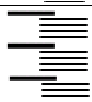
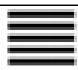
Figure 5.6: Sample sketch of index page

Several categories of each tool were established from the criteria of design, structure, interactivity, layout, levels and the sketch. Across all of the sketches 2 types of search tools were identified, 7 types of sitemap designs, and 5 types of indexes. These are shown in Table 5.3. The N field indicates the number of responses and relative percentages in each category.

The results suggest a very strong expectation regarding the design of a search tool, with all participants indicating a text field design similar to that shown in Figure 5.4 and a high proportion (44%) expecting advanced search features.

There was quite a high level of agreement in the basic design of sitemaps with 17 participants (94%) indicating they would expect a categorical organization with a strong preference for hierarchy (89%). Some nine participants (50%) expected a textual hierarchy as shown in Type A and B with a further five (28%) expecting a graphical, tree-based hierarchy as shown in Types C and D. Most participants expected that they would be able to view 2 or 3 levels and that they should be able to click through to an area of interest. Only a couple of participants indicated that they would expect expand/contract type controls "similar to Windows Explorer" on the Type A sitemap. Most sitemap diagrams fit entirely within the bounds of the page, hence scrolling was generally not required.

Table 5.3: Categories of Navigation Tool Sketches

Tool	Type	Structure	Design	N (%)
Search	A	Text Field		10 (55.6)
	B	Text Field & Adv Search		8 (44.4)
Sitemap	A	Categorical Hierarchical Interactive 2 initial levels		8 (44.4)
	B	Categorical Hierarchical 2 levels only		1 (5.6)
	C	Categorical Hierarchical 3 or 4 levels		3 (16.7)
	D	Categorical Hierarchical 2 or 3 levels		2 (11.1)
	E	Categorical 1 level only		2 (11.1)
	F	Categorical Network		1 (5.6)
	G	Alphabetical		1 (5.6)
Index	A	Alphabetical Internal links		8 (44.4)
	B	Alphabetical		3 (16.7)
	C	Alphabetical		2 (11.1)
	D	Categorical Hierarchical 2 initial levels		3 (16.7)
	E	Categorical 1 level only		2 (11.1)

There was some disagreement in the expected design of indexes with 13 participants (67%) indicating some type of alphabetic representation although the actual organization of the index did vary. Most expected Type A which had the index presented on a single page with an internal index linking to each letter. Three stated that the index would be organised with the different letters on separate pages as shown in Type B. Surprisingly, five participants (28%) indicated that they expected a categorical rather than alphabetically representation which is consistent with the survey which found that 81% of the site indexes on the sites which were surveyed are organised as lists of categories. All participants indicated that they expected to be able to click through to an area of interest.

5.4 Exploratory Survey 3

5.4.1 Introduction

The third survey provides a preliminary investigation into the third targeted research question by examining the level of goal specificity users have when they choose particular navigation tools. The specificity of the user's immediate goal or informational need is one method of examining a user's reason for using a particular tool. A classification of goals according to specificity was presented in Section 3.5 with open goals having a low level of specificity, closed goals being characterised by having a very specific information need resulting in a discrete outcome, and investigative goals defined as those where the outcome is the result of an aggregation or a comparison of information across several locations. This survey provides a preliminary understanding of the reasons users chose particular navigation tools by examining the specificity of user goals for each tool choice.

5.4.2 Participants

This experiment used the same participants who completed the first experiment in this study. See Section 5.3.2 for details.

5.4.3 Method

The survey involved the completion of a checklist which asked participants which supplemental navigation tool they would select for various web site navigation scenarios. In a repeated measures design, participants were instructed to respond to scenarios of three types (open, closed, investigative) as defined in Section 5.4.1.

The Scenario Checklist contained a list of 12 scenarios set in the context of a university web site as shown in Figure 5.7.

Four scenarios of each of the three task types (open, closed and investigative) where presented. The order of task types was randomised. The list contained three columns labelled *Search, Sitemap* and *Index*. Participants were instructed to tick the navigation tool they believed would assist them the most when confronted with each scenario. No hints were given to ensure that all findings were based on their preconceptions.

	Scenario	**Search**	**Sitemap**	**Index**
1	You wish to find out the name of the Vice Chancellor.			
2	You wish to find out what programming languages are taught in the computing courses.			

Figure 5.7: Sample scenario checklist

Participants read the written instructions explaining the procedure and were given the opportunity to ask any questions. A practice activity was provided in order to familarise the participants with the procedure. Participants were allowed 10 minutes to complete the checklist.

5.4.4 Results

The mean number of times participants selected each navigation tool for each task type is shown in Figure 5.8.

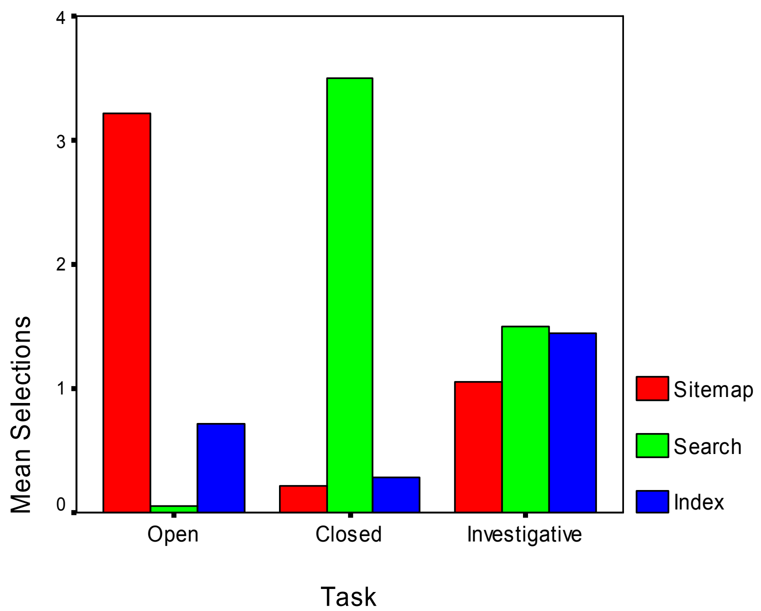


Figure 5.8: Task type / tool selection

Clearly, the level of agreement was very high for the open and closed task types with 80.6% of selections for open tasks being a sitemap (M = 3.22, SD = 1.00) and 87.5% of selections for closed tasks being a search tool (M = 3.50, SD = 0.71). However, there was considerable disagreement with respect to the investigative tasks with no clear preference for any of the three tools.

These results lead to the identification of the following related hypotheses:

(i) Web site users selecting sitemaps are more likely to have an open goal than a closed goal.

(ii) Web site users selecting search tools are more likely to have a closed goal than an open goal.

No hypothesis could be generated for the relationship between the selection of index tools and any particular goal.

With a relatively small sample size this survey cannot make any definite inferences regarding these hypotheses. However, one statistical indicator that might add some general support would be an investigation of the observed findings against what might be expected if the participants had chosen their responses completely randomly. Random selection of a particular tool across the 12 scenarios would yield a mean of 1.33 selections for each tool. To test the extent to which the observed findings differed from a random selection, a series of single sample t-tests were performed. These results differed significantly in the open tasks ($t(17) = 7.99$, $p<0.001$)) and closed tasks ($t(17) = 15.32$, $p<0.001$) supporting the hypothesised relationships. The findings suggest that choices involving the Search and Sitemap tools are unlikely to be randomly decided. Rather, participants chose these tools deliberately for the task they were undertaking. The t-test for the Index tool was not significant as the choices were similar to a random selection, and hence difficult to relate to a particular task type.

5.5 Discussion

5.5.1 Findings relating to the research questions addressed by this study

Q1: *What is the current status of sitemap designs and functionality on the World Wide Web?*

Sitemaps appear to be popular supplemental navigation tools with just over half of the 300 surveyed sites offering a sitemap tool on their web site. This percentage is relatively high when it is compared with the provision of search tools. Only 69% of the surveyed sites provided a search tool which is remarkably low considering strong advice in web site design guidelines (Nielsen, 2000a) that strongly recommends the inclusion of local search tools in medium to large sites. The survey found that all of the sites without a local search tool provided either a sitemap or an index tool. This raises a question whether site designers might regard these other tools as providing equivalent level of navigational support for users.

All of the sitemaps on these commercial web sites provided a list of the major content categories within the site organised into a hierarchy of several levels. Hierarchical structures are considered ‘best practice’ in supporting information seekers as they are well understood by users (Durand and Kahn, 1998) and support decision making (Norman K., 1991).

Despite the historical links of sitemaps with hypertext graphical overview diagrams, only 6 of the 158 sitemaps examined provided a graphical format. The use of textual lists of content headings appears to be dominant style. Possible reasons for the use of text-based sitemaps are that ‘Table of Contents’ formats are familiar and well-understood due to their use in books (Hoffman, 1996). Also, textual formats support auto-generation methods of creating and updating information on the sitemaps, whilst graphical formats usually need human intervention for development and maintenance.

Significantly, most (n=114; 72%) of the sitemaps found on the survey web sites requiring the use of scroll bars in order to view all of the information provided. It is accepted that the use of scroll bars in tasks which require navigating a large two-dimensional space may causing the user to perform sub-optimally (Beard and Walker, 1990). A related finding is that there was almost no use of visualisation techniques such as controls to expand or contract the hierarchy. Contemporary visualisation research provides some guidance regarding the use of display techniques that can control the complexity of the view presented to the sitemap users. Display techniques that provide global and local views, zoom options allowing user-controlled levels of overview detail or fish-eye views that provide varying levels of detail, can all minimise the effects of scroll-bars, however they appear not to be incorporated into sitemaps on commercial web sites.

Q2: *What expectations do users have of the design and functionality of sitemaps?*

The results of the second survey suggested some consensus in user expectation regarding the structure of sitemaps. The results suggested a strong expectation that sitemaps would be presented as a categorical hierarchy of links displayed on a single web page. In some respects, expectation matches the actual practice in commercial sites considering the results of the first survey.

Expectations regarding the design of the hierarchy varied with a relatively equal spread of participants expecting a textual organization with those expecting a graphical view. Here, expectation conflicts with actual practice since only six sitemaps in the first survey used a graphical design as shown in Table 5.1: Types C and D, whereas a greater percentage of participants in the second survey (n=6, 33%) indicated that they would expect a more graphical design.

The layout of the hierarchy also varied between expectation and practice. The first survey found that 38% (n = 61) of the surveyed commercial sites used a single column design (Type A). This is consistent with the results of the second survey which found that eight participants (45%) indicated an expectation of this style of sitemap. An inconsistency was that 57% of the sitemaps in the first survey had multiple columns (Type B), whilst only one participant in the second survey indicated that they would expect this design.

Q3: *What level of goal specificity do users have when they decide to use a sitemap?*

The third survey indicated a probable relationship between the use of sitemap tools and goals of low specificity. The results suggested that when users have a low level of goal-specificity, possibly interested in general rather than specific information, they are more likely to choose a sitemap tool than other navigation tools. Together, the surveys suggested a hypothesis that users who select sitemaps are more likely to be performing tasks of low goal specificity. This may be because sitemaps provides a high level, hierarchical view of the major categories of the web site.

5.5.2 Other findings

Search tools

The second exploratory survey identified a high level of agreement in participant's expectations regarding the design of search tools since all participants indicated that they expect these tools to use a text entry field into which they place a search string. Many participants also indicated that the tool would contain advanced search features or filters. This is consistent with Nielsen's (1997) views: "Search is the user's lifeline for mastering complex web sites" and "the best designs offer a simple search box on the home page and play down advanced search and scoping".

The third exploratory survey suggested a strong relationship between closed goals and selection of a search tools. When users have a very specific information need that would result in a single outcome, they are more likely to choose a search tool than other navigational tools. This strong mapping might be contributed to the consistency of design of search tools where all search tools take a discrete search string as input.

The strong relationship between user expectations and actual tool design is evidenced in the first survey where all sites with a search tool used a text entry field as the major interface component. The clear user expectation of the design and functionality of search tools and the strong mapping to closed tasks indicate that further investigation of search tools would contribute to our understanding of other navigation tools such as sitemaps.

The combined results of the surveys provide a potential hypothesis that local search tools support closed tasks.

Indexes

The results of the first survey indicate that most users expect indexes to provide an alphabetical listing of the contents of the site. Many of the participants in the second survey said they expected a web site index to be similar in structure to an index of a book which is by convention an alphabetic list of keywords and topics. It is remarkable that some of the participants in the second survey indicated that they expected an index to provide a list of the major categories of the web site. Also remarkable are the results of the initial survey that found that most sites that provide an index tool do not use an alphabetical organization. The lack of consistency in expectation and the mismatch between expectation and current practice probably contribute to the overall lack of utilization of indexes in commercial web sites.

5.6 Summary

The combined findings suggest that sitemaps have the potential to be useful tools as there appeared to be some consensus regarding purpose with most participants indicating a preference for a sitemap rather than the other tools when undertaking goals of low specificity. It was noted that the initial survey determined a lack of consistency in the design of sitemaps on commercial web sites. This is an important finding as it aligns with the evidence found in the literature regarding the lack of suitable design guidelines for sitemaps. A hypothesis regarding the relationship between the selection of sitemaps and goals of low specificity was proposed for further investigation.

The strong mapping between closed tasks and search tools and the fact that all of major sites surveyed use a similar design indicated that users will benefit if consistency of design and a clear purpose for a tool can be identified. A user with a well-defined information goal knows what a search tool will do, when to use it and how to use it. Given this strong mapping of expectation to current practice, search tools were investigated further in this project as a model of a successful navigation tool.

There is a lack of consistency with regards to the expectation of the fundamental design of index tools and there appears that there is no particular level of goal specificity that index tools support. The focus of this thesis is on the design and use of sitemaps, hence index tools were not examined further.

A limitation of the third survey was that it relied on participant's claims about how they would act for scenarios of different levels of goal specificity. The next chapter presents the results of a more rigorous investigation which tested the hypothesised relationships between the specificity of user goals and selection of sitemaps and search tools through an empirical investigation into participant's actions when interacting with live web sites.

6 Study 2 – Goals vs Tool Choice

6.1 Introduction

This study addressed the third targeted research question:

> ***Q3:*** *What level of goal specificity do users have when they decide to use a sitemap?*

Findings from the final exploratory survey in the previous chapter suggested that there was a potential relationship between the decision to use specific supplemental navigation tools (sitemap and search tools respectively) and the level of goal-specificity of the task the user is undertaking. The previous study referred to a definition of goal specificity from Section 3.4 which described open tasks as having a low level of goal specificity and closed tasks as having a high level of goal specificity. Open tasks are general in nature without a specific outcome, whilst closed tasks are characterised by a very specific information need resulting in a discrete outcome. The approach taken in Study 1 required participants to simply indicate which navigation tool they would use for a range of tasks of differing goal-specificity. There is evidence that what people say they would do under certain condition differs substantially from what they actually do in reality (Scott et al., 2001). Therefore, this second study investigated participants' supplemental navigation tool use when completing tasks of differing goal-specificity on live web sites.

Specifically, this experiment was designed to confirm the influence of the goal specificity on their tendency to select particular navigation tools. Results from Study 1 informed the following hypothesis:

> ***H*** $_{1}$ *A user who decides to use a sitemap is more likely to be performing an open task than a closed task; A user who decides to use a search tool is more likely to be performing a closed task than an open task.*

This hypothesis was examined from a number of perspectives depending on when the decision to use the tool was made. Web site users have three general options they are considering to use supplemental navigation tools such as sitemaps and search tools. They can decide to use a particular navigation tool immediately upon entering the site, they may initially browse from page to page prior to navigation tool selection before deciding to use a navigation tool, or finally they might browse around the site without using any supplemental navigation tool. Each of the three variants is investigated in the study.

A number of post-hoc analyses are also are reported which provide a further insight into the motivations and actions of participants when interacting with navigation tools. In particular, the mean number of times individual participants selected a particular tool for each task type in order to establish the strength of the hypothesised relationship between task type and tool selection was investigated. The number of navigation actions prior to navigation tool selection was also examined.

6.2 Method

6.2.1 Participants

Fifty students from Swinburne University of Technology (9 female and 41 male) participated. Their age groups varied from 18 to 39 years. Participants were recruited from all academic disciplines using noticeboard advertisements. The experiment took approximately 45 minutes and participants were paid a fee of $20 for their time. Ethics approval had been given prior to conducting the experiment.

6.2.2 Design

Sixteen tasks were designed to represent the two major goal types (open and closed) as defined in Section 6.1. Participants were instructed to complete eight tasks on eight different web sites: four closed and four open tasks. Tasks were presented to the participants such that the order of the task types was counterbalanced as shown in Table 6.1.

Table 6.1: Study 2 Task Order

Participant	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
1 – 25	Open	Closed	Open	Closed	Open	Closed	Open	Closed
25 - 50	Closed	Open	Closed	Open	Closed	Open	Closed	Open

6.2.3 Materials

All materials may be found in Appendix 2. These included:

1. Subject Information Sheet and Consent Form

    The Subject Information Sheet explained the general nature and purpose of the experiment.

2. Subject Instruction Booklet.

    This booklet contained all instructions and materials for the various experimental activities.

    (a) Pre-experiment Questionnaire

    This questionnaire contained six questions relating to the participants age, gender and experiences in searching for information on the web. The first three questions were answered on a five-point Likert scale and related to how often they used the Web, their confidence with using and searching for information on the Web. These questions allowed a correlation analysis to be undertaken with the experimental results. The other three questions related to participant details such as status, age and sex.

    (b) Web Navigation Task Instructions

    These instructions provided the participants with an understanding of the experimental procedure. They explained how the tasks were to be completed and the operation of the control and browser programs

    (c) Practice Task

    A practice task was undertaken in order to familiarise the participants with the experimental procedure. Participants clicked on the "Practice Task" button on the Task Control Screen to activate the browser and commence the practice task. A maximum of the 30 seconds was allowed for this practice task.

(d) Experimental Tasks

The Subject Instruction Booklet contained instructions for eight tasks on separate pages. Two versions of this booklet were developed to ensure that the task order was counterbalanced.

Four open and eight closed tasks were developed. The four open tasks were general informational or meta-informational tasks, and hence were not specific to any web site. These four open tasks were undertaken by all participants. Eight closed tasks which required some specific information to be located on a web site were constructed. These closed tasks were each specific to a particular web site. Each participant performed four open and four closed tasks.

The web sites were selected to ensure that each contained links to search and sitemap tools. The sites were a mixture of large government and commercial sites from Australia and had a maximum of 20 content links on the home page.

(e) Post-experiment Questionnaire

The post-experiment questionnaire asked participants six questions relating their knowledge of sitemaps and their motivations for using sitemaps. Although not required to address the research questions, the first three questions were designed to provide an understanding of the participants' disorientation experiences and their familiarity with sitemaps and use of sitemaps prior to and during the experiment. The final three questions were designed to provide data regarding reasons for using sitemaps which was used to triangulate with the experimental findings. Responses to the first three questions were measured on the five-point Likert scale, whilst the others were open ended. These questions were asked after the experiment as they referred specifically to sitemaps, and hence could have distorted the results if asked prior to the experiment.

6.2.4 Apparatus

A set of computer programs were developed to control the presentation of tasks to the participants. These included a Task Control Screen, Experimental Web Browser and a database to record the browsing activity of participants in a log file.

Each computer workstation was preloaded to display a Task Control Screen (Figure 6.1). When the participant clicked on a task button a purpose-built experimental browser opened and a particular web site was displayed (Figure 6.2). The participant was instructed to perform the task on the web site that was displayed.

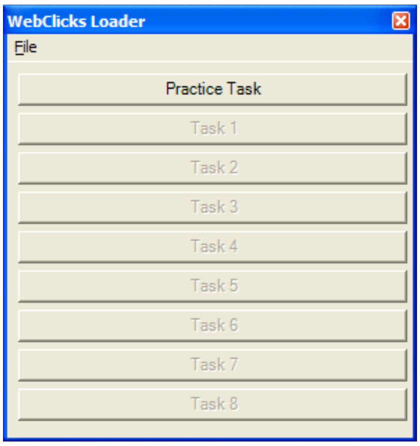


Figure 6.1: Task control screen

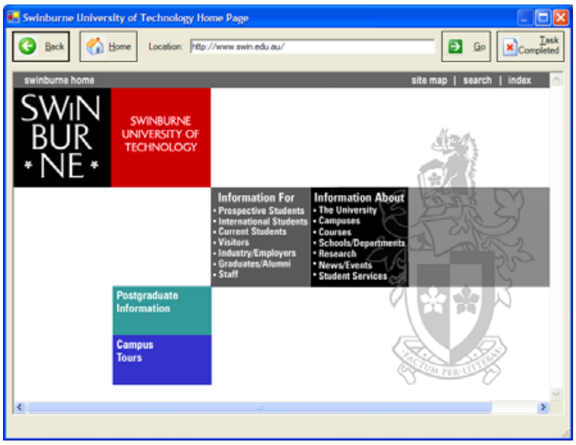


Figure 6.2: Experimental web browser

The web browser interface was purpose-built for this study in order to control complexity and facilitate data collection. The browser interface had standard Home, Back and Go buttons, a location bar and a status bar. The interface also contained a 'Task Completed" button that participants could click if they completed a task before the 3 minute deadline. After 3 minutes that browser closed automatically and returned to a task control interface which allowed the participant to select the next task.

The purpose-built browser was linked to a central database on a MySQL server. This system logged all interactions in the background, including URL visited, system time, subject number and task. This data was sufficient to determine the timing and sequence of pages visited for each task and whether they have visited the search or sitemap tools for a particular site.

6.2.5 Setting

Participants were tested in groups of up to 12 at a time in the same dedicated computer laboratory using the same experimental procedure. Participants were seated at a computer workstation with at least a gap of one empty workstation separating each participant to minimise distractions.

6.2.6 Procedure

Participants read the Subject Information Sheet providing background information for the experiment before completing the informed consent form. Participants were provided with a Subject Instruction Booklet which contained detailed instructions for the experiment. Participants complete the Pre-experiment Questionnaire and then read the instructions for the Web Navigation Task. After having an opportunity to ask any questions, participants performed the practice task that familiarized them with the experimental process and browser interface.

Once all participants had completed the practice task and any further questions were answered, they were instructed to turn the page to reveal the first experimental task. Participants read the task instructions and then clicked on "Task 1" on the Task Control Screen which loaded the target web site into the web browser. Participants either completed the task then clicked on the "Task Completed" button on the web browser which presented the Task Control Screen with the next task highlighted, or after 3 minutes the browser automatically closed to return to the Task Control Screen. Participants turned the page in the Subject Instruction Booklet to reveal the next task, clicked on "Task 2" on the Task Control Screen and then completed the second task. This procedure continued until all eight tasks had been completed.

6.2.7 Measures

The log files indicated that navigation choices of each participant for the eight tasks that they undertook. There were five possible outcomes for each task:

1. selecting the sitemap link immediately
2. browsing first and then selecting the sitemap link
3. selecting the search link immediately
4. browsing first and then selecting the search link
5. browsing only and not choosing to use any navigation tool

6.3 Results

Overall the results showed that participants who selected sitemaps were more likely to be undertaking open than closed tasks and that participants who selected search tools were more likely to be undertaking closed than open tasks, thus supporting the hypothesis.

Details are presented in the sections below. The pre-analysis data screening is described in Section 6.3.1. The hypothesis is tested in Section 6.3.2. Section 6.3.3 reports a post-hoc analysis of how many times each participant used each tool. This is followed by an examination of those subjects who did not use either navigation tool for tasks in Section 6.3.4. Section 6.3.5 reports an analysis of the instances when tools were not selected immediately.

6.3.1 Data screening

Preliminary data screening was undertaken on the dependent measures in order to identify and account for outliers. Box plots were produced using SPSS to identify outliers which were defined as extreme values which extend more than three standard deviation units from the mean. No outliers were identified.

Normal probability plots were produced to check the assumption of normality. Several of the variables exhibited a departure from normality in that they were moderately positively skewed. Given the relatively large sample size (n = 50) and the robustness of the planned parametric tests, it was deemed unnecessary to transform the variables as it is accepted that large sample sizes a violation of normality is unlikely to compromise the test or distort the p value (Gravetter & Wallnau, 2000; Pallant, 2001).

6.3.2 Hypotheses testing

In order to test H_1: "*A user who decides to use a sitemap is more likely to be performing an open task than a closed task; A user who decides to use a search tool is more likely to be performing a closed task than an open task.",* three related analyses were undertaken which examined each of possible participant actions as listed in Section 6.2.7:

(i) Overall navigation tool selection which includes both (ii) and (iii) below.

(ii) Cases only where participants immediately selected a supplemental navigation tool upon entering the site.

(iii) Cases only where participants browsed between several pages in the site prior to selection of a supplemental navigation tool.

Together these analyses provide a comprehensive understanding of the relationship between goal specificity and use of navigation tools.

The number of times that participants used each of the five possible participant actions as listed in Section 6.2.7 across the eight tasks was counted first. Table 6.2 shows the overall use of sitemaps and search tools, collapsed across all participants, all web sites and all tasks. Note that participants each performed four open and four closed tasks, hence the maximum mean number of selections is four for each option.

Table 6.2: Overall Tool Use

Task	Sitemap		Search tool	
	Mean	S.D.	Mean	S.D.
Open	1.78	1.217	0.20	0.404
Closed	0.36	0.631	2.90	1.165

For example, the mean number of selections of sitemaps when performing open tasks is 1.78 times out of four times, i.e., when undertaking open tasks, participants selected sitemaps in 44.5% (1.78/4) of the cases. This may be compared with the 0.05% of the cases when search tools were selected for open tasks. On the other hand, when considering closed tasks we find only 9% of the cases resulting in the selection of a sitemap compared with 72.5% selecting a search tool.

In order to appreciate any interaction between task type and tool selection the data is presented as a graph in Figure 6.3.

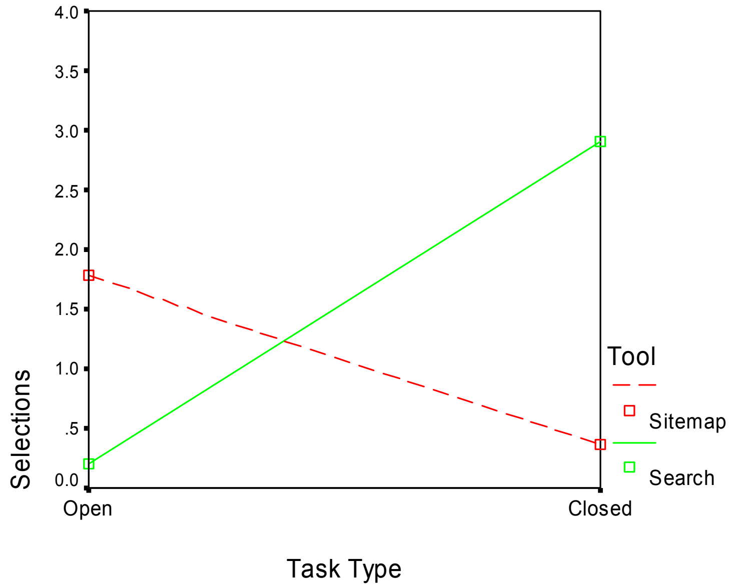


Figure 6.3: Overall tool selection

Figure 6.3 clearly shows an interaction between tool selection and task type. Participants performing open tasks have a greater use of sitemaps than search tools. Search tool use for open tasks is extremely small. On the other hand, when performing closed tasks, participants favoured search tools and had very little use of sitemaps. A 2 (task type) x 2 (tool) ANOVA conducted on the data determined that the interaction between task type and tool selection was significant ($F(1,196)= 249.62$, $p<.001$) thus supporting the hypothesis.

There was also a main effect for task type ($F(1, 196)= 24.09$, $p<.001$) indicating a significant difference in the number of overall selections for each tool type for open and closed tasks.

The hypothesis is also supported when separately considering cases where participants immediately selected a particular tool and those cases where participants browsed the site before selecting a tool. Table 6.3 shows both the immediate and eventual use of sitemaps and search tools, collapsed across all participants, all web sites and all tasks.

Table 6.3: Navigation Tool Selection

Task	Action	Sitemap Mean	Sitemap SD	Search tool Mean	Search tool SD
Open	Immediate selection	0.64	.83	0.12	0.33
	Browse then selection	1.14	1.01	0.08	0.28
Closed	Immediate selection	0.10	0.30	1.84	1.15
	Browse then selection	0.26	0.53	1.06	0.79

The results in Table 6.3 show that when undertaking open tasks, participants selected sitemaps immediately in 16% (.64/4) of the cases compared with immediate use of search tools in only 3% of the cases. The figures for the cases where participants browsed first and then selected a tool are more clearly distinguished with 28.5% of open tasks resulting in a sitemap selection and only 2% in the selection of a search tool.

Conversely, when considering closed tasks we find only 2.5% of the cases resulting in immediate selection of a sitemap compared with 46% immediately selecting a search tool. These figures are similar when considering the cases where participants browsed first before selecting a tool where 6.5% of cases resulted in a sitemap selection and 26.5% in the selection of a search tool.

A 2 (task type) x 2 (tool) ANOVA was conducted on the data for immediate selection of navigational tools and found an interaction between immediate tool selection and task type ($F(1,196)=115.85$, $p<.001$).

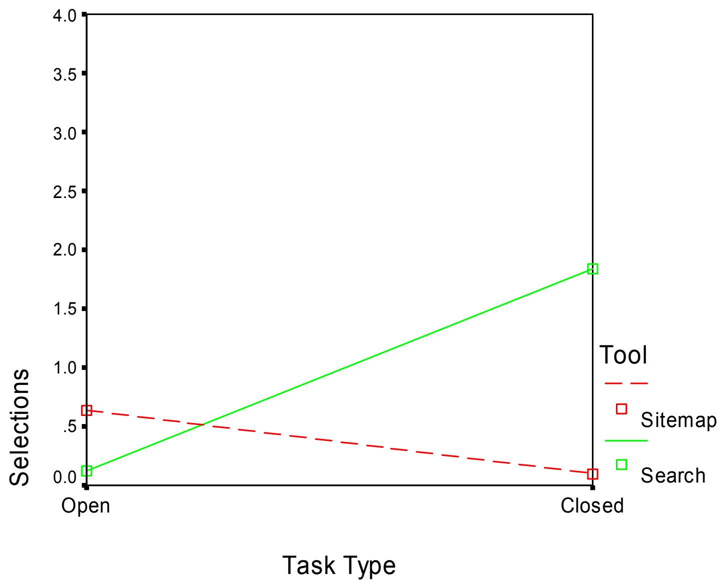


Figure 6.4: Immediate tool selection

As shown in Figure 6.4, participants performing open tasks have a slightly greater use of sitemaps than search tools. Search tool use for open tasks is extremely small. On the other hand, when performing closed tasks, participants favoured search tools with very little use of sitemaps. There was also a main effect for task type ($F(1, 196)=31.58$, $p<.001$) indicating a significant difference in the number of immediate selections for each tool type for open and closed tasks.

Similarly, a 2x2 ANOVA was conducted on the results of the cases where participants browsed prior to tool selection as shown in Figure 6.5. This analysis found the interaction between task type and tool selection to be significant ($F(1,196)=86.37$, $p<.001$). There was no significant main effect for task type.

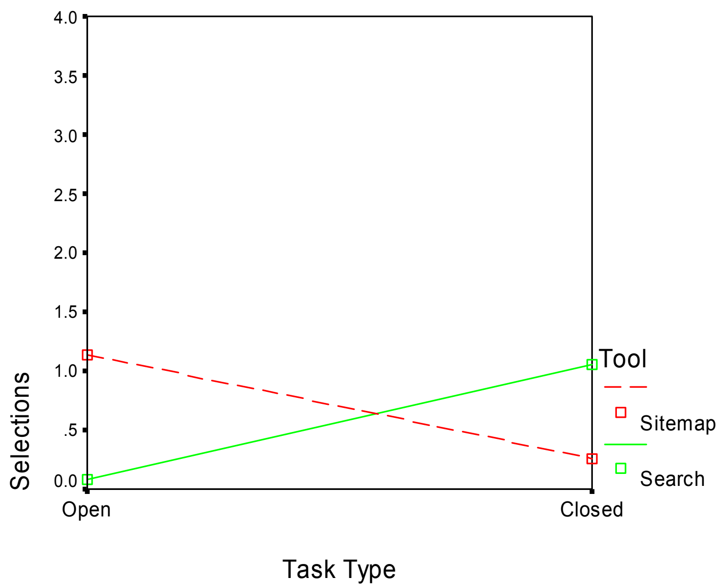


Figure 6.5: Eventual tool selection

Together, these analyses support hypothesis H_1. A user who selects a sitemap, either immediately upon entering the web site or after some page-to-page browsing, is more likely to be undertaking an open task than a closed task. Similarly, a user who selects a search tool is more likely to be undertaking closed task than an open task.

6.3.3 Investigating the use of browsing

In testing the hypothesis the analysis focused on the outcomes where participants selected a navigation tool. The other possible outcome for participants undertaking the experiment was to simply browse around the site from page to page in order to complete the task without the use of either a sitemap or search tool.

An analysis of browsing only behaviour against task type is presented in Figure 6.6. When undertaking open tasks, participants did not select any navigation tool in 49.5% of the tasks events. When undertaking closed tasks only 17.5% of the task events resulted in browsing only.

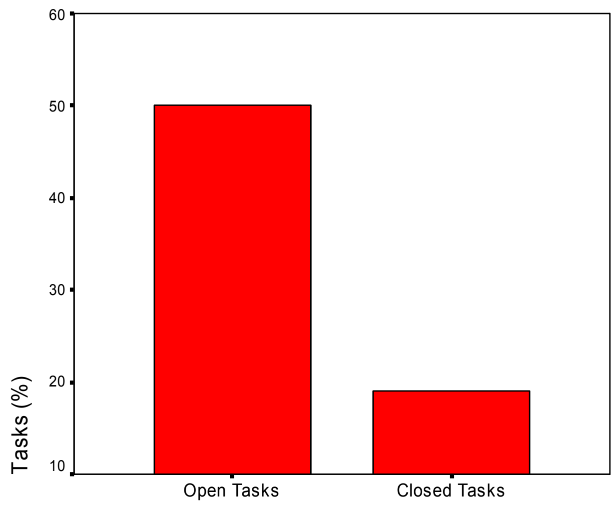


Figure 6.6: Tasks resulting in browsing only (%)

A paired-samples t-test was conducted to evaluate the impact of task type on participant's decision to browse only. There was a statistically significant difference from open tasks ($M=49.5$, $SD=30.1$) to closed tasks ($M=17.5$, $SD=27.3$), ($t(49)=7.57$, $p<.0005$). The eta squared statistic (.54) indicated a large effect size. This suggests a strong use of navigation tools when completing closed tasks (predominately search tools based on the findings from the previous section) whilst navigation tools are used for only half of the open tasks with the others choosing to browse from page to page in order to complete the task.

6.3.4 Post-hoc analysis – repetitions of tool selections

In the experiment participants performed four open tasks and four closed tasks. The possible outcomes of each task were that participants could browse only, or choose either a sitemap or a search tool. This post-hoc analysis examines the number of times each tool was chosen for each task-tool outcome. The data is summarised according to the number of participants who chose each tool 1, 2, 3 or all 4 times for each of the task types. This analysis of 'selection repetitions' provides an alternative perspective to individual choices of participants for each navigation tool under different task conditions.

The data considered is the overall use of navigation tools which includes immediate and eventual selection of a tool.

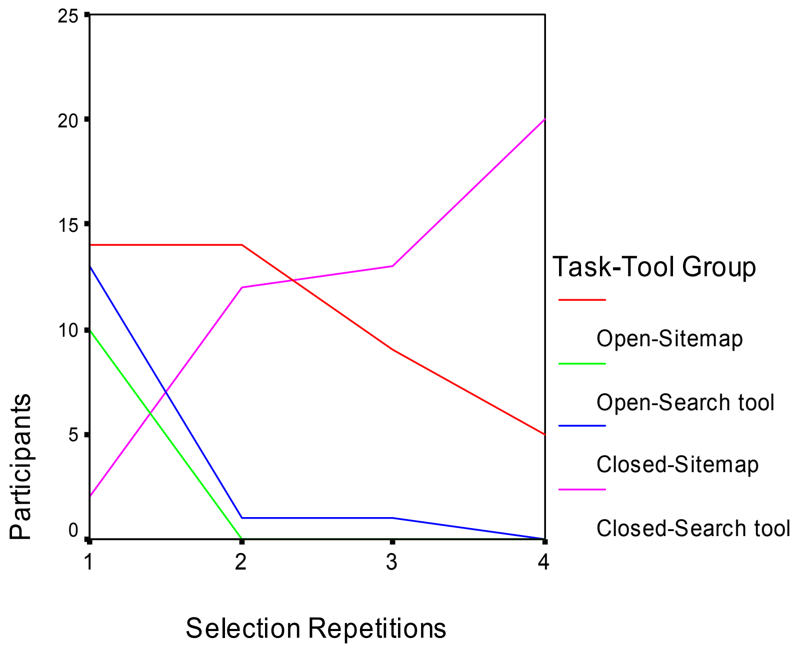


Figure 6.7: Repetitions of selections for task-tool groups

Figure 6.7 reports the number of participants in each of the possible selection repetitions categories (task type - navigation tool groups). For example, the red line shows that 14 participants chose a sitemap only once for their four open tasks. For the same task-tool group (open-sitemap), 14 participants chose a sitemap twice, 9 participants chose a sitemap three times and 5 participants chose a sitemap for all four of their open tasks.

A visual inspection of Figure 6.7 indicates that repetitive use of a tool (i.e. used 2, 3 or 4 times for each task type) is only evidenced in the open-sitemap and closed-search groups. Likewise, the Figure shows that the use of search tools for open tasks and sitemaps for closed tasks is negligible.

Figure 6.7 also shows that 20 participants (out of 50) chose a search tool for all four closed tasks and 45 participants (out of 50) chose a search tool either 2, 3, or

4 times for closed tasks suggesting a strong relationship between selection of a search tool for closed tasks.

Similarly, we see 28 participants (out of 50) chose a sitemap tool 2, 3, or 4 times for open tasks supporting a relationship between open tasks and use sitemap tools. Interestingly, the results show that only eight subjects out of a possible 50 did not use a sitemap at all for open tasks compared with 35 subjects who did not use a sitemap for closed tasks. Also, 5 participants chose a sitemap for all four open tasks.

This analysis clearly demonstrates a preference for sitemaps when performing open tasks, and a strong preference for search tools when performing closed tasks (20 participants choosing a search tool for all four closed tasks), consistent with the findings in Section 6.3.3.

6.3.5 Post-hoc analysis – behaviour prior to tool selection

In the experiment some participants chose a particular navigation tool immediately upon entering a site, whilst others browsed around the site from page to page for some time prior to selecting a tool. In this analysis we examined the behaviour of participants prior to tool selection through an examination of the total number of pages visited and the number of different pages visited prior to the selection of each navigation tool. This analysis provides an understanding of the navigation behaviour of participants prior to selection of each type of tool.

Table 6.4: Pages Visited Before Selection of Tools

	N	Min	Max	Mean	SD
Sitemap	107	1	86	6.46	11.10
Search Tool	155	1	16	2.76	3.148

The experiment involved 50 participants each completing 8 tasks totally 400 task events made up of 200 open and 200 closed tasks. Table 6.4 presents a summary of the number of pages visited before choosing either a sitemap or search tool over the 400 task events.

A sitemap was selected 107 times out of the 400 task events in the study with a mean of 6.46 (SD = 11.10) pages visited before the sitemap tool was selected. A search tool was selected 155 times with a mean of 2.76 (SD = 3.15) pages visited before it was selected. Of the 107 times that sitemaps were selected, participants selected the link immediately upon entering the site only 37 times (35%). In comparison, participants clicked on the Search link immediately upon entering the site 98 times (63%) out of the 155 times that search tools were selected.

The results suggest that participants made a decision to use a search tool after visiting fewer pages than when selecting to use a sitemap. In addition, many more participants immediately selected a search tool upon viewing the opening page of the site than those who immediately selecting a sitemap. These results indicate a difference in navigation behaviour prior to selection of each type of navigation tool with participants in general visiting more pages before selecting a sitemap than a search tool.

A similar analysis was undertaken from the perspective of task type. Table 6.5 presents the total number of pages visited (including revisits) and the total number of different pages visited by each participant for open and closed tasks.

Table 6.5: Pages Visited Before Tool Selection by Task

Measure	Task	Min	Max	Mean	SD
Total Pages	Open	2.75	41.75	12.51	8.02
Different Pages	Open	2.75	23.00	8.62	4.64
Total Pages	Closed	2.00	35.50	6.06	5.70
Different Pages	Closed	2.00	26.00	4.88	3.89

Evident is a clear difference in the total number of pages visited between open and closed tasks. Participants visited a mean of 12.51 pages before selecting a tool when completing open tasks and a mean of 6.06 pages before selecting a tool when completing closed tasks. A paired-samples t-test was conducted to evaluate the effect of task on the total number of pages visited before tool selection. There was a statistically significant difference in the number of pages visited when completing open tasks ($M=12.51$, $SD=8.02$) to closed tasks ($M=6.06$, $SD=5.70$), ($t(49)=4.52$, $p<.0005$). The eta squared statistic (0.29) indicted a large effect size. This suggests a pattern of behaviour that depends on participant's level of goal specificity. When undertaking open tasks users are more likely to browse through twice as many pages before selecting a tool than those who are undertaking closed tasks.

A similar pattern is also detected in an analysis of the number of different pages visited prior to tool selection. Here, participants visited a mean of 8.62 different pages before selecting a tool when completing open tasks compared with a mean of 4.89 different pages before selecting a tool when completing closed tasks. A paired-samples t-test was conducted to evaluate the effect of task on the number of different pages visited before tool selection. There was a statistically significant difference in the number of different pages visited when completing open tasks ($M=8.62$, $SD=4.64$) to closed tasks ($M=4.89$, $SD=3.89$), ($t(49)=4.27$, $p<.0005$) suggesting a behavioural difference due to the nature of the task.

The difference between the number of pages revisited between open tasks (31.0% revisits) and closed tasks (13.2% revisits) shows that users with a high level of goal specificity have fewer revisits suggesting a tighter focus of browsing before selecting a tool. In comparison, those undertaking less specific tasks have twice as many revisits suggesting some random exploration or possibly disorientation prior to tool selection.

6.3.6 Questionnaires

Results of the pre and post-experiment questionnaires are available in Appendices 2.6 and 2.7. The pre-experiment questionnaire established participant's age, sex and their status in the university. Further questions relating to prior experience, confidence and ability to find information on the web were also asked. Results for these further questions (Table 6.6) found that in general the participants were regular Web users who are confident of their ability to use the Web to locate desired information.

Table 6.6: Pre-Experiment Questionnaire

Question	Low*		(N=50)		High*
How often do you use the World Wide Web?	0	0	4	18	28
How confident are you using the World Wide Web?	0	0	4	19	27
Are you always able to find what you are looking for on the World Wide Web?	0	0	5	39	6

*see Appendix 2.7 for actual Likert category descriptions

The post-experiment questionnaire asked participants about previous experiences of disorientation, their familiarity with sitemaps and their previous use of sitemaps. The results (Table 6.7) indicate that 68% of the participants said that they get lost in web sites 'usually' or 'sometimes', whilst 32% said that they 'rarely' get lost. Also 50% of the participants claimed they were 'reasonably' or 'very' familiar with sitemaps with only 2% claimed that they were not familiar with sitemaps at all. In addition, 40% of the participants indicated that they 'never' or 'rarely' use sitemaps with 20% claiming that they use them all or most of the time.

Table 6.7: Post-Experiment Questionnaire

Question	Low*		(N=50)		High*
When using the World Wide Web have you ever become lost in all of the pages of a site and cannot remember where you have been or work out how to get to where you want to go?	0	16	31	3	0
How familiar are you with Sitemaps?	1	12	12	21	4
How often do you use Sitemaps?	4	16	19	7	4

*see Appendix 2.7 for actual Likert category descriptions

The questions which asked the participants about their confidence with Web, their familiarity with sitemaps and their claim to frequently use sitemaps provide an overall indication of self-assessed 'expertise'. A comparison between this self-assessed expertise with each participants actual use of sitemaps when undertaking open tasks was undertaken. Each of the variables was investigated separately using the Pearson product-moment correlation coefficient. In each case there was a positive correlation between a tendency to choose sitemaps when completing open tasks and high levels of self-assessed 'Confidence with the Web' ($r=.39$, $n=50$, $p<0.01$), high levels of self-assessed 'Familiarity with sitemaps' ($r=.45$, $n=50$, $p<0.01$) and high levels of 'Frequently use sitemaps' ($r=.54$, $n=50$, $p<0.01$). This suggests that 'experienced' participants who have an awareness of sitemaps choose to use sitemaps for open tasks more often than 'less-experienced' participants.

The post-experiment questionnaire also asked participants to indicate possible reasons from a list of six options why they would use a sitemap. The results in Table 6.8 show that 70% of the participants claimed that they would use a sitemap to get an overview of the structure of a web site. Interestingly, 50% claimed that they would use a sitemap to find something specific in a web site and 28% said they would use a sitemap to search a web site. Whilst the claims regarding the use of sitemaps to obtain an overview is expected considering the experimental results from this study, having 50% of participants who claimed that they would use a sitemap to search for something specific is not consistent with the experimental findings. Many participants also provided some further reasons why they would use a sitemap, including 3 participants who stated that they would use a sitemap as "a last resort" and 6 who indicated they would use a sitemap if they "could not find something with a search tool".

Table 6.8: Reasons for Use of Sitemap

Option (participants chose one or more)	Responses	Percent of participants
I never use them	6	12
To find something specific in the web site	25	50
When I am lost in a web site	30	60
To get an overview of the structure of a web site	35	70
To search the web site	14	28
To find out how large the web site is	16	38

The post-experiment questionnaire also asked participants to indicate the reasons why they used or did not use a sitemap during the experiment. The complete list of reasons provided by participants is available in Appendix 2.7. A sample of comments is provided in Table 6.9.

Table 6.9: Sample Reasons Why Sitemap Chosen

Reasons why participants used a sitemap (Sample from Appendix 2.7)
"I sometimes get lost within the design of the web site. Rollover effects and submenus can sometimes be distracting. Sitemaps are usually helpful because they are in pure text and indented, so it's easy to see the general structure of the site."
"To get to know the main areas of a web site, because it is in an easy to read format (well most are) with sub-headings and list of information within the sub-heading."
"I used the sitemap just to have an overall look at the site."
"It showed me the structure of the web site which helped me navigate easily"
"Sitemaps provide all the links that is in the web site. In order not to waste time in browsing the web site, I prefer of using sitemaps to look for the things that I want."

An analysis of some key phrases used by participants in this in their responses to the question regarding reasons why they chose to use a sitemap in the experiment is shown in Table 6.10. Whilst there was a clear preference for the obtaining a view of the overall structure and size it is interesting that 6 participants indicated that they chose a sitemap to find something specific and 5 participants had indicated that their choice of the sitemap was as an alternative to the search tool.

Table 6.10: Analysis of Questionnaire Responses

Comment	N
Gives overall structure and size	25
To find specific	6
Could not get search to work or could not find search	5
Assist in navigating	5
Get general context of web site	4
Saves time when browsing	1
Last resort	1

6.4 Discussion

6.4.1 Significant findings

A summary of key statistical and observational findings is presented:

- A statistically significant difference in the use sitemaps between open tasks and closed tasks.
- A statistically significant difference in the use search tools between open tasks and closed tasks.

Together, these first two findings support hypothesis H_1: Users who select a sitemap when navigating a web site are more likely to have a low level of goal specificity. Likewise, users who select a search tool when navigating a web site are more likely to have a high level of goal specificity.

Other significant findings include:

- A statistically significant difference in the decision to browse only in order to complete the task between open tasks and closed tasks. These results indicate web site users are more likely to use a navigation tool for closed tasks than open tasks. Half of those undertaking open tasks used no navigation tool at all.
- A statistically significant difference in the number of pages visited when completing open tasks to closed tasks. Further, participants visited more pages before selecting a sitemap than the number of pages before selecting

a search tool. Similarly, immediate use of a search tool was more common than immediate use of a sitemap.

- Participants performing closed tasks revisited fewer pages than those performing open tasks. These results suggest those undertaking open tasks may be undertaking random exploration or may be disoriented.
- There were positive correlations between a tendency to choose sitemaps when completing open tasks and high levels of self-assessed claims of confidence with the Web, familiarity with sitemaps and frequent use of sitemaps. These results suggest that experienced Web users recognise the benefits of the use of sitemaps for open tasks.

A discussion of these findings is presented in the following sections.

6.4.2 Findings relating to the research question addressed by this study

Q3: *What level of goal specificity do users have when they decide to use a sitemap?*

The experiment found that participants performing open tasks had a greater use of sitemaps than search tools. Search tool use for open tasks was extremely rare. When performing closed tasks, participants favoured search tools with very little use of sitemaps. Statistical analysis of the data was undertaken for both of the possible situations: when users select a particular navigation tool immediately upon entering the site, and when they initially browse from page to page prior to navigation tool selection. The data was analysed for these immediate and eventual use situations separately, as well as combined into an analysis of overall use. In all cases there was a significant interaction between task type and tool selection therefore supporting the hypothesis H_1: a user who has chosen to use a sitemap is more likely to have a low level of goal specificity.

The results indicate that use of sitemaps is relatively low, with subjects opening the sitemap immediately in slightly less than 10% of all open and closed tasks, and in just over 25% of the tasks when including immediate and eventual use. In contrast, a search was issued immediately in nearly 25% of all open and closed tasks, and overall use in nearly 40% of the tasks. These findings are consistent with those of Stover et al. (2002) who reported an empirical study that suggests that there is a lack of overall use of sitemaps. However, it was observed that only 8 of the 50 participants did not use a sitemap at all for open tasks and that 5 participants selected a sitemap for all four open tasks.

What these findings do add to our understanding of the use of sitemaps is that whilst the overall use of sitemaps is relatively low when compared with that of search tools, it is relatively high when considering only those situations when a user is undertaking a task of low goal specificity, i.e. when considering overall usage of sitemaps, including both immediate and eventual use for the 200 open tasks, 44.5% of the tasks resulted in the selection of a sitemap.

The findings suggest that users with general questions or who are interested in meta-information about a particular web site are more likely to browse rather than choose to use a navigation tool. If a navigation tool is selected under those circumstances, it is significantly more likely to be a sitemap than a search tool, and it is more likely that users will browse the site for a period of time before selecting the sitemap.

Several immediate implications for the design of sitemap interfaces arise from this study. The acknowledgment that sitemaps must primarily support users with low goal specificity who are after general overview information about the site provides interface designers with guidance regarding the level of detail that users should be exposed to in a sitemap. Sitemap designers should consider either a basic overview design or alternatively employ visualisation techniques to manage complexity. A detailed discussion of the implications for design of sitemaps is provided in Chapter 8.

A further implication is that empirical studies into the design of supplemental navigation tools for web sites should consider task as a key factor. Interfaces to support users with less specific information needs are likely to have different requirements than those designed to support a search for something specific. A common assumption in empirical studies is that sitemaps are selected by users who wish to search for something specific and use fact-finding tasks with measures of completion times and task success in their experimental design (e.g.: McDonald and Stevenson 1998b, Hornbæk & Frøkjær, 1999; Bernard and Chaparro, 2000; Danielson, 2002; Yip, 2004). This assumption may be appropriate for evaluating the usability of search tools which are designed for users with a specific information need, however may not be suitable for other types of navigation tools such as sitemaps.

6.4.3 Other findings

The results confirm that a user who has a goal of high specificity and is undertaking a task where they are looking for a specific answer to a specific question, are highly likely to select a search tool. These results are consistent with the findings in the second survey in Study 1 that found that users have consistent expectations of the design and functionality of search tools. Such a strong mapping is likely to be a result of the consistency in search tool design: users know what a search tool will do for them, when to use them and how to use them.

The analysis found some remarkable differences in the numbers of actual pages visited, and page revisits, between open and closed tasks. When undertaking open tasks users are more likely to browse through twice as many pages before selecting a tool than those who are undertaking closed tasks. Also, the number of page revisits varied with 31% of pages being revisited when undertaking an open task compared with 13.2% of pages revisited when performing a closed task. These findings are related to the browse path measures that were described in Section 3.6.2.5, particularly the issue of browse path breadth and depth. It appears from the results of this experiment that users undertaking open tasks visit many pages and backtrack through these pages resulting in a high number of revisits. This might be caused by a broad browsing pattern that facilitates an investigation of the range of topics and different sections of the web site. An alternative explanation is that the users are revisiting many pages due to a random exploration pattern, or the users might possibly be disoriented. Those undertaking closed tasks visit fewer pages with a highly focused browse path with little back tracking. These types of browse paths are investigated in detail in Study 3.

The questionnaires provided a measure of participants 'self-assessed' experience according to their confidence with Web, their familiarity with sitemaps and their claim to frequently use sitemaps. The analysis showed that there was a positive correlation between this self-assessed experience and a tendency to choose sitemaps when undertaking open tasks. This raises the question of whether experience is a factor. We know that experience with the task domain, information seeking experience, and experience with an interface are directly linked with the user's ability to formulate an information need and translate it into actions at the interface level (Marchionini & Shneiderman, 1988). Also, changes in information seeking behaviour occur as a result of increased experience of using the Web (Martzoukou, 2005). Research into previous hypertext systems found significant differences in strategies selected by experienced and inexperienced users (Canter et al., 1985; Rada and Murphy, 1992; Wright and Lickorish 1994; McDonald and Stevenson, 1998b). Recent research into Web systems has found that that experience with the Web in general, or with the particular context, have both been found to be factors in navigation (Navarro-Prieto et al., 1999; Lazonder et al., 2000; Saito & Miwa, 2001; Jenkins et al., 2003). Whist experience was not a primary factor in this present study, this finding informed the design of Study 3 as well as future research.

6.4.4 Limitations

The web sites used in this experiment were reasonably simple, with a maximum of 20 content links on the home page. Other home page models such as the portal-type home page with a large number of content links and flat hierarchical structures were not examined here, but should be explored in further research. Likewise, the experimental tasks represent the extremes of the goal specificity continuum, with the closed tasks being very specific and open tasks being very general. Other task types and levels of specificity and complexity could be considered in future studies. Finally the participant population consisted of undergraduate students, most with a high level of experience with using the Web. Future studies could extend the population to include both domain and technical experience as factors.

6.5 Summary

The experiment found that when participants used a sitemap, they were significantly more likely to have a low level of goal specificity. Conversely, when using a search tool, participants were significantly more likely to have a high level of goal specificity. Furthermore, when undertaking open tasks, participants were significantly less likely to use any navigation tool than when undertaking closed tasks. These findings have important implications for the design of sitemap interfaces as well as the design of empirical studies into web navigation.

7 Study 3 – Goals vs Strategy

7.1 Introduction

This study addressed the final targeted research question:

> ***Q4:*** *What primary navigational strategy should sitemaps support?*

The review of the literature in Chapter 3 found that web site users have two basic options when considering their next navigational decision: they can either use a supplemental navigation tool provided by the web site developer, or browse from page to page by following content links, backtracking where necessary. Study 2 reported in the previous chapter investigated the use of supplemental navigation tools. The aim of this study was to investigate the 'browse only' option.

There were two objectives. The first was to examine whether goal-specificity influenced browsing strategy. Participants were asked to use a web site to perform a task of a particular level of goal specificity. An analysis of each participant's browse path was undertaken in order to ascertain if browsing behaviour differed as a function of goal specificity. These analyses led to the identification of specific browsing strategies for each level of goal specificity.

The second objective was to examine differences in browsing patterns between experienced participants with significant general web use who are familiar with the test web site and inexperienced participants. The relevance of experience as a factor in navigation was suggested in Study 2. This comparison assisted in establishing that experience influences browsing strategies. The browsing strategies of experienced participants provided particular insights into the type of interface support that should be provided when users are undertaking tasks of each level of goal specificity.

7.2 Method

7.2.1 Participants

Eighteen volunteer staff and students at Swinburne University of Technology (8 female and 10 male) participated. Participants were asked to indicate their age group (10-19; 20-29; 30-39; 40-49; >50). The modal age category was 20-29 (50%).

Participants were divided into inexperienced and experienced groups for the purpose of analysis. A questionnaire that examined their level of prior experience with the WWW and their familiarity with the test web site determined the group to which they were assigned. The nine participants who formed the 'Experienced' group had used the World Wide Web for at least 6 months, rated their familiarity with the World Wide Web as being either 'Intermediate' or 'Advanced', their familiarity with the test site as being 'Somewhat familiar' or 'Very familiar', and had used the test site at least once each week. Nine participants who did not meet all of these criteria were assigned to the 'Inexperienced' group.

Ethics approval was obtained prior to the experiment.

7.2.2 Design

Table 7.1 presents the plan of treatment. There were two levels of experience: experienced and inexperienced, and three goal types: open, closed and investigative. Three tasks were designed to represent each of the three goal types identified from the goal-specificity continuum, i.e. Open, Closed and Investigative goals. Open goals have a low level of specificity, closed goals are characterised by having a very specific information need resulting in a discrete outcome, and investigative goals are defined as those where the outcome is the result of an aggregation or a comparison of information across several locations.

Table 7.1: Study 3 Experimental Design

		Goal Type			
		Open	Closed	Investigative	
Experience Group	Experienced	3	3	3	n=9
	Inexperienced	3	3	3	n=9
		n=6	n=6	n=6	n=18

Three participants from each group were randomly assigned to one of the three goal conditions. Participants completed only one task each.

7.2.3 Materials

All materials may be found in Appendix 3. These included:

1. Subject Information and Consent Form

   This form explained the general nature and purpose of the experiment, contained the consent statement and instructions for the task that the participant undertook.

2. Questionnaire

   This questionnaire asked participants for their age, gender and experiences in searching for information on the web.

7.2.4 Apparatus

The web site for the Swinburne University Department of Computer Science and Software Engineering was selected for the study. This web site was a typical university department web site containing over 500 individual pages describing courses, subjects, staff, research and administrative information. The structure of the site was fundamentally hierarchical with six main level one options, however there was a large number of links between the major sections providing multiple paths to the same page. For the purpose of the study the site was replicated on the test computer in order to maintain consistency of system response times. The supplemental navigational tools (sitemap, index and search) were removed from all pages and all external links were disabled.

7.2.5 Setting

The experiment was conducted in the Swinburne Human-Computer Interaction Laboratory (SCHIL) usability laboratory. Participants were tested individually on the same dedicated computer using the same experimental procedure.

7.2.6 Procedure

Participants began the experiment by reading the Subject Information and Consent Form and signed the informed consent section. After having an opportunity to ask any questions, participants were instructed to read the task statement and then silently complete it in a maximum of 10 minutes. The 'NetDiary' logging program ran in the background recording the URL and the actual system time that interactions were undertaken. A video camera recorded all screen activity. Once the experimental task was concluded, or after the maximum time of 10 minutes was exceed, the video tape was rewound and played back. A post-experiment interview was conducted in which participants were asked a series of unstructured questions about their navigation decisions whilst the tape was reviewed to stimulate recall. Finally, the participants completed the post-experiment questionnaire and were thanked. Each session took approximately 30 minutes.

7.2.7 Measures

Browse paths and times were formally documented using the NetDiary logs. A range of measures were developed to operationalise the browse path taken by each participant. The measures used for this experiment (Table 7.2) were based on those that were identified from the literature review in Section 3.6.2.5.

Table 7.2: Dependent Measures

Measure	Operational Definition
Number of pages visited	The number of pages visited including revisits
Number of unique pages visited	The number of pages visited not including revisits
Home button use	The number of times the participant clicked on the Home button on the browser
Back button use	The number of times the participant clicked on the Back button on the browser
Breadth of browse path	There were six main sections in the web site accessed via six links on the home page. This measure indicates the number of main sections visited during the browsing session
Average depth of browse path	The depth of a page is defined as the shortest number of hops from the home page. This measure was calculated as the sum of the depths of each page visited divided by the total number of pages visited
Hub-and-spoke utilisation	Spokes are defined as routes where the inward return journey retraces exactly the path taken on the initial outward journey (Canter et al., 1985). Hubs are defined as pages where at least 3 consecutive spokes originate. The utilisation measure is defined as the number of spokes multiplied by the average depth of spokes
Home page revisits	The number of visits to the home page including where either the home or back button was used to reach the home page
Landmarks established	Landmarks are pages which users frequently visit during a browsing session. Landmarks are defined as pages visited 3 or more times, excluding the home page
Top-level pages visited	The number of visits to the home page and pages at level 1 in the site
Lower-level pages visited	The number of visits to pages at levels 2 or deeper in the site

7.3 Results

7.3.1 Pre-analysis data screening

Preliminary data screening was undertaken on the two key dependent variables of the number of pages visited, and the number of unique pages visited, in order to identify and account for outliers. Box plots were produced using SPSS to identify outliers which were defined as extreme values which extend more than three standard-deviation units from the mean.

This procedure revealed two outliers, both being 'experienced' participants. One participant who undertook the open task visited 52 pages in total and 20 unique pages. Another participant who undertook the investigative task visited 55 pages of which 27 were unique. These outliers were investigated by examining the 5% trimmed mean value as recommended by Pallant (2001). In both variables this trimmed mean value was similar to the actual mean, hence the influence of the outliers was determined to be negligible, and hence the values were subsequently retained.

7.3.2 Analysis of browse path measures

The analysis of each of the browse path measures was undertaken as follows: In the primary analysis, two-way ANOVAs were used to test three task types and two levels of experience for each of the dependent measures. The primary two-way ANOVA was used to explore interactions. When an interaction was detected, an analysis of simple effects was performed using one-way ANOVAs. When an effect was detected, a post-hoc comparison using a Tukey HSD test was used to determine where the significant difference occurred. Whilst the Scheffe test is a more conservative test when exploring differences, the Tukey test is considered appropriate when the sample sizes are the same (Pallant, 2001). All statistical tests of significance used a two-tailed alpha level of .05.

7.3.3 Primary analysis

Table 7.3 presents the primary analysis of the browse path data combined for all subjects across the three task types. Table 7.4 presents the primary analysis of the browse path data for experienced subjects only across the three task types.

Table 7.3: Primary Analysis of Browse Paths (All Subjects)

	Open Task		Closed Task		Investigative Task		p
	Mean #	SD	Mean #	SD	Mean #	SD	
Pages visited	30.17	11.46	18.00	8.76	32.50	11.68	.071
Unique pages visited	15.17	3.06	9.83	3.55	16.50	5.47	.033 *
Home button	1.50	1.52	1.83	2.79	1.67	2.25	.968
Back button	11.83	6.21	5.83	3.25	13.33	6.74	.080
Breadth	3.83	1.17	2.00	1.55	2.83	1.47	.111
Average Depth	1.17	0.54	1.38	0.39	1.71	0.66	.491
Hub and Spoke Util	15.07	5.66	8.65	5.23	16.25	6.10	.074
Home page revisits	5.17	2.14	3.50	3.27	4.67	3.01	.593
Landmark pages	2.33	1.75	1.50	1.38	2.50	2.17	.597
Top-level visits	13.83	5.49	9.83	6.21	15.00	4.73	.006 *
Low-level visits	17.67	11.33	9.17	4.21	18.67	12.65	.242

* significant at $p < 0.05$

Table 7.4: Primary Analysis of Browse Paths (Experienced Subjects Only)

	Open Task		Closed Task		Investigative Task		p
	Mean #	SD	Mean #	SD	Mean #	SD	
Pages visited	37.00	13.08	11.33	6.43	38.33	15.28	.060
Unique pages visited	17.33	2.31	7.33	2.89	19.33	6.81	.035 *
Home button	2.00	2.00	0.33	.58	2.00	2.67	.518
Back button	14.67	8.08	4.33	3.77	15.33	9.29	.207
Breadth	4.33	1.16	1.33	0.58	2.00	1.00	.018 *
Average Depth	1.63	0.58	1.47	0.58	2.13	0.75	.462
Hub and Spoke Util	18.35	6.37	4.67	3.21	19.07	8.00	.050 *
Home page revisits	6.33	2.08	1.33	0.58	3.67	3.06	.078
Landmark pages	2.67	2.08	1.00	1.00	4.00	2.00	.194
Top-level visits	18.00	2.64	5.00	1.00	13.00	6.56	.023 *
Low-level visits	20.00	15.62	7.33	5.51	26.67	14.22	.241

* significant at $p < 0.05$

7.3.4 Number of pages visited

Figure 7.1 shows the mean number of navigation acts performed for all three tasks types (Open, Closed and Investigative) and for experienced and inexperienced participants.

A visual examination of the graph suggests the number of pages visited by inexperienced participants across all tasks is relatively consistent suggesting their behaviour did not change as a function of the type of task. However, the number of pages that experienced participants visited changed as a function of the type.

A 2 x 3 ANOVA for participant group and task type was conducted to explore the impact of task type and experience on the number of navigation acts. There was a significant interaction between level of experience and goal-specificity [$F(2,12)=4.19$, $p<0.05$] supporting the hypothesis that experienced browsers change their browsing patterns. There was also a statistically significant main effect for task type [$F(2,12)=4.49$, $p<0.05$]. Post-hoc comparisons using the Tukey HSD test indicated that the mean number of page visits on closed tasks was significantly less than investigative tasks. The group performing open tasks did not differ significantly from either of the other groups. The main effect for experience was not statistically significant.

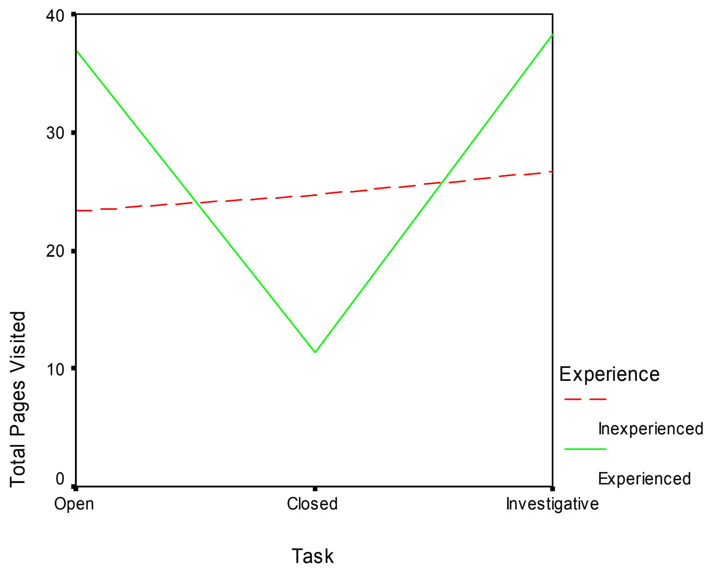


Figure 7.1: Mean number of pages visited

As can be seen from Figure 7.1, the mean number of page visits only differs substantially for experienced participants. The observed behaviour can be understood by assuming that participants experienced with the test site, particularly with its structure, out-performed new or infrequent users. Experienced participants completed the closed task in significantly fewer steps than inexperienced users. Experienced participants performing the investigative task visited more pages in the same time than inexperienced participants. The investigative task required participant to visit multiple pages in order to aggregate an answer, hence experienced subjects appear to complete this task more comprehensively. We assume from this pattern that the more efficient browse paths of experienced participants are due to prior experience with the structure of the test site.

7.3.5 Number of unique pages visited

Statistical analysis of the visits to unique pages data aligned with the finding in the previous section where the number of pages visited varied with task only for the experienced participants as shown in Figure 7.2. A 2 x 3 ANOVA was performed for subject group (experienced and inexperienced) and task type (open, closed and investigative).

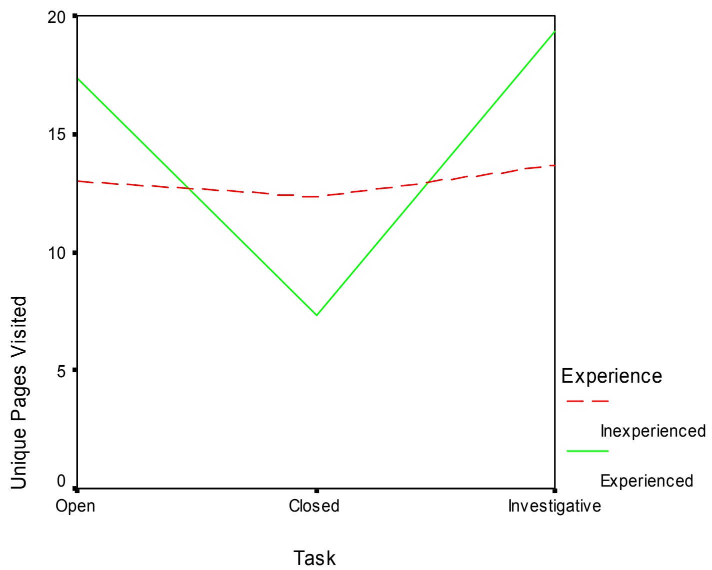


Figure 7.2: Mean number of unique pages visited

The ANOVA showed a significant interaction [($F(2,12) = 4.18$, $p<0.05$)]. An analysis of simple main effects yielded a significant difference in the experienced group [($F(2,8) = 6.20$, $p<0.05$)] but no significant differences in the inexperienced group. A Tukey HSD test indicated that the Closed and Investigative tasks differed significantly in the experienced group ($p<0.05$). Thus, task type and experience affect browsing behaviour in closed and investigative tasks.

The analysis also revealed a significant main effect of task type [($F(2,12) = 6.17$, $p<0.05$)] but not for subject group. Post-hoc comparisons using the Tukey HSD test indicated that the number of unique pages visited by participants performing closed tasks was significantly different from both the group performing investigative tasks ($p<0.05$) and the group performing the open tasks ($p=0.05$).

7.3.6 Back and home button use

Figures 7.3 and 7.4 display the average use of the browser's back and home buttons respectively, for all three task types and for both experienced and inexperienced participants.

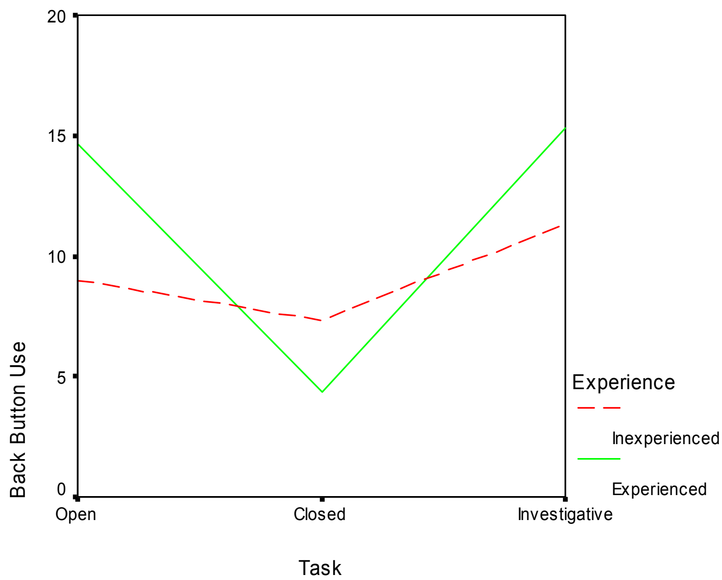


Figure 7.3: Back button use

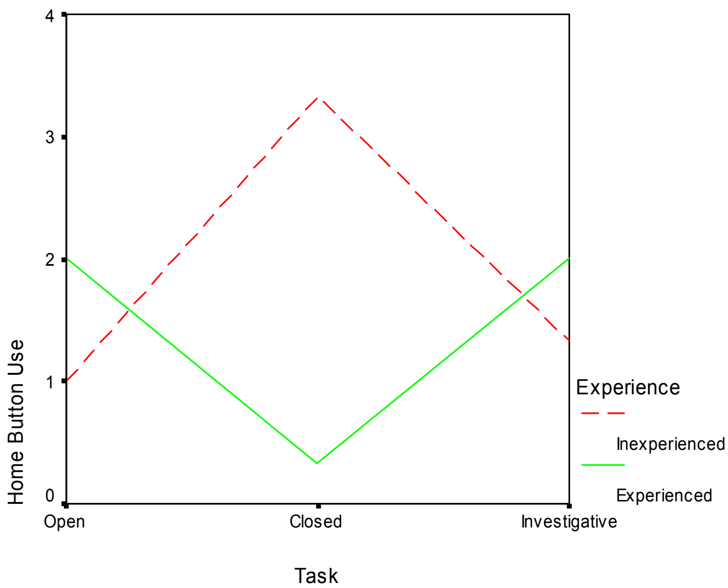


Figure 7.4: Home button use

No significant results were found. However, visual trend in Figure 7.3 suggests that experienced participants utilised the back button more than inexperienced participants for the open and investigative tasks than for the closed task. This effect is expected since experienced participants should have more focus and accuracy in their browse paths for closed, search oriented-tasks, and hence would be less likely to backtrack.

7.3.7 Browse breadth and depth

The test site had six major sections accessible from the home page. Browse breadth has been defined as the number of major sections visited during the experiment session. The depth of a page is defined as the shortest number of hops from the home page. The average browse depth was calculated as the sum of the depths of each page visited divided by the total number of pages visited.

Together, measures of browse breadth and depth provide an indication of the focus of the browse path. A subject may have a highly focused browse path that would be characterized by high depth and low breadth. Alternatively a subject that who has a low focus would have a high breadth and low depth.

Figure 7.5 shows the browse breadth for all three tasks and both subject groups, whilst Figure 7.6 shows the average browse depth of the pages that participants visited during a browsing session.

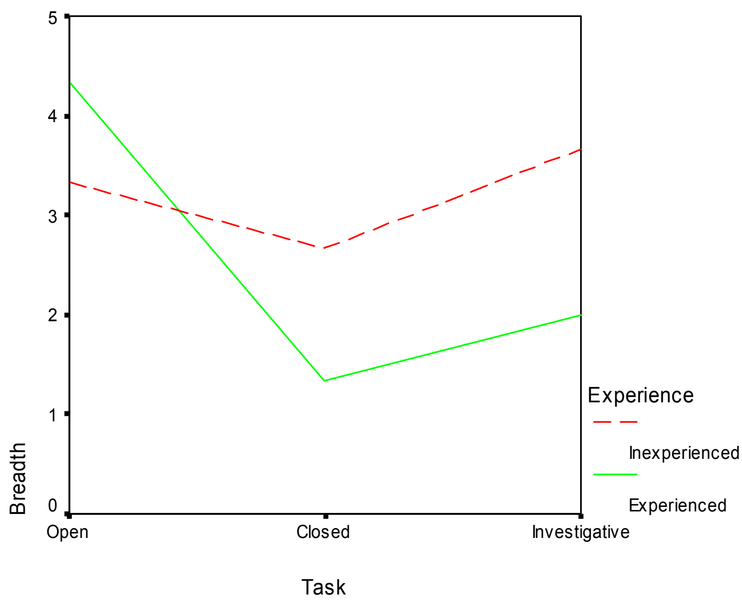


Figure 7.5: Browse breadth

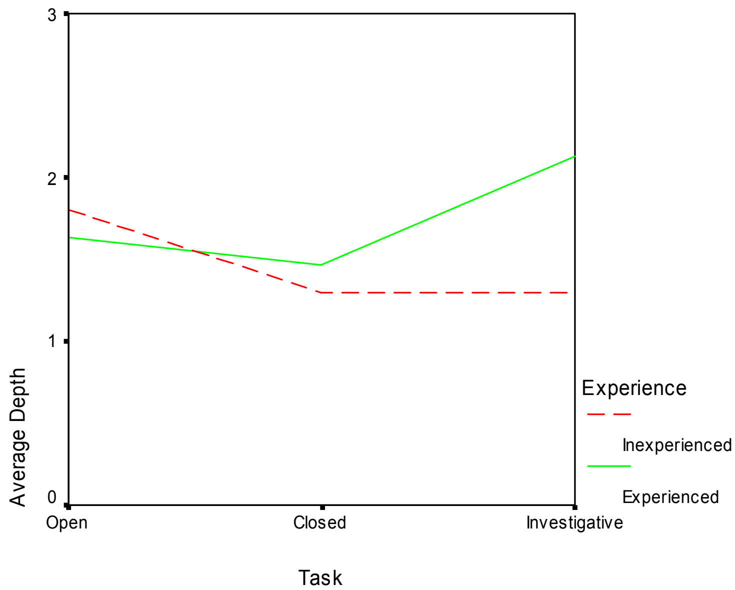


Figure 7.6: Average browse depth

Whilst the statistical analysis yielded no significant differences, a visual examination of the data suggests a number of general patterns as described in Table 7.5.

Table 7.5: Browse Coverage

	Open		Closed		Investigative	
	Novice	**Exp**	**Novice**	**Exp**	**Novice**	**Exp**
Breadth	High	High	Med	Low	High	Med
Avg Depth	Med	Med	Low	Low	Low	High
Browse Coverage	Wide and medium deep	Wide and medium deep	Medium wide and shallow	Narrow and shallow	Wide and shallow	Medium wide and deep

This table shows a summary of the coverage of the browse paths across the task types. The ranking of levels of breadth and depth into high, medium and low are based on the relative levels of each measure in Figures 7.5 and 7.6. The triangular figure at the bottom of each column is a representation of the browse coverage with the home page on the top apex. Participants who performed the closed task appeared to have a more focused browse path than those who performed the open task, suggesting that goal specificity influences the breadth of browse path. This behaviour is more pronounced in those participants who are familiar with the web site who would probably locate the target page in a shorter, more directed browse path due to prior knowledge of the site structure.

It is also interesting that both experienced and inexperienced participants performing the open task have a relatively high breadth and a medium depth. This pattern can be understood by considering the nature of the task which allows the participant to browse without a specific information need. We see participants visiting most of the major sections of the site but not exploring any in depth. Also apparent in the Investigative task, inexperienced participants have a wider coverage, whilst experienced participants have a deeper browse path. Thus there is a tendency for inexperienced web users to remain at the same browse depth when required to explore several sections of the site, whilst experienced web users will focus in on the relevant sections and explore them in depth.

7.3.8 Hub-and-spoke utilisation

Spokes are defined as routes where a browse path is retraced by a return journey (Canter et al., 1985). Hubs are defined as pages where at least three consecutive spokes originate. The utilisation measure is defined as the number of spokes multiplied by the average depth of spokes. For example, Figure 7.7 shows a browse path diagram with a hub page with three spokes. This hub page has a hub-and-spoke utilisation of 5.99.

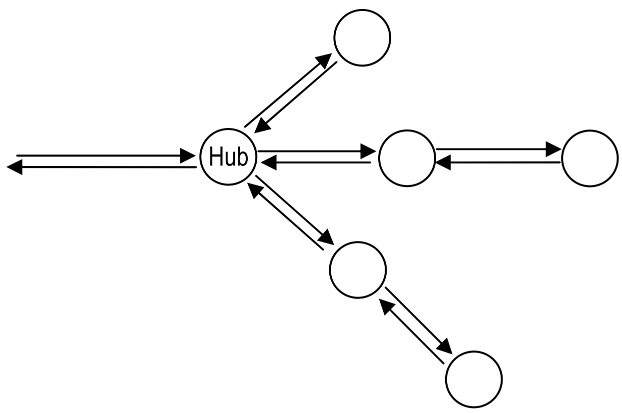


Figure 7.7: Hub-and-Spoke pattern

Figure 7.8 shows the average 'hub-and-spoke' browse pattern utilisation for all three task types, for both experience groups.

A visual examination of the graph suggests that inexperienced participants' hub and spoke exploration patterns are relatively consistent across all tasks suggesting their behaviour does not change with the task type. However, experienced participants' hub-and-spoke patterns change with task type.

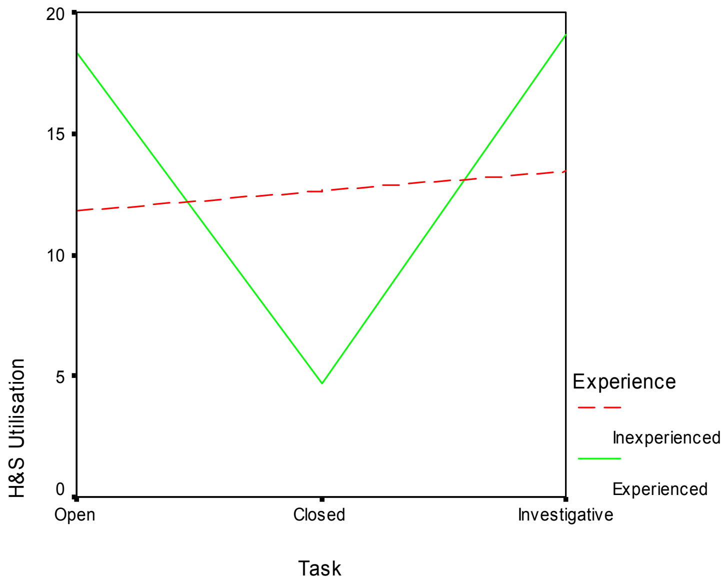


Figure 7.8: Hub and spoke utilisation

A 2 x 3 ANOVA for participant group (experienced, inexperienced) and task type (open, closed, investigative) was conducted to explore the impact of task type and experience on the use of hub-and-spoke patterns. There was a significant interaction [$F(2,12)=4.32$, $p<0.05$]. An analysis of simple main effects found a significant difference in the experienced group [($F(2,8) = 5.16$, $p<0.05$)] but no significant differences in the inexperienced group. This is illustrated in Figure 9 which shows the use of hub-and-spoke patterns only differs substantially for experienced participants.

There was also a main effect for task type [$F(2,12)=4.37$, $p<0.05$]. Post-hoc comparisons using the Tukey HSD test indicated that the hub-and-spoke patterns for the group of participants performing closed tasks were significantly different from the group performing investigative tasks ($p<0.05$). The group performing open tasks did not differ significantly from either of the other groups. The main effect for experience did not reach statistical significance.

It appears that experienced participants performing highly focused search tasks (closed tasks) do not rely on a 'hub-and-spoke' browse pattern to find the target page. Instead these participants, who are probably more familiar with the structure of the site, appeared to follow a single path using purposeful link selection taking them directly to target page.

We observe a reversal in the behaviour of experienced participants performing the Investigative task in which there is significantly more use of the 'hub-and-spoke' browse pattern compared with closed tasks. This Investigative task had no single correct answer. Instead, the nature of this task required comparisons between different sections of the web site in order to build up an answer. Experienced participants appear to employ the 'hub-and-spoke' pattern in order to systematically explore the site by spiking out and then backtracking.

7.3.9 Landmarks

Landmarks are pages which users frequently visit during a browsing session. In this study, landmarks were defined as pages visited three or more times, excluding the home page. Figure 7.9 displays the average use of landmarks for all three task types, for experienced and novice subjects. No significant results were found in the analysis, however the Figure suggests that experienced subjects utilise landmarks more than novices for goal-specific tasks, i.e. Closed and Investigative, but not for Open tasks.

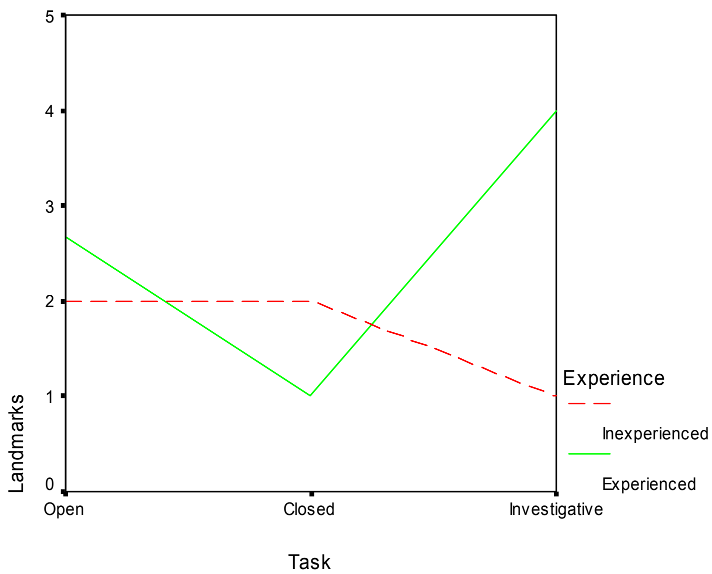


Figure 7.9: Landmarks created

This is consistent with research (Anderson 1980; Cohen & Schuepfer, 1980) that suggests that an advanced search strategy commonly used by explorers is to develop landmarks as bases for subsequent exploration.

7.3.10 Home page revisits

Figure 7.10 shows the mean number of home page revisits, for all three task types and both participant groups.

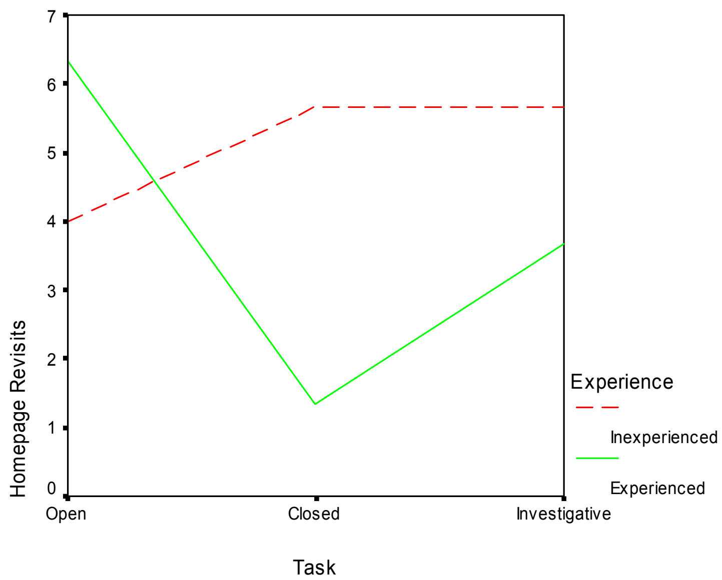


Figure 7.10: Home page revisits

Whilst not statistically significant, the figure suggests that inexperienced participants return to the home page more frequently than experienced users for the goal-oriented tasks (Closed and Investigative). The figure also suggests that experienced participants returned to the home page more frequently when undertaking open tasks suggesting that experienced web site users utilise the home page as a base when scanning the web site. This is consistent with Figure 7.9 where we find the number of non-homepage landmark pages created by experienced participants in the open task lower than the number of homepage revisits in Figure 7.10. It appears that experienced web site users explore sites in long spikes radiating out from the home page and backtracking directly to the home page without doing any side exploration. This is reversed for goal-specific tasks (Closed and Investigative) where it appears that the experienced web site users establish landmarks further down in the hierarchy for subsequent exploration of lower levels.

7.3.11 Top-level and lower-level page visits

The number of visits to top-level pages is calculated as the number of visits to the home page (level 0) and pages at first level in the site. The number of lower-level page visits is the number of visits to pages at levels two or deeper in the site. Figures 7.11 and 7.12 show the mean number of top-level pages (Levels 0 and 1) visited and the mean number of lower-level pages visited for all three task types, for experienced and inexperienced participant groups.

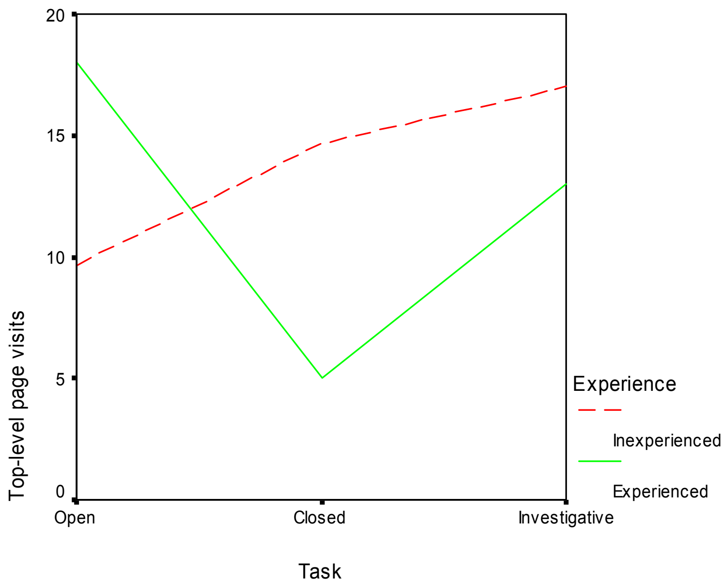


Figure 7.11: Top-level page visits

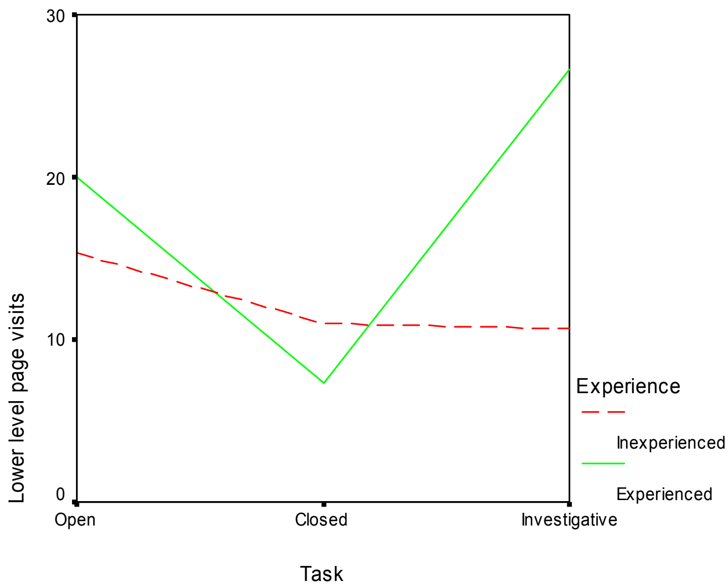


Figure 7.12: Lower-level page visits

A 2 x 3 ANOVA was performed for subject group (experienced and inexperienced) and task type (open, closed and investigative) for both data sets. The ANOVA for top-level page visits showed a significant interaction [$(F(2,12) = 8.14, p<0.05)$], however there was no significance for the lower-level page visits. An analysis of simple main effects for the top-level page visits yielded a significant difference in the experienced group [$(F(2,8) = 7.59, p<0.05)$] but no significant differences in the inexperienced group. A Tukey HSD test indicated that the differences between the open and closed tasks in the experienced group was significant ($p<0.05$). Figure 7.12 illustrates this difference showing that experienced participants visiting more high level pages for open tasks possibly to gain an overview of the site without any detail. Inexperienced participants had more top level visits than experienced participants for closed tasks who would have located the target page in a more efficient manner and therefore requiring less exploration at higher levels.

7.4 Discussion

7.4.1 Significant findings

A summary of key results is presented below. This summary details the important effects and interactions as well as some of the observational findings.

- A significant main effect ($p<0.05$) for the task factor for both the number of pages visited and the number of unique pages visited was revealed. These results indicate that participants viewed more pages and revisited more pages for the investigative and open tasks than the closed task.
- A significant interaction ($p<0.05$) was discovered between the task and experience factors for both the number of pages visited and the number of unique pages visited. Post-hoc analysis on these interactions showed that experienced subjects had more page revisits for investigative tasks than closed tasks.
- An analysis of the use of the home and back buttons found no statistically significant results, however a visual examination of the results suggests that experienced participants utilised the back button more than inexperienced participants for the open and investigative tasks than the

closed task, and that inexperienced subjects performing closed tasks utilised the home button regularly.

- A visual examination of the browse path breadth and depth data suggests a number of general patterns of browsing behaviour as shown in Table 7.5.
- The use of a hub-and-spoke navigation pattern was significantly different (main effect; $p<0.05$) for those participants undertaking the closed task and those performing the investigative task. A significant interaction between task and experience was also found showing that experienced participants use of this pattern depended on task. This suggests that when undertaking investigative tasks that involve the aggregation or comparison of information found on different parts of the web site, users will systematically explore and then backtrack. This is in contrast to the highly focused browse path of those undertaking closed tasks.
- A significant interaction ($p<0.05$) between task and experience for the number of top-level visits indicated that experienced participants had more visits to top-level pages when undertaking open tasks than closed tasks. This supports the general patterns of browsing behaviour as shown in Table 7.4 where browse paths for open tasks were broad and shallows, whilst those for closed tasks were narrow and deep. It also suggests that experienced users only scan the main categories of a web site and do not explore deeper sections of the site when performing open tasks.

A discussion of these findings is presented in the following sections.

7.4.2 Findings relating to navigational strategies

The study identified several patterns of behaviour for each of the task types. It is proposed that these patterns provide the basis for discerning a number of particular navigational strategies

The experiment found that participants who performed the open task had a broad browse focus and did not visit any section in depth. The ‘hub-and-spoke’ pattern was relatively common, however the results indicated that there was a lesser degree of landmark usage and that these participants did return to the home page frequently. This overall pattern could be labelled *scanning* as it involved a broad and shallow browse path with frequent home page revisits.

The results showed that participants who performed the closed task visited fewer pages, had a tighter focus of browse path and did not exhibit hub-and-spoke patterns as much as the participants who performed other tasks. This pattern could be labelled *searching* having the characteristics of highly focused browse paths relying more on purposeful link selection rather than random exploration. This pattern was more pronounced in experienced participants who had a better understanding of the structure of the web site accounting for the more efficient (shorter) browse paths when compared with inexperienced participants. However, it was found that experienced participants who performed the closed task utilised landmarks to a greater extent than participants who performed the open task.

Participants who performed the investigative task had a much wider browse focus and exhibited both the hub-and-spoke pattern and landmarks more than those who performed the closed task. This pattern could be entitled *selecting* which is characterised by a wide focus utilising systematic exploratory strategies at deeper levels in the web site. This strong use of this pattern was only evident in experienced participants with the inexperienced participants revisiting the home page more times probably due to a higher degree of disorientation.

Table 7.6 provides a summary of the browsing patterns for each level of goal specificity. A navigational strategy is proposed for each category.

Table 7.6: Browsing Patterns and Navigational Strategies

Goal Specificity	Behaviour/Pattern	Navigation Strategy
Open no specific content-based information need. Interest in meta-information	**Scanning** a broad and shallow browse path with frequent home page revisits	**Scan Browsing**
Closed a very specific information need	**Searching** a narrow pattern with visits to few pages with tight browse focus. Purposeful link selection	**Directed Browsing**
Investigative aggregation or comparison of different parts of the content	**Selecting** a wide focus utilising systematic exploratory strategies in some lower levels of the web site	**Selective Browsing**

The characteristics of each of the proposed browsing navigation strategies are:

Scan Browsing

Scan browsing suits ill-defined problems and new task domains (Marchionini & Shneiderman, 1988) where the user has a low level of goal-specificity. This strategy of navigation offers incidental learning (Marchionini & Shneiderman, 1988) and promotes discovery through serendipity. Whilst the user may not have a specific information need, the strategy might be used in order to obtain meta-information about the site such as the general organisation and size of the web site. Benyon & Hook (1997) describe this as "the contextual knowledge of the information space that is obtained during an exploration". We would expect to observe a general pattern of visiting most of the sections of the site in little detail in order to establish in the users mind an appreciation of the nature and extent of the web site. Hence, the breadth of the navigation path would be larger than the other browsing strategies, whilst the depth would be shallower. Use of this strategy my result in disorientation due to the random nature of their browse path, and hence would result frequently revisits to the home page.

Directed Browsing

Directed browsing strategies are characterised by a very specific information need resulting in a single outcome. Note that this strategy relates to the use of a page-to-page browsing and excludes the use of tools such as search engines. Users drill down through the web site towards the target information making navigational decisions at each page on the basis of the link information provided. The success of this strategy is relative to the quality of the link information (residue) and architecture of the web site. We would expect to observe users visiting fewer pages than the other strategies since the path would have a conclusion once the target page is located. The highly focused browse path would concentrate on the area of interest, hence the breadth would be narrow and the depth relative to the depth of the target page. It would be characteristic of a directed browsing path to have very few deviations since the user would simply be drilling down in the site towards the target. Hence, the utilisation of hub-and-spoke and landmarks would be expected to be low, as would the need to return to the home page.

Selective Browsing

Selective browsing is also characterised by a specific information need, however the outcome may be the result of an aggregation or comparison of information across several pages. Typical of such goals would be comparing a particular feature of different versions of a product or collecting the names of products which have a particular feature. Users would be required to systematically visit and revisit multiple pages in the site to compile an outcome. Again the success of this strategy is relative to the quality of the link information and is also strongly determined by the architecture of the information structure. The selective browsing strategy would involve visits to several sections of the site multiple times in order to perform the comparison or aggregation, hence it would be expected that the breadth of the navigation path to be wider than the directed browsing strategy. The average depth would again be relative to the depth of the target information. We would expect these users to utilise hub-and-spoke strategies and develop multiple landmarks in order to facilitate a structured approach to multiple visits over the site. Such users would be at risk of becoming disorientated due to their movement over multiple sections of the web site, hence we would expect that the number of home page revisits to be higher than the other strategies.

A flexibility/complexity trade-off exists between each of the strategies (Marchionini & Shneiderman, 1988). This trade-off is based on goal-specificity, system size, incidental learning, error risk and contextual knowledge. Directed browsing and selective browsing suit well-defined goals, whilst scan browsing is used for goals of low specificity. There is a high risk of error in directed searching as the target may not be able to be found due to the quality of the link information or poor site architecture. Scan browsing and to some extent selective browsing provide incidental learning and contextual knowledge that might improve the outcome of a directed search strategy. These tradeoffs are made by the user when considering the most appropriate browsing strategy to be employed for a particular information goal.

7.4.3 Findings relating to the research question addressed by this study

Q4: *What primary navigational strategy should sitemaps support?*

Study 2 established that when participants used a sitemap, they were significantly more likely to have a low level of goal specificity. This present study found that users with a low level of goal specificity will generally employ a *scan browsing* strategy that involves *scanning* browse path patterns which are characterised by broad and shallow browse paths with frequent home page revisits. Therefore, the primary navigation strategy that sitemaps should support is the *scan browsing* strategy characterised by *scanning* browse path patterns.

Sitemaps provide users with a representation of the architecture of a web site. They are typically structured either as an overview of the major categories of information available in the web site, or in some cases a view of the physical structure of the site. Actual sitemaps vary widely in the amount of detail that they provide. Users with goals of low-specificity are only interested in general information such as achieving an overview of the site's purpose and contents, or an understanding of its size and structure. Padovani and Lansdale (2003) recognise that this general information is meta-information or meta-knowledge and that accessing certain tools such as sitemaps can provide a "cognitive investment for future retrieval". Sitemaps that provide high level overview information will meet the immediate needs of those users with low levels of goal specificity.

It was evident from the results that the level of experience significantly influenced the browsing pattern for each of the goal-specific tasks. In many of the browse path measures, inexperienced participants behaved in a similar way independent of task, whilst the experienced participants extensively modified their behaviour depending on the type of task they performed. These findings are consistent with those of Rouet (2003), Jenkins et al. (2003) and Navarro-Prieto et al. (1999) as discussed in Section 3.6.

7.5 Summary

The experiment identified several patterns of behaviour for each level of goal specificity that were regarded as the foundations of a definable strategy. The results suggest that users with a highly specific goal utilise a *directed browsing* strategy that involves *searching* patterns with a highly focused browse path relying more on purposeful link selection rather than random exploration. Users with a specific goal that involves aggregations or comparisons across the web site use a *selecting browsing* strategy that involves a *selective* pattern characterised by a wide focus utilising systematic exploratory strategies at deeper levels in the web site.

More significantly, the results found that users with less specified goals employ a *scan browsing* strategy that involves *scanning* patterns which are distinguished by a broad and shallow browse path with frequent home page revisits. It was also evident from the results that the level of experience significantly influenced the browsing pattern for each of the goal-specific tasks. When considering these findings in conjunction with those of Study 2, it may be concluded that the primary navigation strategy that sitemaps should support is the *scan browsing* strategy characterised by *scanning* browse path patterns. The implications of this finding for the design of sitemap systems will be discussed in the next chapter.

8 Design Guidelines for Sitemaps

8.1 Introduction

The previous three chapters describe empirical studies into a number of research questions relating to sitemaps. This present chapter discusses several implications for the design of sitemaps that arise from the findings of the empirical studies. Structured design guidelines for sitemaps are developed, including a number of examples of sitemap systems which demonstrate the application of these guidelines.

8.2 Summary of Findings Relating to the Design of Sitemaps

The review of the literature relating to hypertext and web systems presented in Chapter 2 discussed the problems of navigation and disorientation in hypertext and web systems and the use of supplemental navigation tools, particularly sitemaps, to alleviate such problems. The chapter established that current sitemap design guidelines were deficient as they were not sensitive to the informational goals of users who decide to use sitemaps. Few connections with underlying theories and a lack of an empirical foundation were also raised as concerns with current guidelines.

Chapter 3 continued the literature review by focusing on the role of the user in the activity of web navigation. A conceptual framework of human-web interaction was proposed which provided the structure for a subsequent discussion relating to user goals and navigational strategies. A continuum of goal-specificity was proposed that included one axis extending from ill-defined (open goals) to tightly-defined goals which require either a single (closed goals) or an aggregate answer (investigative goals). The chapter concluded by identifying two issues for investigation: (i) the impact that the users' goal type has on a decision to select a particular web site navigation tool, and (ii) the impact of the users' goal type on the strategy that they employ when undertaking page-to-page browsing. Three empirical studies were undertaken to investigate these issues.

The exploratory surveys in Study 1 found little consistency in the design of sitemaps on commercial web sites confirming evidence found in the literature regarding inadequate design guidelines for sitemaps. A survey that investigated user expectations of the design and purpose of sitemaps resulted in the identification of a hypothesis regarding the relationship between the selection of sitemaps and goals of low specificity. Experimental findings from Study 2 supported this hypothesis showing that when users chose to a sitemap, they were significantly more likely to have a low level of goal specificity (i.e. open goals).

Study 3 examined whether goal-specificity influenced browsing strategies. The experiment identified certain browse path patterns for each level of goal specificity that led to the identification of a number of browsing strategies.

The relationship between the findings from the main empirical studies, Study 2 and Study 3, are shown in Figure 8.1.

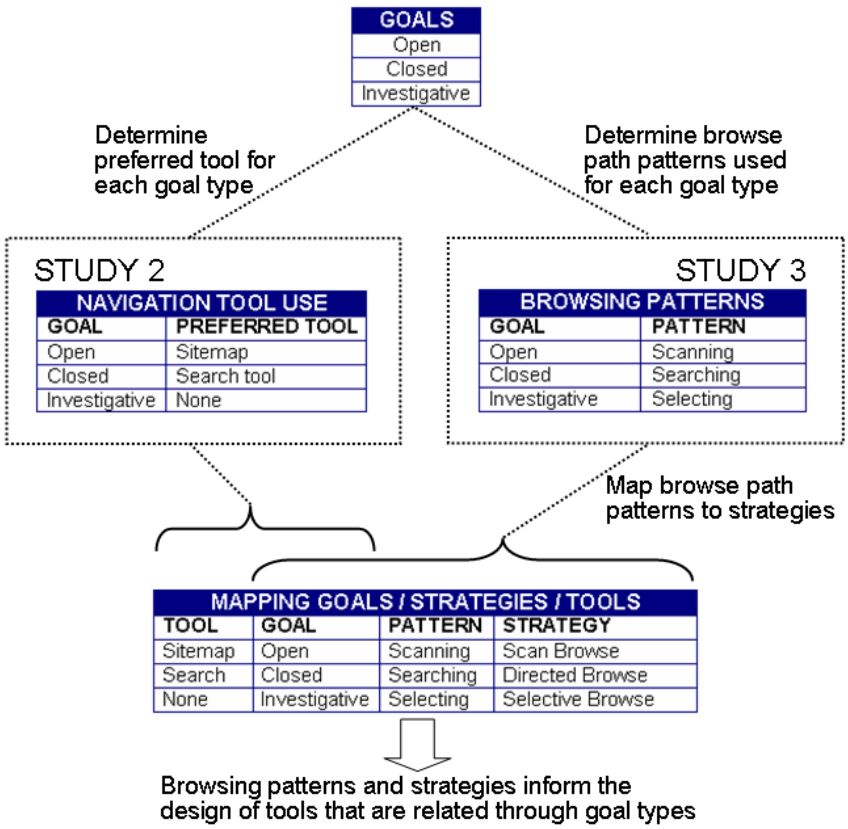


Figure 8.1: Summary of empirical findings

When considering the preferred tools for goal types (as determined by Study 2) in conjunction with the mapping of goal types to browsing path patterns (as determined by Study 3), it may be concluded that the primary navigation strategy that sitemaps should support is the *scan browsing* strategy. This strategy is associated with *scanning* browse path patterns which are characterised by broad and shallow browse paths with frequent home page re-visits and regular use of hub-and-spoke exploration paths.

Together, these studies inform the design of sitemap tools by providing designers with an understanding of the goals of the typical sitemap user. This link between goal specificity and their related browse path patterns and navigational strategies must become an important consideration in the design decisions for interfaces of supplemental navigation tools such as sitemaps.

The principle finding from the empirical studies with respect to the research questions is that users who choose sitemaps are more likely to have a goal of low specificity. Hence, support for the *scan browsing* strategy should be the primary consideration in the interface design of sitemaps. The *scan browsing* strategy involves obtaining an overall view of the major sections of a web site without visiting any section in detail. The user might be using this strategy to attempt to gain an appreciation of the general nature and extent of the web site. Accordingly, sitemaps should primarily provide an overview of the major sections of the site without much detail. They should also provide orientation within the site with respect to the home page, and should allow users to explore deeper into the site if desired.

The recommendation that sitemaps should primarily provide an overview representation is consistent with the participant feedback from the questionnaire in Study 2 where 70% indicated that they would use a sitemap to obtain an overview of a web site. In addition, 60% indicated they would use a sitemap if they were lost and 38% claimed they would use a sitemap to find out how large the site was.

The empirical studies also produced several other findings that may contribute to specific advice to sitemap designers that will ensure that their sitemaps are sensitive to the needs of the users of these tools. These other findings relate to:

General Design

> Sitemaps should employ a hierarchical design with 89% of the participants in Study 1 indicating that they expected a hierarchy. This is consistent with the finding that all of the commercial sitemaps that were reviewed in Study 1 were hierarchical. There is a strong expectation from participants

in Study 1 (94%) that sitemaps present a categorical list of topics with 50% of participants expecting a textual 'table-of-contents' style and 27% a graphical sitemap.

Study 3 found that experienced participants returned to the home page more frequently when undertaking open tasks, hence designers should consider making the home page a significant feature in the sitemap.

Link Placement

Users who selected a sitemap in Study 2 browsed on average 6.5 pages prior to clicking on the sitemap link. This finding necessitates the placement of the sitemap link on the general site template making it available from any page in the web site. This advice is consistent with the comments made by participants in Study 2 regarding the use of sitemaps as 'a last resort' and when they are lost in the web site.

Study 2 found that 50% of participants undertaking open tasks chose to browse only rather than using a navigation tool may indicate that they were not aware of sitemaps (25% of participants rated themselves as unfamiliar or 'a little familiar' with sitemaps), or could not find the link to the sitemap (as suggested by Stover et al. (2002)). This suggests that the link to sitemap be placed in a prominent position on the general page template.

Interactivity

The findings from Study 2 and Study 3 demonstrate that the primary use of sitemaps is to provide an overview of a web site. This may be to assist a user in gaining an overall appreciation of the site's organisation, purpose and extent. To facilitate an overview experience it is desirable to design the sitemap so that it can be viewed without the need to scroll. Research confirms that the use of scroll bars to view large maps can result in sub-optimal performance (Beard and Walker, 1990). It is noted that Study 1 found that 71% of the commercial sitemaps that were reviewed required the use of scroll-bars on screen with normal resolution, hence this is a significant problem with current design practice. Specific visualisation techniques such as those described in Section 2.4.4 could be incorporated into the design of sitemaps in order to maintain overall context if the sitemap exceeds standard screen dimensions.

Although a significant finding in Study 3 was that experienced users focused their activity at the higher levels of web sites when undertaking open tasks, such users also did on occasions explore some of the deeper sections of the site. Also, although Study 2 found that the primary use of sitemaps was for open tasks, 9% of the closed tasks resulted in the selection of a sitemap. Therefore, whilst sitemaps should primarily provide an overview representation without much detail, it would be desirable to have functionality to support those users who wish to explore deeper into the structure of the web site. Again, certain visualisation techniques such as those described in Section 2.4.4 could be employed in order to control the complexity of the sitemap and still provide the opportunity to view information about the lower levels.

Finally, it was noted in Study 3 that browse paths for open tasks resulted in 31% of pages being revisited. This may be a result of the use of 'hub-and-spoke' patterns or alternatively might be cause by disorientation. Consideration might be given to techniques that indicate pages on the sitemap that had been visited in the current browsing session similar to the systems developed by Ayers & Stasko (1995) and Cockburn et al. (2003).

Results of the survey of commercial web sites in Study 1 found that only 1.2% of sitemaps had any additional controls, hence the lack of interactivity and visualisation controls is a significant issue.

The following section describes design guidelines that have been informed by these findings.

8.3 Design Guidelines for Sitemaps

The approach to the documentation of the guidelines was based on the technique used by Smith and Mosier (1986) in their widely cited guidelines for design of user interface software. The guidelines are expressed in a structured format that includes title, description, example, comment and reference. Smith and Mosier worded guidelines in terms of the functions that a user must perform, and the functional capabilities that a designer should provide. Each guideline is stated as a single sentence and described as simple as possible to allow some interpretation in their application. Each guideline is accompanied by one or more examples which illustrate a possible application of the guidelines. Smith and Mosier are careful to point out that a reader who relies only on the example that is provided may interpret the guideline as having a narrower meaning than was intended, and hence recommend that examples not be used to limit the interpretation of guidelines. Each guideline is also accompanied by supplementary comments and references. The comments may provide some ways to interpret and implement the guidelines, whilst the references provide details of where the guideline has been derived from and the rationale behind the guideline.

8.3.1 Guideline 1: Sitemaps should primarily provide an overview

The sitemap should present an overview, preferably limited to the 2nd level in the hierarchy. The sitemap should convey overview information at a glance, hence a basic overview design without extensive detail is recommended. The entire sitemap should be able to be viewed in a standard window without scrolling.

Examples

The sitemaps presented in Figure 8.2 are self contained on one screen allowing the user to view all main sections without scrolling. They clearly highlight the major section headings and provide links to level 2 headings.

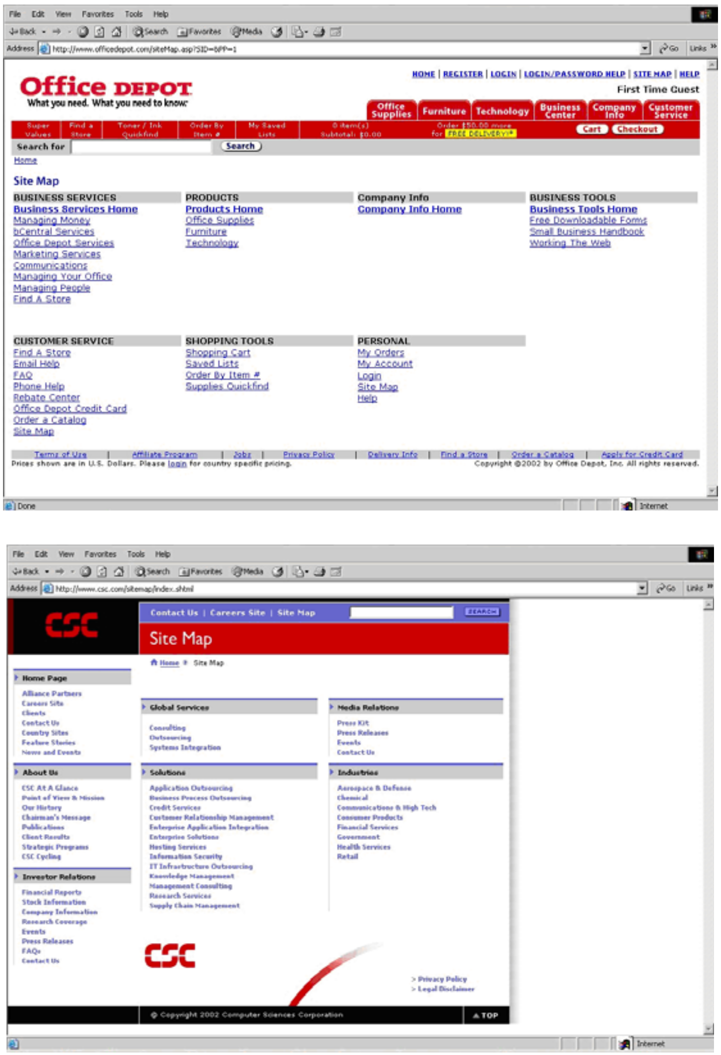


Figure 8.2: Sitemap examples with good overview

In contrast, the sitemap shown in Figure 8.3 only allows the user to view only around 30% of the full contents at once.

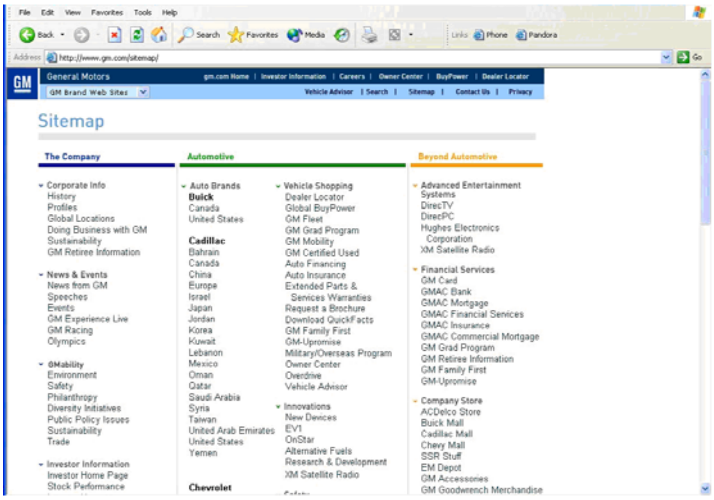


Figure 8.3: Sitemap example with poor overview

Rationale

- Study 3 found that participants undertaking open tasks perform a *scanning* strategy in which they explored across the breadth of the top-level categories of the site. Participants in this experiment visited most of the major sections of the site but not exploring any in depth. Study 2 found that participants choosing sitemaps were more likely to be undertaking tasks of low goal specificity.

- Participants in Study 1 indicated that they expected that they would be able to view 2 or 3 levels in the sitemap.

- Study 3 found that experienced participants used a 'hub-and-spoke' exploration strategy when undertaking open tasks. This is consistent with the finding that experienced subjects also used the back button more than inexperienced subjects for open tasks, and that they had more top-level page visits for open tasks. Overviews provide an immediate 'hub-and-spoke' effect by providing a view of the first two levels in a web site.

- 70% of participants in the Study 2 indicated that they would use a sitemap to "get an overview of the structure of the web site".

- Beard and Walker (1990) have provided empirical evidence to suggest that users perform sub-optimally with scroll bars in tasks which require navigating a large two-dimensional space. An overview should be able to be viewed without scrolling in order to maintain relationships between sections of the web site.

8.3.2 *Guideline 2: Use hierarchy in sitemaps*

Sitemaps should be presented as a hierarchy of the major information categories. The hierarchy should present the semantic relationships between the content rather than the physical structure of the file system.

Examples

The sitemaps in Figure 8.4 present strong hierarchies. They clearly highlight the level headings and various sections of the web site are visually distinct from each other.

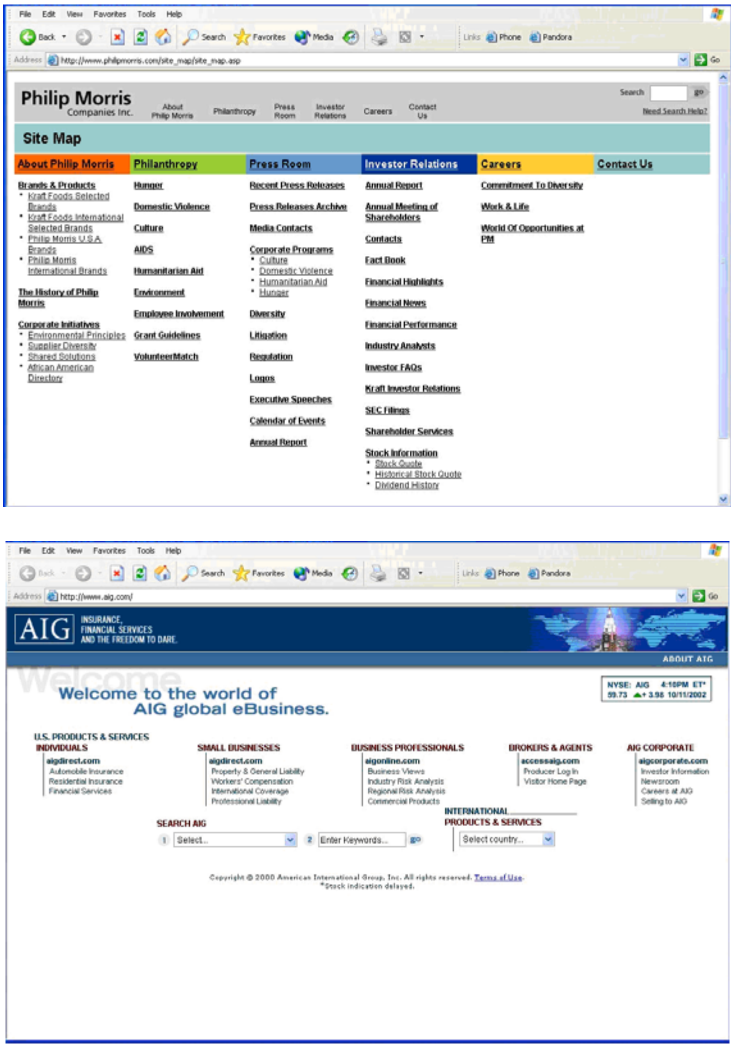


Figure 8.4: Sitemap examples with strong hierarchies

The sitemap shown in Figure 8.5 presents a relatively weak hierarchy. Whilst it appears that the level 2 headings have been indented this may not very clear to users who only give the sitemap a cursory glance.

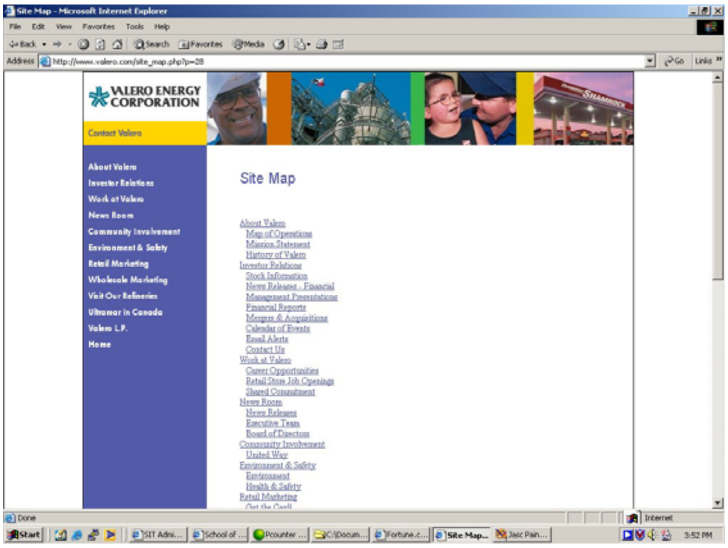


Figure 8.5: Sitemap example with a weak hierarchy

Rationale

- 89% of participants in Study 1 indicated that they would expect a sitemap to provide a categorical presentation structured into a hierarchy.
- All commercial sitemaps surveyed in Study 1 that had sitemaps presented them as a hierarchical view of the site based on a list of the major categories within the content.
- The literature indicates that hierarchy is a desirable format for presenting structured information (Norman K., 1991; Durand and Kahn, 1998).

8.3.3 *Guideline 3: Consider a 'Table-of-Contents' design*

Sitemaps may be considered similar to the table-of-contents of a book providing a list of the major categories of information (i.e. chapters) and their subsections. Whilst graphical or metaphorical style of sitemap designs might be appealing, there is the risk that users will find these designs difficult to immediately comprehend. 'Table-of-Contents' designs reduce the inherent navigational difficulties of sitemaps as have they are a well known device from our experience with books.

Examples

The sitemaps in presented Figure 8.6 present examples of graphically orientated designs created manually and automatically. These designs may present navigational difficulties themselves.

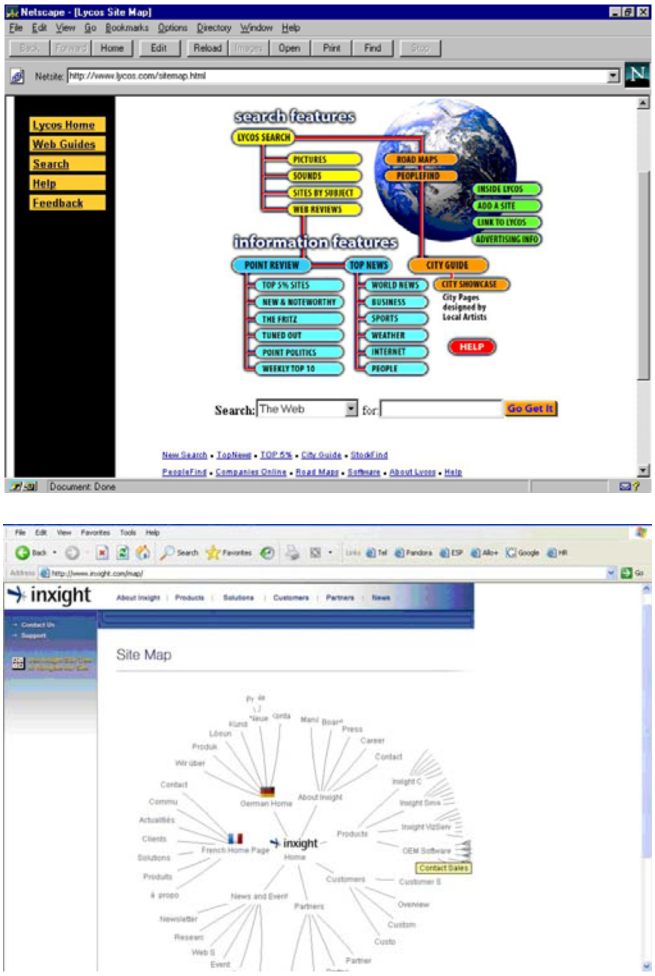


Figure 8.6: Manually and automatically generated graphical sitemaps

Figure 8.7 presents a sitemap that that has a design similar to a 'Table of Contents' that might be found in a book. Major 'chapter' headings and subheadings are readily evident at a glance.

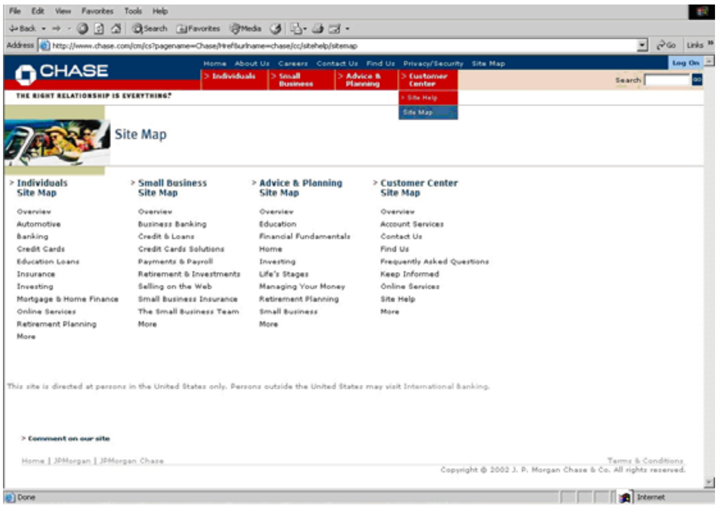


Figure 8.7: Sitemap example using a Table of Contents design

Rationale

- Study 1 found that 50% of the participants claimed that they expected a sitemap to provide a textual hierarchy similar to a table-of-contents. Only 27% indicated that they expected a graphical, tree-based hierarchy.

- Only 6 of the 158 sites surveyed in Study 1 that had sitemap presented graphical format with lines connecting relationships between levels and nodes. 95% provided a textual presentation similar to a table of contents.

- 'Table-of-Contents' formats are well-established devices providing a familiar order and functionality (Hoffman, 1996).

8.3.4 *Guideline 4: The sitemap link should be prominent*

The name of the link should be 'sitemap', not 'site index' or 'site directory'. The link to the sitemap should be in a prominent position in the general site template and should be placed proximate to the search tool.

Example

Figure 8.8 presents a sitemap that has links to search and sitemap in a proximate and prominent position.

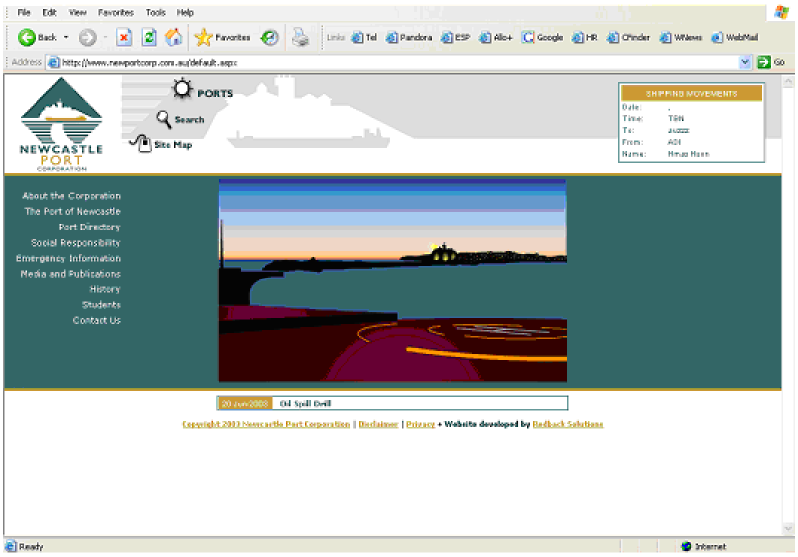


Figure 8.8: Sitemap with prominent sitemap link

Rationale

- Sitemaps are not frequently used. Study 2 found that 40% of participants indicated that they 'never' or 'rarely' use sitemaps and 25% of participants rated themselves as unfamiliar or 'a little familiar' with sitemaps. Study 2 also found that 50% of the participants undertaking open tasks chose to browse only rather than using a navigation tool. Stover et al. (2002) claim that some users have problems finding the link to the sitemap on web sites. A more prominent location of the link to the sitemap might provide users with additional navigational opportunities.

- Users who selected a sitemap in Study 2 browsed on average 6.5 pages prior to clicking on the sitemap link. This finding necessitates the placement of the sitemap link on the general site template making it available from any page in the web site. This advice is consistent with the comments made by participants in Study 2 regarding the use of sitemaps as “a last resort’ or when they are lost in the web site.

- Some participants in Study 2 indicated that they use sitemaps if they “could not find something with a search tool”. A sitemap can provide clues to the vocabulary used in the web site. The sitemap link should be placed near the search tool to provide support for users who have difficulty in creating successful search strings.

8.3.5 Guideline 5: Control complexity in sitemaps

Sitemaps should primarily provide a representation of the major content categories at a level of detail that would enable the user to gain an overview of the purpose, structure and extent of the web site. A secondary function would be to facilitate exploration of content deeper in the site, however it is important that the level of detail be minimised in the initial view.

At least, all sitemaps should permit users to click through to a section of interest. An alternative is the use of visualisation techniques that facilitate exploration of sections of the sitemap but controls the level of complexity presented to users so that the sitemap itself does not become a navigational challenge.

Examples

> Section 2.5.4 of this report introduced a variety of visualisation techniques that provide user control over the level of complexity and detail in a sitemap. These include thresholding and distortion techniques.
>
> Thresholding presentations provide a systematic way of suppressing or revealing the information to be presented. Techniques include the use of dynamic filtering tools that allow the user to control the number of levels in structure to be viewed. Filters may also be applied to other attributes such as size, date and department that would control the visibility of elements in the sitemap.
>
> The examples provided in Figure 8.9 present two examples of sitemaps found on commercial web sites that employ the use of filters to control the level of complexity presented to the user. The first example provides a list of content headings for the site along with the instruction to "click to expand". When an option is clicked the map reveals the sub-headings for that particular option. This functionality is similar to the Windows File Explorer, and hence would be readily understood by users. The second example presents a graphical design with nine headings. Instructions inform the user to click the link to go to that section or page, or to click an icon to present a site directory for that section. In both examples an overview containing only the major headings is initially presented, however the user can manipulate filter controls to reveal further details.

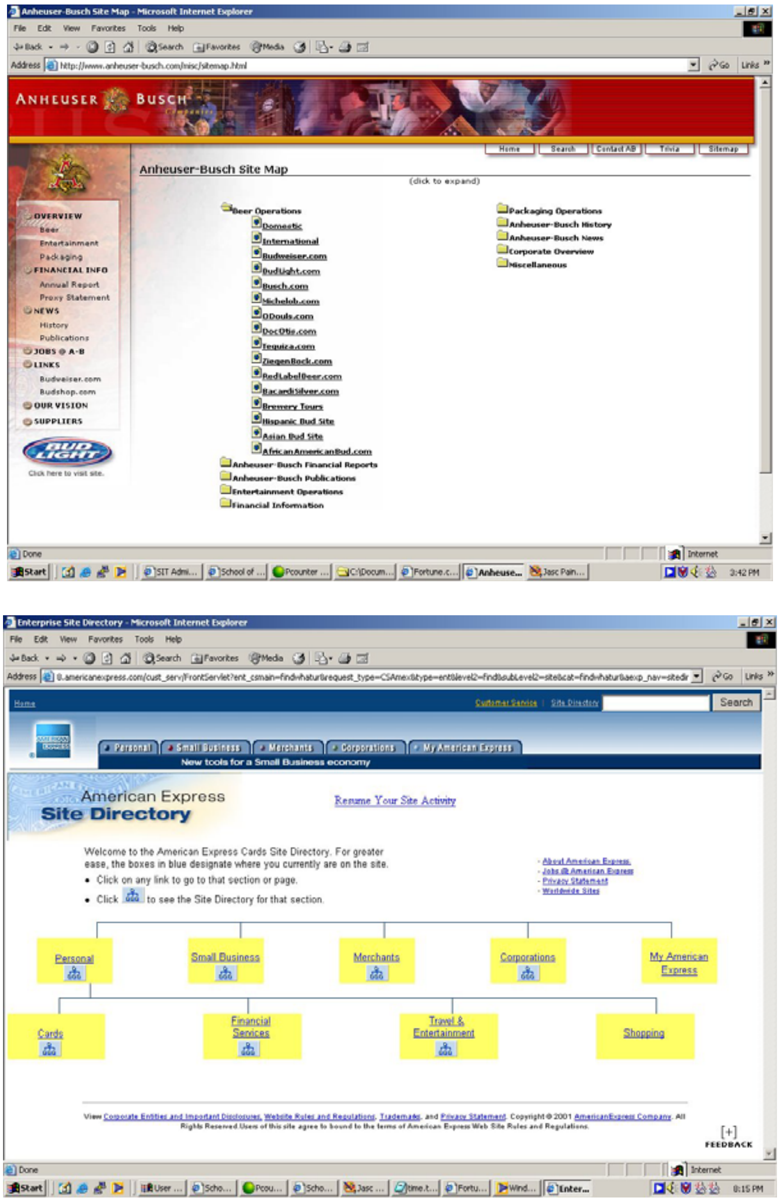


Figure 8.9: Sitemaps with threshold filters

A further example of the application of thresholding visualisation techniques to sitemaps is the 'SiteTree' experimental sitemap system (Pilgrim and Leung, 1999b). This system automatically generated a sitemap from a scan of an entire web site. The sitemap was implemented as a Java applet that dynamically built a hierarchical representation of the structure of the web site from a database of pages and links. The sitemap initially displayed all pages in the first level of the site as shown in Figure 8.10. The user could control visibility of sections of the sitemap by manipulating familiar expand/contract controls that provide the ability to switch between a global overview and a local representation. Filtering tools were provided to hide or display external links and links to non-html pages. The system also provided the ability to filter out pages of ‘low-priority’ leaving only ‘landmark’ pages. The sitemap applet utilised a colour-coding scheme to indicate differing priority values for pages from blue (cold) to red (hot). The priority values were set according to usage (the number of hits the page has) and importance in the structure (the number of links to and from each page). Users could change the ‘viewing threshold’ by clicking on the appropriate colour in the control panel. This control provided the user with the ability to filter out groups of pages in the sitemap based on the value of the priority attribute leaving more important ‘landmark’ pages. This experimental sitemap system demonstrated that thresholding-based visualisations, such as expand/contract displays, may provide users with control over the complexity of a sitemap display.

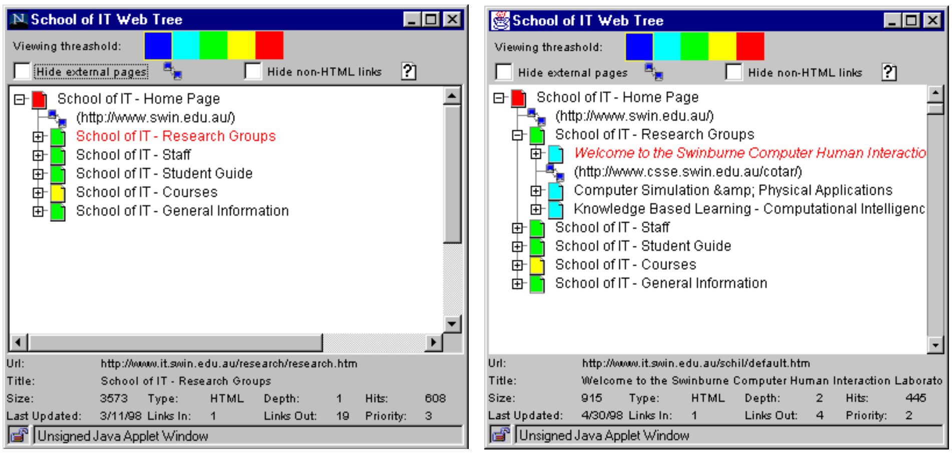


Figure 8.10: ‘SiteTree’ experimental sitemap applet (Pilgrim and Leung, 1999b)

An alternative visualisation technique is distortion. Distortion techniques provide users with an integrated local and global view of the web site allowing exploration of detail whilst maintaining overall context. Techniques include the use of zooming, split screens, magnifying glasses, and distortion oriented displays such as fisheye lenses and bifocal displays.

Figure 8.11 presents a bifocal sitemap display (Pilgrim and Leung, 1996). The bifocal display was proposed by Spence and Apperley (1982) as a technique to overcome the keyhole problem described in Section 2.2.3.1 by providing concurrent presentation of local detail with global context.

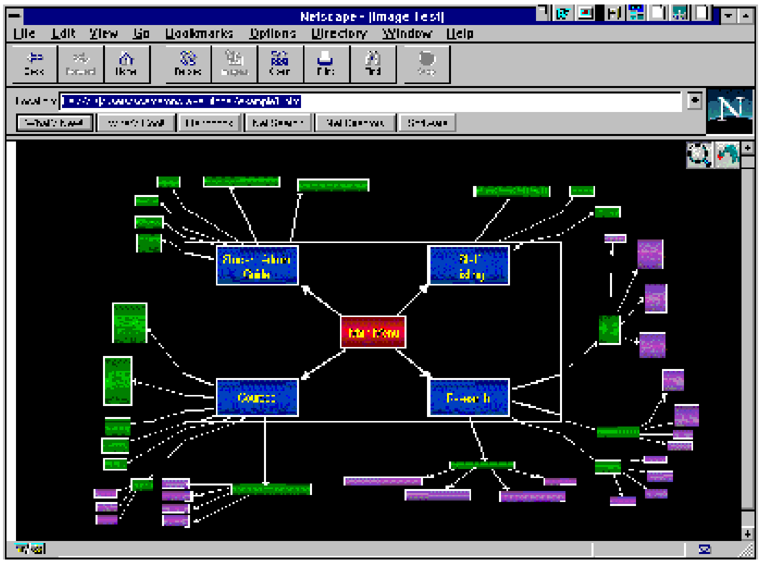


Figure 8.11: Bifocal sitemap display (Pilgrim & Leung, 1996)

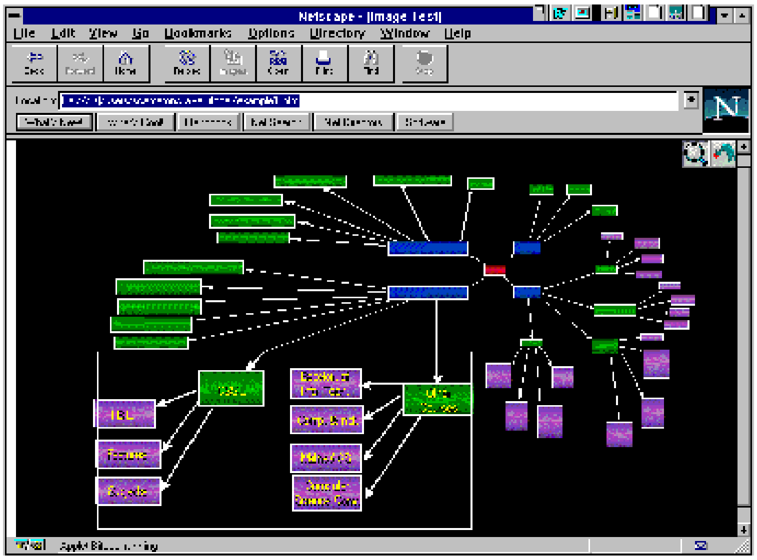


Figure 8.12: Movement of region of focus

The two dimensional bifocal display comprises of nine distinct regions with the central focus region providing a detailed view of part of the entire map. The surrounding eight regions are demagnified by a constant value in either x, y or x and y dimensions depending upon their position relative to the central focus region. The original graphical sitemap required the use of scroll bars to view the overall structure. The bifocal distortion-oriented bifocal display reduces the overall display to fit inside a standard window. The user can establish overall orientation within the web site and then view the detail of the section of interest by dynamically controlling the focal area of the map by mouse movements (Figure 8.12). The area of the map outside of the focus region is distorted in such a manner that the user can place the focus region in the context of the whole sitemap. The links between the nodes do not lose continuity over the boundary of the focal area thereby allowing the user to visually follow a path. This prototype demonstrates that distortion-based visualisations, such as bifocal display techniques, are an effective way of controlling complexity in a sitemap by concurrently providing the user with a detailed local view to facilitate navigation and a global context to assist with overall orientation.

Rationale

- Most participants in Study 1 expected that they would be able to initially view 2 or 3 levels and then click through to an area of interest.
- Study 3 found that experienced participants focused their activity at the higher levels of web sites when undertaking open tasks but did on occasions explore some of the deeper sections of the site.
- Study 2 found that the primary use of sitemaps was for open tasks, however 9% of the closed tasks also resulted in the selection of a sitemap. Therefore, whilst sitemaps should primarily provide an overview representation without much detail, it would be desirable to have functionality to support those users who wish to explore deeper into the structure of the web site.
- Bieber et al. (1997) describe the problems of navigating sitemaps themselves, especially when they are large or complex.

8.4 Summary

This chapter identified a number of design considerations for the development of sitemaps. Five specific design guidelines were proposed each with an empirical and theoretical rationale and examples of application.

9 Summary and Conclusions

9.1 Introduction

This chapter presents a summary of the project and the major findings. The findings are expressed in terms of responses to the targeted research questions. Some additional research outcomes are also presented and discussed in terms of their contribution to the field. The significance of the research is discussed and some areas for future research are presented.

9.2 Summary of the Thesis

The aim of this project was to examine the effects of goal specificity on the use of supplemental navigation tools for web sites, specifically how goal specificity influence the browsing strategies of web site users, and their decisions to use particular supplemental navigation tools. The research outcomes included a set of empirically-based design guidelines for sitemaps.

A review of the related literature reported in Chapter 2 examined the architecture of the web, inherent navigation problems, the design and use of supplemental navigation tools, particularly sitemaps, and design guidelines for sitemaps. The literature review continued in Chapter 3 focusing on web navigation from the perspective of the web being used by humans when seeking information. A human-web interaction framework was proposed that contextualised the project in terms of previous theories and provided a structure which assisted in the identification of issues for investigation. The specific research issues chosen for this project related to user goals and navigation strategies, and their impact on the design of sitemap tools.

The review of the literature determined that current design guidelines for sitemaps were inadequate as they were based largely on expert opinion or observational evaluations. Further, previous empirical studies examining navigational tools such as sitemaps did not considered goal specificity as a factor.

Several targeted research questions were devised and methods of investigation selected. Three empirical studies were undertaken.

Chapter 5 presented the results of a set of surveys that suggested that there is substantial confusion regarding user expectations of the design and functionality of sitemap tools. The surveys led to a hypothesis regarding the relationship between the selection of sitemaps and goals of low specificity.

Chapter 6 reported an experiment that tested the hypothesis identified in the previous chapter. The experimental findings suggested that users with general questions, or those who are interested in meta-information about a particular web site, are more likely to browse than to choose to use a navigation tool. If a navigation tool is selected under those circumstances, it is significantly more likely to be a sitemap than a search tool, and it is more likely that users will browse through several pages on the web site before selecting the sitemap. The findings supported the hypothesis that goal specificity influences the selection of different types of supplemental navigation tools.

Chapter 7 reported an experiment that examined the effects of goal-specificity on browsing strategies. The experiment identified certain browse path patterns for each level of goal specificity that led to the identification of a number of browsing strategies. The findings showed that users, particularly experienced users, employ different strategies when pursuing goals of different levels of specificity. In particular, those users with open goals used a *scanning* strategy that involves a broad, shallow browse path with frequent home page revisits.

Chapter 8 presented several design implications for sitemap systems expressed as formal design guidelines that have an empirical and theoretical rationale. Examples of the application of each guideline were presented.

9.3 Main Findings

The focus question for the study was: *Does goal specificity influence the navigational behaviour of users when visiting web sites, particularly in relation to their use of sitemaps; and what are the design implications for sitemaps?*

This focus question resulted in four targeted research questions that were derived from the literature review in the context of the proposed human-web interaction framework. This section revisits each of those research questions in the light of the findings from the various studies.

9.3.1 Question 1: What is the current status of sitemap designs and functionality on the World Wide Web?

The findings from the initial exploratory survey in Study 1 suggested that approximately half of commercial web sites on the Web provide a sitemap. Also determined was that most sitemaps on commercial web sites are presented as a textual list of the major content categories within the site organised into a hierarchy of several levels. Few sitemaps in practice employ a graphical format. A significant proportion of sitemaps are too large to allow the entire sitemap to be viewed without the use of scroll bars. Finally, the use of visualisation techniques to support the user in understanding the sitemap is negligible.

9.3.2 Question 2: What expectations do users have of the design and functionality of sitemaps?

The results of the second exploratory survey in Study 1 found some consensus in user expectation regarding the structure of sitemaps. The findings suggest that most users expect that sitemaps would be presented as a categorical hierarchy of links displayed on a single web page. Users expect that they would be able to view 2 or 3 levels in the hierarchy and that they should be able to click through to an area of interest. Users appear to be equally divided regarding the design of the hierarchy, with some expecting a textual organization and others a graphical view. User expectation of visualisation support for controlling the view of the sitemap is low.

9.3.3 Question 3: What level of goal specificity do users have when they decide to use a sitemap?

The final exploratory survey in Study 1 indicated a potential relationship between the selection of sitemap tools and users with ill-defined goals. A hypothesised relationship between tool use and goal specificity was tested in Study 2. The hypothesis was supported, suggesting that users selecting sitemaps are more likely to have a low level of goal specificity, and are probably more interested in general or meta-information about the web site rather than a specific piece of content on the site.

9.3.4 Question 4: What primary navigational strategy should sitemaps support?

Study 2 established that users selecting sitemaps are more likely to have a low level of goal specificity. Study 3 examined navigation patterns as a function of goal specificity and determined that users with a low level of goal specificity generally employ a *scan-browsing* strategy that is characterised by a broad, shallow browse path with frequent home page revisits.

Considering the findings of Study 2 and Study 3 together, the primary navigation strategy that sitemaps should support is a *scan-browsing* strategy involving a general pattern of visiting most of the sections of the site but without going into detail in any particular section. This strategy would be used to gain an overview of the site's purpose and contents, or an understanding of its extent and structure.

9.4 Research Outcomes and Contributions

9.4.1 Guidelines for sitemap design

The review of the literature presented in Chapters 2 and 3 established that current sitemap design guidelines were deficient as they were not sensitive to the informational goals of users who select to use a sitemap. Few connections with underlying theories and a lack of an empirical foundation were also raised as concerns with previous guidelines.

As a result of a review of the related literature and the findings from the empirical studies, five specific design guidelines were proposed in Chapter 8, each with an empirical base and a theoretical rationale, and examples of application.

Guideline 1: Sitemaps should primarily provide an overview

> The sitemap should convey overview information at a glance, hence a basic overview design without extensive detail is recommended. The entire sitemap should be able to be viewed with minimal scrolling

Guideline 2: Use hierarchy in sitemaps

> Sitemaps should be presented as a hierarchy of the major information categories. The hierarchy should present the semantic relationships between the content rather than the physical structure of the file system.

Guideline 3: Consider a 'Table-of-Contents' design

Whilst graphical or metaphorical style of sitemap designs might be appealing, there is the risk that users will find these designs difficult to immediately comprehend. 'Table-of-Contents' designs reduce the inherent navigational difficulties of sitemaps as they provide a familiar structure to users.

Guideline 4: The sitemap link should be prominent

The name of the link should be 'sitemap', not site index or site directory. The link to the sitemap should be in a prominent position in the general site template and should be placed proximate to the search tool.

Guideline 5: Control complexity in sitemaps

The level of detail should be minimised in the initial view. The use of visualisation techniques that facilitate exploration of the detail in sections of the sitemap but control the level of complexity presented to the user should be considered.

9.4.2 A framework for human-web interaction

A significant outcome of this research project is the proposed framework for human-web interaction (Figure 3.4). Conceptual frameworks such as this are a way of representing an object, system, process, structure or concept, by first identifying all of the essential elements and then representing their relationships in an organised manner. Whilst frameworks can be used in a range of ways, the motivation for the development and use of a framework in this project was to provide orientation and direction to the research allowing the various variables, research questions and underlying theories to be considered logically and systematically without losing the overall context. These types of frameworks are not meant to be theories to be empirically tested or proven (Saracevic, 1997), but rather they operate at theory formation stage, and are used to guide research by suggesting relationships that might be fruitful to explore or test (Wilson, 1999). Furthermore, frameworks can also provide the basis for evaluating the relevance of research outcomes and to facilitate the identification of areas of application and further research.

The proposed framework comprised four stages with a concurrent perception process and an interlinked cognitive model. It was used in this research project to clarify the relationships between user goals and navigation strategies within the context of web navigation, and guided the development of the research questions.

9.4.3 Implications for empirical investigations into web navigation

This research project determined that goal specificity is a major factor in the decision of a user to select particular navigation tools. Many previous empirical studies examining the use or design of navigational tools such as sitemaps or search tools have not considered goal specificity as a factor. Instead, these previous studies used search-oriented tasks in their experimental design and restricted data collection to measures of completion times and task success. Whilst such measures support the analysis of closed, fact-finding tasks, they do not investigate possible strategies utilised for other goal types. Goals of low specificity require measures that provide an understanding of more general attributes of navigation paths such as the extent of the site visited and the patterns of the paths that are followed.

It is recommended that design of future empirical studies into web navigation, particularly studies which aim to develop or validate design guidelines for navigation tools, should consider goal specificity as a factor. Appropriate experimental measures that are sensitive to a range of goal types should be chosen.

9.5 Significance of the Project

9.5.1 For web site developers/designers

This project has established that links entitled ‘Sitemap’ may be found on approximately 50% of commercial web sites. The costs of providing sitemaps would translate into many millions of dollars of design, development, storage, maintenance and upgrades each year across the world.

Furthermore, this project reported that many users indicated that they select to use sitemaps when they are disoriented, or as a ‘last resort’ when navigating through web sites. We know that web users are impatient, require instant gratification and will leave a site if they cannot immediately figure out how to find what they want

(Nielsen, 2000a). Poorly designed sitemaps could result in a user being further disoriented or disillusioned about the quality of the web site. The consequences of poor design could lead to a loss of opportunity to the organisation.

Given the significant costs of implementing sitemaps into web sites, and the importance of providing appropriate navigational support for users, it could be assumed that there would be well established guidelines for the design and development of sitemap interfaces underpinned by rigorous empirical research and usability studies. It is therefore surprising that the limited guidelines that do exist are either based on extrapolation of navigation research into pre-web hypertext systems or on empirical studies that use methods and measures that may not take into account the particular nature of sitemap tools.

This project demonstrates that users who choose to use a sitemap are most likely to be interested in overview and meta-information about the site. Sitemap interfaces should be designed to primarily provide overview information. The project confirms and extends existing design guidelines for the design of navigational tools for web sites, and recommends the use of visualisation techniques to control complexity of the interface when implementing sitemaps in large and complex sites. The guidelines developed out of this project address a significant gap in current research, and will benefit designers of sitemap tools by assisting them in developing interfaces that will align with the expectations of users.

9.5.2 For researchers

The project contributes to the design and conduct of future research into web navigation tools. Goal specificity was found to be a major factor in the decision to use navigation tools, and hence it is recommended that in the design of empirical studies into web navigation, particularly studies which aim to develop or validate design guidelines for navigation tools, goal specificity should be considered as a factor. This recommendation overcomes a limitation that was detected in previous research.

The project also proposed a framework for human-web interaction which may be used by researchers to guide research by suggesting relationships that might investigated. Whilst other frameworks exist, the proposed framework is designed specifically for the context of human-web interaction as a variant of the general framework for the navigation process as proposed by Juls and Furnas (1997).

9.6 Limitations and Future Research

This section identifies several limitations of the research conducted for this project that have resulted from the scope of the project, or as a result of the methods employed. These limitations give rise to several areas of future research.

The web sites used for the experiment reported in Study 2 were reasonably simple, with a maximum of 20 content links on each home page. Other types of home page designs such as the portal-type home page which contain a large number of content links and resultant flat hierarchical structures were not examined here, but could be explored further. Likewise, the experimental tasks employed in this experiment represent the extremes of the goal specificity continuum, with the closed tasks being very specific and open tasks being very general. A variety of levels of specificity and complexity could be considered in future studies.

Users vary in many ways having different goals, prior experiences, cognitive styles and cognitive abilities. The issues of individual differences and cognitive abilities were outside the scope of this project. However, whilst some actions were taken to control for goals, context experience and system experience, it is acknowledged that these other factors could have affected the results. Future studies could investigate whether cognitive styles and abilities affect an individual's tendency to select particular navigation tools under different levels of goal specificity. In particular, the issue of spatial ability is worthy of investigation. Research has identified spatial visualisation ability as a key factor in predicting effectiveness and efficiency when performing search tasks on information retrieval systems (Vicente & Willeges, 1988, Sein, et al., 1993; Hook et al., 1996). Given this, individuals with high spatial visualisation ability might tend to select interfaces that present a view of the information system using a spatial metaphor, e.g. a sitemap. Further research is required to investigate the effect of individual differences, such as spatial ability, on navigation strategies.

The empirical studies in this project were carried out with a sample of undergraduate and postgraduate students, most with a high level of experience with using the Web, which might restrict the degree to which the results can be generalised. Future studies might involve a broader-based sample of participants and could investigate the effect of age, gender and work domains on use of navigation tools.

The key finding from this project was that the primary purpose of sitemaps is to provide a high-level overview of the purpose, structure and extent of a web site. A secondary function of sitemaps is to facilitate exploration of content deeper in the site, however it is important that the level of detail be minimised in the initial view. The proposed design guidelines recommend the use of visualisation techniques that could facilitate exploration of sections of the sitemap but control the level of complexity presented to users so that the sitemap itself does not become a navigational challenge. Further work is required to investigate the application of appropriate visualisation techniques to support sitemap systems.

In conclusion, this thesis has deepened our understanding of the factors underlying people's decisions to use supplemental navigation tools such as sitemaps. In addition, it has contributed a set of empirically based, hence sound, guidelines for designers of such tools.

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