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ABSTRACT

Because the complex link and node structure awaiting users can lead them into becoming lost in hyperspace and cause them cognitive overload, navigating the hypertext system is often not an easy task, especially for novices. They may have difficulty perceiving a structure of an entire system, locating specific information, or using a navigational aid. This phenomenon can be expected to occur even more in the highly structured electronic performance support system (EPSS). Content providers and designers of Web-based integrated EPSS should know how to design interfaces and information structures based on content and purpose. This study analyzed four interface design methods (simple selection menu style, menu with global navigation, menu with global and local navigation, and pull-down menu) and four information structures (linear structure, grid, hierarchy, and network) in terms of the complexity, flexibility, navigation, domain knowledge, and cognitive load. Based on this analysis, guidelines for building the integrated Web-based EPSS effectively are provided. (Contains 28 references.) (Author)

Strategies for Building Integrated EPSS

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Abstract

Because the complex link and node structure awaiting users can lead them into becoming lost in hyperspace and cause them cognitive overload, navigating the hypertext system is often not an easy task, especially for novices. They have a difficulty perceiving a structure a structure of entire system, locating specifying information, using navigational aid. This phenomenon can be more expected in the highly structured EPSS. In that point, content providers or designers for web-based integrated EPSS should know how to design interface and information structure based on its content and purpose.

This study analyzed four interface design methods (simple selection menu style, menu with global navigation, menu with global and local navigation, and pull-down menu) and four information structures (linear structure, grid, hierarchy, and network) in terms of the complexity, flexibility, navigation, domain knowledge, and cognitive load. Based on this analysis, guidelines for building the integrated web-based EPSS effectively are provided.

Introduction

Building an effective EPSS has been a major issue not only in business but also in education and government. As more people come to depend on the use of computers and networking to perform their jobs, and as hardware and software technologies continue to advance, the potential for EPSS appears tremendous (Collis & Verwijs, 1995; Malcolm,1998; Ockerman et al., 1997).

Hypertext and hypermedia system enabled designers and programmers to tile all performance support system elements together in a way that allowed users to follow their own streams of thought in searching for information (Gery, 1991). Hypertext is such a technology that provides a powerful new way of organizing, displaying, and accessing information that could affect all forms of systems (Shneiderman and Kearsley 1989). Hypertext consists of the associative links between multiple nodes, which are one or more parts of information, forming an interconnected networked (Nelson 1974; Conklin 1987). The linking system in the hypertext system allows users to browse through the system utilizing navigational tools (Eklund 1995). However, navigating the hypertext system is often not an easy task, especially for novices (King, 1996). The potentially complex link and node structure awaiting users can lead them into becoming lost in hyperspace (Nielsen 1990) and cause them cognitive overhead (Conklin, 1987). Users have a difficulty perceiving a structure of entire system, locating specifying information, using navigational aid. This phenomenon can be more expected in the highly structured EPSS.

Such problems have prompted research on the manner in which users interact with hypertext system. Usable design guidelines and principles for navigation can maximize coherence of integrated EPSS and minimize users' cognitive overhead and disorientation.

Interface design

When designing an integrated EPSS, two important issues are involved: 1) interface design - how to present link system that provide access to the structure, and 2) information structure - how to incorporate the original structure of the content into the structure of an EPSS.

Interface design is basically concerned with the presentation of text, graphics, and linking system on the screen. It provides a contextual or structural model for the specification of the logical and functional organization of the user interface component, as well as a communication and means between users and system (Laverson, Norman

et al. 1987; Norman and Chin 1988; Lai and Waugh 1994; Oliveira, Goncalves et al. 1999). Many researchers has been agreed that interface should be designed to provide users efficient and effective organizational model that can help users understand the entire system and navigate system to find information without getting lost or cognitive overload (Lai and Waugh 1994; Dieberger 1997; Shneiderman 1997; Schenkman and Jonsson 2000).

Interface on an EPSS provides three major roles for navigation; 1) presenting links, 2) supporting structural cues, and 3) providing path mechanism. The interface is the most immediately visible part when a system was user-centered (Nielsen 1990). The most fundamental function of interface is to display links one the screen so that a user could navigate through a system (Shneiderman 1998). Selecting the links is frequently difficult to navigate in spite of the fact that a graphical browser provides the easy to navigation method, "point and click." One factor of difficulty in selecting paths for navigation is the presentation of link system. The user navigation performance can be influenced by the design and placement of links (Carlson and Kacmar 1999).

The second role is to support the user perception of structural cues for an effective navigation. If the interface does not provide appropriate structural information, users cannot perceive where they are and cannot decide where to go. Users also could experience "lost in space" (Dieberger, 1997).

Information is structured by links and users follow paths developed by designer. As a result, if interface design provides the flexible path mechanism that can allow users to jump to the information directly without passing pages that are not necessary to get the information, users could find information fast. However, there is some possibility to increase user's cognitive load without providing structural and navigational cues.

There are four generally used interfaces for navigating the web site: 1) simple selection style, 2) global navigation aid, 3) global and local navigation, and 4) pull-down menu styles.

1) Simple Selection Menu Style

One type of menu style is simple selection menu style, which is much similar to a table of contents for a print book (Chimera and Shneiderman 1994). In this menu style, a user can go to deeper levels of the web site by selecting links presented in the current web page. The major drawback of this menu style is that a user has a difficulty in perceiving the entire structure of the web site (Chimera, 1994), since when a user moves into lower levels, previous menu is replaced with new level. Another drawback of this menu style is that a user is unable to traverse to beyond below level because a user has to wait for a new below level select link again before moving lower level and select the link below level again. An experienced user is unable to navigate faster than that that of novice and this is inefficient and frustrating for experienced users (Laverson, 1987).

2) Global Navigation Aid Menu Style

The second menu style is persistent menu that has two split parts. The links on the top level remain in the similar area on the left all the time. The content is located in the area on the right and is replaced by its subsequent menu when users move other pages. The advantage of this menu style is that a user can go to each page of the top level by clicking top level links on the left side from any page in the web sit and that it provides the global structural cue to users (Nanard and Nanard 1991).

3) Global and Local Navigation Menu Style

The third menu style has two parts of navigation link for global level and local level (Nanard & Nanard, 1991). The navigation links of top-level pages on the web site usually place on the top of web page and the navigation links of current level pages on the web site usually place on left side. The advantage of this menu style is to provide not only global structure cue with the top-level navigation links but also local structure cue with current level navigation links (Furnas 1997). A user can skip several levels in the web site and it can more efficient than other menu design because a "jump-ahead" capability can reduce the time to navigate and find information (Laverson, 1987).

4) Pull-Down Menu Style

Pull-down menu style appears over objects in the interface instead of in static menu area. Pull-down menu allow users with a mouse to access the Web page they want directly. The advantage of the menu style is jump to the any page with mouse move and click. However, users can be disoriented or get lost since this menu can't provide structural cues. This menu style would be useful for experienced users.

Table 1. Summary of Menu Style

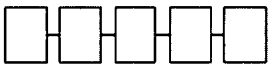
	Use	Complexity	Flexibility	Access Speed	Disorientation
Simple Selection	Easy	Low	Low	Slow	Low
Global Navigation	Easy	Middle	Middle	Middle	Middle
Global & Local Navigation	Hard	High	High	Fast	High
Pull-Down	Middle	Very High	Very High	Very High	Very High

Information Structure

The structure of a hypertext system can take many different forms. Four basic structures are linear, grid, hierarchical, and network structure. However, a web-based integrated EPSS can be designed with more than one structure.

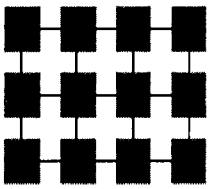
1) Linear Structure

The simplest way to organize information is in a sequence based on chronological or logical orders. Typically it is useful structure to retain the original documentation. Linear structure can be used for guided tour, job aids, tutorials, and demonstration of procedure in Web-based EPSS.



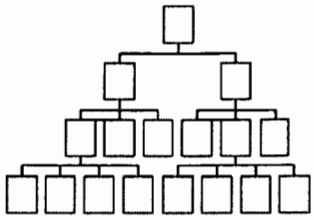
2) Grid

Grid structure organizes multi-dimensional concepts or categorizations. A serous of procedural manuals and list of training courses and materials can be best organized. Grid structure can be organized with one concept or categorization in horizontal axis by vertical axis with other concept or categorization. Unfortunately, grid structure can be difficult not only to organize but also to understand unless the designer or user recognizes the interrelationships between concepts and categorizations of whole information. Therefore, it is best for who already have knowledge on topics and its organization (Lynch 1999).



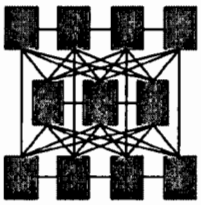
3) Hierarchy

A hierarchical structure bas been used widely in the web site (Lynch, 1999), on-line documentation (Gloor 1997), information retrieval system (Rosenfeld and Morville 1998), and computer-based instructional programs and training (Lai, 1994; Jonassen, 1986). Organization of hierarchical structure starts with general concept or topic into specific ones, which are in turn divided into more specific to individual based on precedence and significance (Lynch, 1999; Norman, 1988; Sano, 1996). Users can move from general to specific and back to general through the linking system presented by menu design. The advantage of hierarchical structure is that familiar to most people since it reflects the structure of printed materials (Shneiderman and Kearsley 1989), it is ubiquitous in everyday life (Sand 1996), and it is the most natural structures for organizing levels of abstraction (Gloor, 1997). Because of its familiarity and pervasiveness, users can easily and quickly understand web sites and hypertext system (Rosenfeld, 1998) without heavy cognitive overload. In organized hierarchical information structure, the disorientation problem can be minimized and users can easily navigate among information nodes by following the linking system (Conklin, 1987). They are able to develop a mental model of the site's structure and their location within that structure (Rosenfeld, 1998).



4) Network

Network structure is composed of associative links that network related concepts and information together. While this structure provides relatively effective navigation mechanism, users can easily get lost or disoriented because it is so hard for users to understand and predict entire. This structure can apply on small size of Web site for high level of training, such as simulation game, strategy training. It would be difficult to manage linking system if size is getting bigger (Lynch, 1999).



Most complex web sites share aspects of all four types of information structures. Except in sites that rigorously enforce a sequence of pages, users are likely to use any web site in a free-form "web-like" manner, just as most non-fiction or reference books are used. But the nonlinear usage patterns typical of web surfers do not absolve developers of the need to organize their thinking and present it within a clear, consistent structure that comple ments design goals for the site. Table 2 shows the characteristics of four basic organization patterns explained above in terms of the complexity, flexibility, easy-to-navigation, domain knowledge, and cognitive load.

Table 2. Summary of Information Structure

	Complexity	Flexibility	Navigation	Domain Knowledge	Cognitive Load
Linear	Low	Low	Very Easy	Low	Low
Grid	High	High	Middle	High	High
Hierarchy	Middle	Middle	Easy	Middle	Middle
Network	Very High	Very High	Hard	Very High	Very High

Depth and Breadth

The most discussed issues in information structure are branching factors, depth (thc number of vertical levels or links) and breadth (the number of horizontal documents or links) (Shneiderman 1997). Much has been known about tradeoff of "depth and breadth ", and "complexity and flexibility issues (Larson, 1998; Shneiderman, 1997). The previous results generally support that deeper hierarchical structure, the less helpful and less favorable for navigation. Users have to move through more levels to located information in the deeper structure and should need more not only cognitive effort but also physical effort to interact with more displays and links for information searching (Shneiderman, 1989).

Guidelines for building an integrated EPSS

Design of integrated EPSS can be affected by many factors. These factors include as follows:

1) Analyzing the nature of information or knowledge

In building an effective web-based integrated EPSS, one of the most important things developers have to keep in mind is to analyze the nature of information or knowledge to be supported by the site as exactly as possible. Depending on the professional medical knowledge with a complex information structure or the general knowledge with a simple information structure for its delivery, it might be totally different in terms of the interface design, information structure, and the depth and breadth of the information.

2) Analyzing user characteristics

In order to build an effective web-based integrated EPSS, developers should clearly analyze the characteristics of the target users of the site. That is, the developers need to make a more detailed analysis of the target audiences, such as teenagers, professionals of some fields, and so forth. Based on that analysis, the developers can grasp the major concerns of the audiences and predict their preferences. This will lead to providing appropriate functions just in time when such needs arise. If the EPSS is developed without considering the users' characteristics including their preferences, the site, no matter how well organized or useful, will not appeal to the some portion of the users any more.

3) Localizing contents and categories

Due to the rapid development and spread of communication technology, traditional borders disappeared in the terms of information sharing. In other words, we can share any content as soon as it is developed. Considering the importance of sharing information, this is very desirable. The problem arises for the fact that every country has unique cultural and social context as well as different language. Even in the same country, there can be various cultural groups. Certain problems are expected in the use of certain contents in different countries or cultural groups. For example, item 'I', which is categorized as 'A' in one country, can be categorized as 'B' in another country. There is a need to readjust contents or categories in terms of cultural and social contexts. The easiest solution is to prepare different versions for different groups. Here, the developers may most likely face the effect of tradeoff due to additional cost.

4) Analyzing client system capability

The developers need to be cognizant of the system environment under which the users are learning. This is closely associated with analyzing users characteristics. While the latter is more concerned with physical and affective characteristics of the users, the former is more focused on their learning milieu. With the rapid development of technologies, we have recently seen many products with newly-added features. Even the products marketed in the same year maybe different from one another in terms of system capability. In this vein, the developers need to continue their analysis on the learning environment of the users.

5) Analyzing information accessibility

We cannot overemphasize the importance of information accessibility for building an effective web-based integrated EPSS because the EPSS is delivered via electronic telecommunication technology like Internet. While most users with intent to access to Internet use LAN in their office, they rely on modem at home. So, their major concern is how expeditiously and conveniently they can access the needed information. When they cannot obtain the information they need at their convenience, they will experience inconveniences arising from the use of the site. This will eventually turn the users away from the site. Therefore, high level of information accessibility is very important factor of a successful EPSS.

6) Planning information updatability

Information updatability is another critical issue. In EPSS, this factor is more important than any other fields, because the users want information, which is most recently updated at their convenience. In this regard, two most important issues arise as to how promptly the information can be updated and who will assume the role of updating the information.

7) Harmonizing internal relationships between other information sources

Information in EPSS is sophisticated rather than fragmentary. As seen in Figure 1, even the same types of information can be restored and delivered in various ways. Some information can be delivered by visual formats such as text or graphics or by audible formats such as audio. In this sense, harmonizing internal relationship between other information sources is very important. If the internal relationship is not well organized, the EPSS is just an archive of unrelated, individual information.

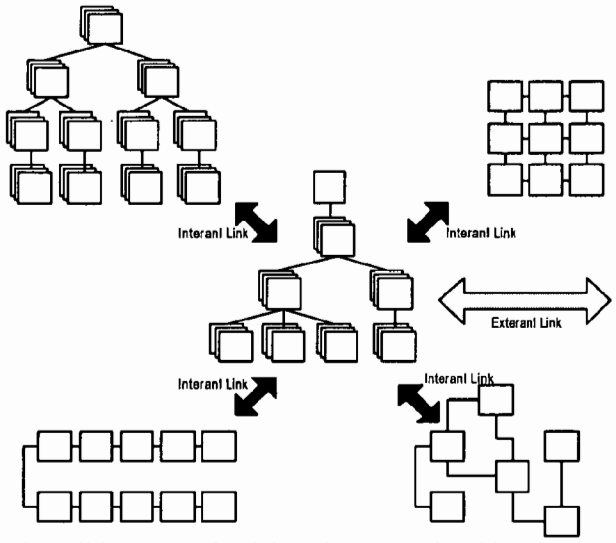


Figure 1. Overall Structure of Web-based Integrated EPSS

8) Integrating external relationships between other EPSS

Finally, integrating external relationships between other EPSS is another important issue. The developers should consider that the EPSS has to be related to external sources at some degree in order to maximize its effectiveness. Just as harmonizing internal relationship between other information sources was important, integrating external relationship between other EPSS in a harmonious way is a very important factor of successful EPSS.

All of these factors impact the way to present and structure the web-based integrated EPSS. In order to maximize the usability of web-based integrated EPSS, therefore, we need to identify and select appropriate menu systems and information structures.

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