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6-1998

### A framework for effective commercial web application development

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#### Recommended Citation

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**A FRAMEWORK FOR EFFECTIVE  
COMMERCIAL WEB APPLICATION  
DEVELOPMENT**

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*\*Published in the Internet Research*  
*Electronic Networking Applications And Policy,*  
*Vol. 8, No.2*

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† This work is supported by a grant from Research Grant Committee of the University Grants Committee of Hong Kong.

## **ABSTRACT**

The World Wide Web (WWW) or the Web has been recognized as a powerful new information exchange channel in recent years. Today, an ever-increasing number of businesses have set up Web sites to publicize their products and services. However, careful planning and preparation is needed to achieve the intended purpose of this new information exchange channel. This paper proposes a comprehensive framework for effective commercial Web application development based on prior research in hypermedia and human-computer interfaces. The framework regards Web application development as a special type of software development projects. At the onset of the project, its social acceptability is investigated. Next, economic, technical, operational, and organizational viability are examined. For Web page design, both the functionality and usability of Web pages are thoroughly considered. The use of the framework should result in more effective commercial Web application development.

## INTRODUCTION

The Internet has been hailed as the dawn of a new era of global communication (Microsoft, 1996). In fact, Microsoft regards it as a technical revolution at least as important as the popularization of the personal computer. The Internet originated in 1969 as a special communication tool among selected academic and governmental researchers. In the early years, e-mail, file transfers, and listservs were the major Internet applications; in the last few years, owing to the introduction of user-friendly browsers, World Wide Web (WWW) applications, or simply Web applications, have been increasing in an exponential fashion and have become the driving force behind the expansion of the Internet user base. Today, as many as 71 million people (including 14 million using e-mail only) are said to have access to the Internet (Fox, 1997).

With its expanding user base, the Internet has been recognized as a technology which can make a significant contribution to components of a company's value chain (Cronin 1995, 56-62), for it can improve a company's relationships with vendors and suppliers, internal operations, and customer relations. Many businesses are using the Internet as a new information exchange channel to transact business (Maney et al., 1996); at the retail level, these activities have been called digital retail, e-shopping, e-tailing, cybershopping, or virtual retail sites (Margolis, 1996). In this paper, the totality of these activities will be referred to as Internet commerce. According to INPUT, an electronic commerce consulting firm, electronic marketing will generate US\$230 billion of sales by the year 2000 (Information Management, 1996). Among the various media in the electronic marketplace, Internet commerce will account for more than 50% of predicted sales.

Due to its enormous market potential, many academics and businesses are closely studying and monitoring the explosive growth in this marketplace. Since the WWW has become the major instrument of Internet commerce, studies on the WWW as a new information exchange channel (Maney et al., 1996) have been conducted to gain more insights into how organizations are using Web sites to carry out various activities in Internet commerce. However, no comprehensive framework for the effective development of

commercial Web applications has come forth. This article proposes such a framework so that organizations can better utilize their resources in launching and engaging in Internet commerce. After the Introduction section, a review of literature on hypermedia development and human-computer interface is given; it shows that many prior research findings are applicable to commercial Web application development. Next, a comprehensive framework for Web application development and Web page design is presented. Lastly, the Conclusion section provides suggestions for future research.

## **LITERATURE REVIEW**

Hypermedia research predates the WWW due to the earlier introduction of hyperdocuments. Since Web pages employ hyperlinks and multimedia technology, they are regarded as a type of distributed multimedia hyperdocuments which are accessible with a standard communication protocol, HTTP (hypertext transfer protocol); thus, previous research in hypermedia are applicable to Web application development and design. On the other hand, in the 1970s and 1980s, on-line transaction processing systems (OLTP) were developed so that clients and customers could use terminals or special point-of-sales (POS) devices to complete transactions directly with organizations marketing goods and services. Examples include airline reservation systems, special order entry systems, and ATMs. The nature of these systems is similar to Internet commerce; thus most of their human-computer interface design factors are also applicable to commercial Web applications. In recent years, due to globalization of the software market, designing interfaces for international users has received increasing attention from software developers and researchers. Some of the design considerations faced in international interface design are not unlike Web page interfaces. Key research in hypermedia and human-computer interface which may be helpful to Web application development and design are presented below:

### **System Acceptability**

At the project level, hyperdocument development can be considered as a special type of software development project. Several frameworks or models have been proposed at this

level for effective hyperdocument development. For example, Nielsen (1993, pp.23-37; 1995, pp.279-285) provided a framework for the so-called system acceptability for hyperdocuments. In this framework, hyperdocument acceptability is viewed as a combination of social acceptability and practical acceptability. Social acceptability refers to whether the interface is acceptable to the users in the context of the culture of the society in which the users are from, while practical acceptability considers factors such as cost, support, reliability, compatibility with existing systems, together with the so-called “usefulness” of the interface. Usefulness as defined by Nielsen is the issue of whether a hypermedia system can achieve its goal. Usefulness is further divided into “utility” and “usability”. Utility refers to the functionality of the system, while usability means how well the users can use the functionality in the following respects: easy to learn; efficient to use; easy to remember; few errors; pleasant to use. Usability is a combination of the usability of the underlying hypermedia system engine and the usability of the contents and structure of the hyperdocument information base, and how these two elements fit together.

### **Structural Analysis**

Along the line of usability, problems created by a hyperdocument’s flexible structure and great freedom in browsing have long been recognized. Various attempts have been made to reduce the scope of the problem; for example, structural analysis looks at a hyperdocument’s interdocument structure. Botafogo, Rivlin, and Shneiderman (1992) proposed the use of metrics as part of the structural analysis of hyperdocuments to provide clear and precise values so that subjectivity is avoided. In addition to the readability metric (an indication of how easily one can read the document, which may be a composite of length of words, length of sentences, and the use of passive voice), they developed an array of global and node metrics. Global metrics are related to the structural properties of the directed graph-representation of a hyperdocument, while node metrics center on the properties of individual nodes. To capture some notions of complexity and connectedness in a hyperdocument, two global metrics, compactness and stratum, were developed.

The compactness metric indicates whether each node can easily reach any other node in a hyperdocument, while the stratum metric suggests whether there is an order in which a hyperdocument can be read. High compactness indicates that each node in the document can be reached from any other node; low compactness indicates insufficient links and suggests that parts of the document may be disconnected. The stratum metric measures the linear ordering of a hyperdocument and is based on the concepts of status and contrastatus defined by Harary (1959) to reveal to what degree the hyperdocument is organized so that some nodes must be read before others. Botafogo, Rivlin and Shneiderman also defined two node metrics, namely, depth and imbalance. The depth of a node is the distance between that node and the root; nodes which are deep in a hyperdocument may be hard to reach. Imbalanced nodes are those at the bottom of an imbalanced tree.

### **Software Quality Model**

Hatzimanikatis, Tsalidis and Christodoulakis (1995) developed a quality model to determine the quality of hyperdocuments based on the Factor-Criteria-Metric hierarchical model in software engineering. First, high-level factors such as readability, maintainability, correctness, integrity, usability and testability which determine the quality of hyperdocuments are identified. Hatzimanikatis, Tsalidis and Christodoulakis specifically singled out readability and maintainability to illustrate the use of the quality model. Readability refers to the degree of difficulty in navigating a hyperdocument, while maintainability measures the difficulty of extending, changing, and correcting the hyperdocument after completion.

Maintainability and readability cannot be measured directly on a hyperdocument but need to be decomposed into lower-level criteria which are measurable attributes of the hyperdocument. Criteria affecting both maintainability and readability may include: size, path complexity, tree impurity, modularity, individual node complexity, coherence, complexity of node contents, simplicity, etc. Next, metrics are developed to provide quantitative values to reflect the attainment of these criteria.



Hatzimanikatis, Tsalidis, and Christodoulakis (1995) suggest a size metric based on the software science concept of a program being a collection of *tokens* that can be classified as either *operands* or *operators* (Halstead, 1977). Keywords that describe nodes and links as well as those describing the layout of the contents of the nodes, such as bold, center, etc. in a hyperdocument, may be considered as operators. The contents of nodes, lines of text or graphs, may be considered as operands. A composite formula of operands and operators can be used to represent the *volume* or the size metric of the document. Compactness and stratum metrics developed by Botafogo Rivlin, and Shneiderman (1992) are cited as possible measures of path complexity among others.

With respect to quality models for Web applications, Day (1997) considers the quality of a Web site as “customer focused” and “customer led” and divides the notion of quality into static quality and dynamic quality. The static quality of a Web site is affected by design elements related to the purpose, content and structure of a Web site, whereas the dynamic quality is related to customer interactivity and feedback. To ensure Web site quality, Day suggests the following procedure:

- (1) Identifying our customers.
- (2) Articulating the site’s purpose.
- (3) Providing relevant content.
- (4) Creating coherent structures to mirror customers’ needs.
- (5) Arranging visual elements to reflect (1), (2) and (3) above (housestyle).
- (6) Creating relevant concluding/action points.
- (7) Delivering the promises we made at the action points.

Concerning a Web site’s purpose and content, Day advocates that the purpose should be distinctly clear and have a quantifiable customer-focused measure and the content should be based on an understanding of the target audience and how they behave.

## **EOS Interface Design**

Lu and Song (1987) examined the role of the human component in retail business transactions for the design of the interface for an extra-organizational system (EOS) through which clients of an organization may complete transactions unassisted. For example, some of the functions performed by the human in a retail business transaction may include: collecting payments and making change; surveillance; packaging; providing information on merchandise; providing information on operational policies; personal selling and bargaining; individualized consultations. Lu and Song claim that as the level of technology advances, more and more of those functions may be replaced by machine, i.e., computer, yet at the same time, the pace of automation of those functions is affected by the traditional way of life in a society. Based on the framework of a human-dominated to machine-dominated interface continuum, Lu and Song describe those key factors affecting interface design for EOS as follows:

*Client considerations*—The attributes or behavior of the target clients for the EOS should be taken into account for its interface design. These may include skill in using the terminals; frequency of purchase; the amount of purchase; the geographic distribution of customers.

*Products/services considerations*—The information content of products or services has an impact on the design of an EOS interface. The higher the information content needed by potential clients/customers, the more difficult it is to replace the human component by machine. These considerations may include the complexity of products/services; stability of products/services; variety of products/services; value of products/services. Lu and Song pointed out that as clients/customers become more familiar with the product, the need for information is reduced.

*Control and other considerations*—There are ancillary operations in a normal business transaction, e.g., handling and showing merchandise, demonstrating the use of merchandise, surveillance of customers, and personalized consultations. The more a

transaction requires these functions, the more difficult it is to automate it.

Even though Web technologies have different characteristics and interface issues from those of EOS addressed by Lu and Song, many of the basic design principles they proposed are still applicable to Internet commerce; for example, the client and products/services considerations are apparently important to commercial Web application development.

### **International Human-Computer Interface**

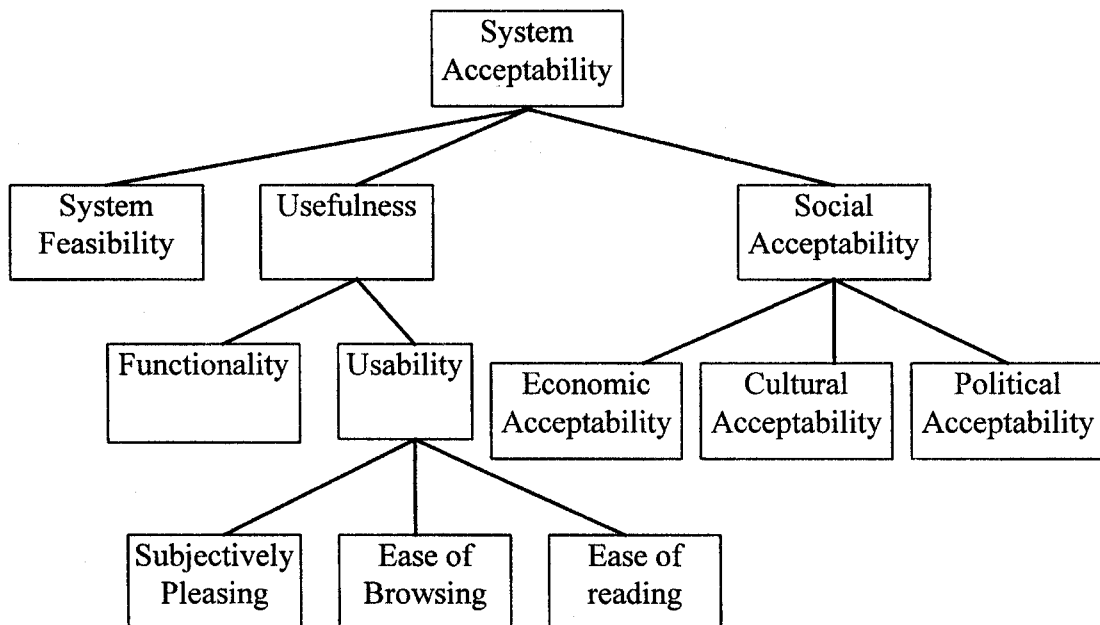
The area of international human-computer interfaces (Del Galdo and Nielsen, 1996; Nielsen, 1990) has received much attention in recent years due to the globalization of the software market. Del Galdo and Nielsen believe that there are three levels at which the issues of international user interface can be addressed (Del Galdo and Nielsen, 1996). The first level refers to the display and processing of the user's native language, character set, notations, and formats; the second level is about the ability to produce an interface and information that is understandable and usable in the user's language; the third level concerns the creation of an interface that accommodates the user's cultural characteristics and mindset. In other words, to achieve the third level, the interface design has to incorporate the way business is conducted and the way people communicate in the target society.

Based on prior research in hypermedia and the human-computer interface, and the special characteristics of the WWW as an information exchange channel, a comprehensive framework for effective Web application development and Web page design is formulated next. This framework examines Web application development both at the project and at the design levels. It addresses the social acceptability, system feasibility, and usefulness of Web application development and Web page design with the aim of fulfilling the objectives of commercial Web applications more effectively. This general to specific approach is not unlike Day's (1997) recommended procedures for Web site development.

## A FRAMEWORK FOR EFFECTIVE WEB APPLICATIONS

A framework for developing effective commercial Web applications is proposed as an extension of prior research (see Figure 1) presented in the above section. It regards Web applications as a special type of software development project with specific target user populations. It suggests that before the development of a Web application begins, the merit of the project should be assessed. In other words, one should ask “Are the products/services intended for the Web application viable for the target population?” Next, the Web application development effort has to be scrutinized in the same way as in other systems projects with respect to its economic, technical, operational, and organizational viability. For Web page design, it has to be examined at both the functionality and usability levels.

**Figure 1: A framework for effective Web application development.**



## **Social Acceptability**

When an organization embarks on a commercial Web application project, the project's eventual success hinges on whether its intended purposes and contents are acceptable to the members of the target population in the context of the legal, political, economic and cultural environment of their society. The social acceptability here is a broader concept than Nielsen's concept (Nielsen, 1993 & 1995), for he was primarily concerned with hypermedia interface issues.

Given the Internet's communication capability, technically speaking, the target audience of a commercial Web application could be scattered around the world; yet, in reality, the social acceptability of a commercial Web application often reduces its target audience to a much smaller group. Social acceptability may be viewed from legal, political, economical, and cultural perspectives:

*Legal acceptability*—If the messages, products or services to be promoted or sold on the Internet are prohibited by laws in certain societies, these societies would not be part of the target population for the Web application. Examples may include the sales of liquors, cigarettes, contraceptives, and political sensitive materials in some countries.

*Political acceptability*—If the messages, products or services are politically unacceptable or incorrect, the consequences are not only loss of sales, but also trouble for the organization which publicizes them on the Web. Quelch and Klein (1996) state that foreign government support and cooperation are critical in determining how the Internet business environment would evolve. Governments may exert influence on Internet commerce by legislation on external access and internal use of the Internet, on data security, and taxation on transactions. Some of the obstacles put up by a government may practically exclude the country from being part of the target population for a commercial Web site.

*Economical acceptability*—If the messages, products or services can reach a sufficient number of potential interested parties or customers who have sufficient financial means to make the purchases, then the project is economically acceptable. For example, to promote expensive condominiums on the Internet to the vast population in the PRC may not be a good idea, for most of the Internet users are either academics who do not have enough income to be the buyers of those properties or expatriates who may not in a position to acquire those properties.

*Cultural acceptability*— Messages, products or services to be promoted on the Web should be acceptable to the members of the target population in terms of their ways of life, habits and religious belief. Key factors for interface design for extra-organizational systems (EOS) considered by Lu and Song (1987) are mostly shaped by the culture of the target population. Those key factors include clients and products/services considerations presented in the literature review section. For example, it would be quite difficult to sell clothing to people in Hong Kong because sizes have not been standardized and they prefer to go to stores to shop. On the other hand, it is a good idea to sell grocery items on the Web in Hong Kong (e.g., <http://imspool.netvigator.com/shopping/wellcome/index.html>) unlike residents of the U.S., most of the residents do not have cars to carry heavy grocery items home; thus Web sites promising home delivery would be welcomed. In addition, products or services which are complex and have high information content may not be suitable for Internet commerce, yet if they have been standardized or they are of well-known brands, the customers would then be willing to purchase them sight unseen. Knowledge of products and services, of course, are often culturally dependent.

### **System Feasibility**

Since Web application development projects are also a kind of a software development project, system feasibility, including economic, technical, operational, and organizational feasibility, should be evaluated. Economic feasibility refers to whether the perceived benefits, such as increased revenue, profits, reduced costs, and other intangible benefits, would outweigh the costs of creating and maintaining the Web application. Increased revenue and profits can be estimated based on the estimated size of the

potential market in the study of the economic acceptability. Reduced costs may be estimated by comparing the channel costs with the Web application added. Intangible benefits often derive from better image and exposure to potential customers and improved customer services (Kambil, 1995).

When a business embarks on a Web application development project, the common mistake is to underestimate the total cost of such a project over time due to the relatively low start-up hardware and software costs. A properly carried out economic feasibility study should include the cost of maintaining the Web pages over time and the added costs of providing back-end support to online transactions. It has been reported that the annual costs of Web site maintenance may be two to four times the initial launch cost (Bernoff and Ott, 1995).

When considering technical feasibility, one has to assess it not only from a developer's point of view, such as possible difficulties in linking the Web pages with the legacy transaction processing systems, but also from the user's point of view; for example, including bells and whistles which will not be used by the majority of the target viewers due to their level of technical sophistication and limited capabilities of their PCs will not only be a waste of resources, but will also increase viewers' download time and frustration.

Organizational feasibility addresses whether the proposed Web site supports the objectives of the organization and its strategic plan with respect to marketing channels of distribution. Some of the questions that need to be asked are: What is its relationship with the existing channel, and what channel functions will it carry? (Stern, El-Ansary and Coughlan, 1996, pp.8-10); Are we reaching the same target market, or are we reaching a different market via the Web? Information obtained from social acceptability study would be most helpful here.

In addition, operational feasibility investigates whether management, employees, customers, suppliers and other parties are willing to support, operate, and use the proposed system. For example, if target viewers lack confidence in on-line payment methods, the

likelihood that they will make purchases on-line will be diminished. To overcome this problem, telephone and fax numbers could be provided so that customers may use the normal purchasing channel. On the other hand, if employees perceive that a proposed Web application will take away their commission income, they may not be enthusiastic about the project; as a consequence, low morale and productivity may result.

### **Usefulness**

Usefulness refers to whether a Web application would be helpful to the users, or potential clients and customers, in accomplishing its intended purposes. In other words, does it have the functionality which would meet their needs; do Web pages provide sufficient information about the products and services being promoted, such as the size, color, materials, quality? How about the payment and shipping methods? How secure are the payment methods? How long does it take to order the goods?

Providing functionality does not guarantee that Web pages are useful to viewers, for usefulness also depends on usability. Usability consists of the issues of whether Web pages are easy to read, easy to browse, and subjectively pleasing (Nielsen, 1993 & 1995).

As research in hypermedia suggests, usability can be addressed at two levels: at the node level (or page-level), and at the structure level (or site-level) (Botafogo et al, 1992). Metrics may also be computed as measures of Web page properties both at the page-level and site-level. At the page-level, the readability of the words and phrases on the page should be consistent with the reading level of the target audiences; attention should be paid to the accuracy of the meanings of the words and phrases. Download time should also be estimated so that later on the total amount of time for completing transactions of different types can be determined. The fact that different users using PCs and communication lines with different capabilities should be taken into consideration in estimating the download time. Also, knowledge about distributions of download time is more valuable than the averages. The depth and imbalance node metrics may be computed to indicate a node's (or a page's) distance from the root (the home page) and whether the node is at the bottom of an



imbalanced tree.

At the site-level, the structure of the Web pages may be represented by a directed graph so that various structural analyses may be performed. Global metrics, such as compactness and stratum, suggested by Botafogo, Rivlin and Shneiderman (1992) may be computed to indicate whether a Web page can easily reach other pages and whether Web pages are properly ordered for sequential reading.

In terms of ease of reading, it is especially important for the Web pages developers to design an interface for the target population in the context of their culture. Even though Web pages currently are predominantly English, and even though English is presumed to be the business language of the world, reaching the majority of the potential customers worldwide will necessitate the development of international interfaces for Web applications (Del Galdo and Nielsen, 1996). The minimum requirement for a Web application user interface should be that the interface and information is understandable and usable in the user's language. The goal, however, should be the creation of an interface that accommodates the user's cultural characteristics and mindset.

The application of the above framework allows Web application developers to address first the issue of whether Web technologies and the intended applications are compatible in the social acceptability phase. Next, other effectiveness issues, such as economic, technical, operational, and organizational feasibility are examined. Finally, efficiency issues associated with Web page design are addressed for those Web projects deemed viable in the previous phases. As a result, the effectiveness of the developed Web application can be assured.

## **CONCLUSION**

The framework presented above enables an organization to examine the viability of a commercial Web application development project before it is launched. Social acceptability ensures that the messages, products and services to be presented are compatible with

the living habits, the culture and social system of the target population. A study of social acceptability may lead to a better understanding of the size and the attributes of the target market, resulting in a more precise estimate of the potential market for the products and services. Further research in this area may identify the attributes of products or services that are suitable for Internet commerce for different regions of the world.

Estimation of the potential revenue, costs, and profit in the potential market through the new information exchange channel, the Web, is part of the economic feasibility study. However, care should be taken to ensure that only incremental revenues are considered, for Internet commerce may dig into the sales of existing channels. Since the WWW is still a relatively new technology, new functionalities will emerge in the future. Today's emerging technologies such as 3D images and virtual reality, may become common in the future. In the future Web pages might provide more realistic images of products or services and the differences between shopping in the real world and on the Web might be substantially narrowed.

In terms of usability for hypermedia, Botafogo, Rivlin and Shneiderman (1992) cited three different fronts in an attempt to solve the problem of "lost in hyperspace": user interface, textual analysis, and structural analysis. Improvements in the user interface include help menus, multiple windows, maps, tours or path mechanisms; textual analysis is often carried out by the hyperdocument authors using software aids to statistically analyze word frequencies in a document so as to index documents according to significant terms; structural analysis gives a better understanding of the hyperdocument's overall structure. Further research and developments in all three areas by software vendors and Web page developers will help produce more effective Web pages.

With the increasing importance of Internet commerce, more corporate resources are being spent on the creation of more effective Web pages, which are easier to read and subjectively pleasing. As a consequence, third party agencies, not unlike ad agencies which have expertise in the field will thrive. These agencies will be quite different from the individuals and parties which are currently helping organizations design Web pages, for these

new agencies will conduct tasks associated with market assessment and system feasibility as outlined in the proposed framework and will emphasize the contents and structures of the Web pages with technical sophistication taken for granted.

Technical issues should not be the predominant considerations for commercial Web application development as many currently view. It is the intent of this paper to provide a comprehensive framework for commercial Web application development so that all important design considerations are viewed in the proper perspective to ensure that business purposes are achieved.

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