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Qingyu Zhang

Mei Cao

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HUMAN-MACHINE WEB INTERFACE DESIGN FOR ELECTRONIC COMMERCE: A REVIEW OF DESIGN PERSPECTIVES, OBJECTIVES, DIMENSIONS, AND TECHNIQUES

Qingyu Zhang
Department of Economics and Decision Sciences
Arkansas State University, State University, AR 72467, USA
Phone: 870-972-3416; Fax: 870-910-8187; Email: qzhang@astate.edu

Mei Cao
Department of Information Systems, E-commerce, Marketing and Sales
University of Toledo, Toledo, OH 43606, USA
Email: mcao2@pop3.utoledo.edu

ABSTRACT

Web technology revolutionizes the information transfer and delivery modes of physical products. In the field of consumer-oriented business, buyers have on-line search capabilities for finding products and services, for comparing prices and for ease of purchase. Sellers can reach and serve more customers at lower costs and provide on-line support. Most on-line merchant-consumer interactions require direct manipulation of interface. Thus the design of human-machine web interfaces is a critical factor to determine whether e-commerce can succeed in supporting and facilitating the electronic transaction in an electronic market and hierarchy. This paper reviews the web design perspectives, objectives, dimensions, and techniques, addresses their interrelationships, and further points out promising future research directions.

INTRODUCTION

Currently, although the economy, especially networking industry, is slowing down, electronic commerce (e-commerce) / electronic business still has great potential to create new ways of doing business. Indeed, web technology revolutionizes the information transfer and delivery modes of physical products. This new information economy provides a great opportunity for innovative managerial practices; however, the rapid advance of information technology makes the managerial research fall far behind and fail to respond. Thus the gap between technology development and managerial research left one important issue: the managerial and profit potential of new technology is never exploited [1, 3, 4]. Especially, in the field of consumer-oriented business, buyers have on-line search capabilities for finding products and services, for comparing prices and for ease of purchase. Sellers can reach and serve more customers at lower costs and provide on-line support. Most on-line merchant-consumer interactions require direct manipulation of interface. Thus the design of human-machine web interfaces is a critical factor to determine whether e commerce can succeed in supporting and facilitating the electronic transaction in an electronic market and hierarchy.

A FRAMEWORK OF REVIEW AND ANALYSIS

Zwass [22] provides a hierarchical framework of e-commerce including three meta-levels: infrastructure, services, and markets. The foundation (infrastructure) of e-commerce is the intermeshed network of wide-area telecommunications networks. At the apex of e-commerce are the electronic marketplaces and electronic hierarchies that facilitate business relationships and transactions between firms. Electronic markets are created to facilitate transactions over telecommunication networks between multiple buyers and multiple suppliers. Electronic hierarchies are long-term supplier-customer relationships between firms, coordinated largely by management rather than the market force. The most highly touted application is consumer-oriented. They include remote shopping, banking, and stock brokerage, and on-line advertising.

Shaw [17, 18] reviews the practices, scope, and opportunities of e-commerce. He holds that e-commerce can be viewed from a number of perspectives to fully appreciate a particular functional emphasis: (1) Technology (internet is the major contributor), (2) Marketing and new consumer processes, (3) Economic (information-based activities characterized by instant information flows, the delaying of value chains, the emergence of new intermediaries, and the shifting economic rules and market dynamics), and (4) Information value adding, electronic linkage, and service infrastructure.

Web Storefront and consumer interface such as Amazon.com has developed an innovative business model using web storefronts as their main channel. One of the critical aspects influencing the success of electronic commerce will be the effectiveness of the

interface interacting with the consumers. It is not clear what deciding factors will attract people to shop on the web. What makes internet shopping different from mail-order catalogues or TV shopping? What are the behavioral and demographic traits in virtual communities? What elements of electronic commerce affect the consumers' perception of a product/service? What types of electronic commerce hinder its acceptance and use by consumers? What strategies are the most successful in overcoming the resistance to change by consumers toward various forms of electronic commerce? These research questions call for an integrated technological, business, and behavioral perspective.

Specifically, one of the major issues confronting those concerned with electronic commerce is the issue of consumer acceptance. User acceptance includes the perception of the product/service by the targeted user/consumer and targeted consumers' actual usage of product/services. There is a well-established literature available in consumer behavior, social psychology, and diffusion of innovation research to address these issues. But more accurate measures on the relevant perceptions that influence the adoption of electronic commerce are needed.

The web can provide aggregate information and interactive transmission to make presentation more interesting. One enhancement to the human computer interface incorporates virtual reality (VR) with 3D visual and audio displays to enrich the web shopping experience. How human beings interact with computers to access information over the web presents one of the biggest barriers for the implementation of electronic commerce. How marketing strategies (i.e., web pages) are combined with back-end information technology (i.e., database, collecting customer information, mass customization, and data mining) is important to the success of web design, however, the customers do not care about the web page's internal connections with the database; all their perceptions come from their experiences with the front-end web design interfaces.

Human behaves in a goal-oriented way. Within their limited perceptual and information processing abilities, they attempt to adapt to the task environment to attain their goals. Therefore, web interfaces design should be driven by design perspective and customers' objectives (shown in Figure 1), which in turn affects the emphasis on certain design dimensions and selections of design techniques. In the following sections, we will review each component in Figure 1 and point out the possible research paths.

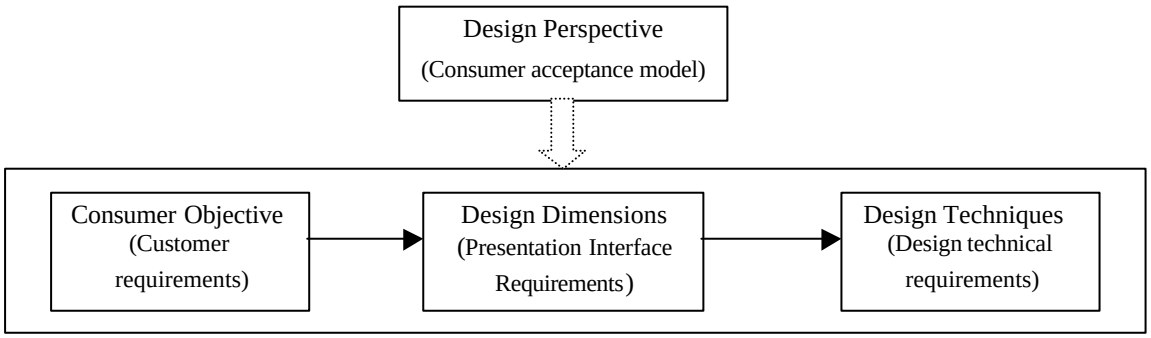

Figure 1: A Frame work of Review and Analysis of E-Commerce Design and Acceptance

DESIGN PERSPECTIVES

Many published materials address the issues of IT design and evaluations to enhance usability and acceptance and the determinants of IT use and acceptance [6]. User acceptance is a critical factor to determine the success or failure of a web design project. It is addressed by interdisciplinary disciplines such as economics, marketing (consumer psychology), and MIS.

Both practitioners and researchers have a strong interest in understanding why people accept e-commerce so that better methods for designing, evaluating, and predicting how users will respond to it can be developed. It remains an open question in many instances how to translate usability evaluation results to specific interface design improvements. Acceptance theory seeks to extend the traditional model of user-centered design espoused in usability engineering approaches [14] from questions of interface improvement to predictions of likely usage.

Researchers have studied a range of issues, from individual user characteristics, such as cognitive style

[8], to internal beliefs and their impact on user behavior [9]. Acceptance has been viewed as a function of user involvement in system development [2]. The type of system development process used and the process by which technology is implemented and diffused [13]. Although the search for determining variables is unlikely to yield an explanation of the level of acceptance any IT will receive among its intended users, it is appropriate to address some insights into the range of perspectives that converge on this problem.

Innovation diffusion model. The principal theoretical perspective on technology acceptance is innovation diffusion theory, shown in Figure 2, at the individual level and organizational level of analysis [16]. It provides an account of the manner that technological innovation moves from the stage of invention to widespread use. The determining variables included are relative advantage (the extent to which a technology offers improvements over currently available tools), compatibility (its consistency with social practices among its users), complexity (its ease of use and learning), trialability (the opportunity to try an innovation before committing its use), and observability (the extent to which the technology' output and its gain are clear). Each individual variable alone is insufficient to predict either the extent or the rate of diffusion, but diffusion studies have demonstrated that the innovation with all these characteristics, as mentioned above, will diffuse more extensively and rapidly than the innovation with the cluster of opposite characteristics.

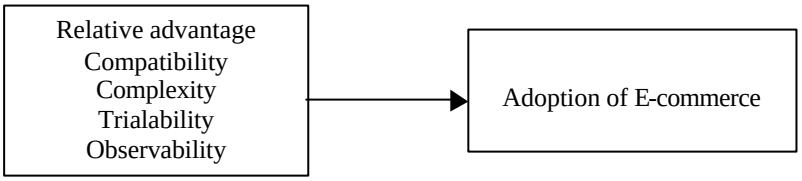

Figure 2: Innovation Diffusion Model of E-Commerce

Theory of reasoned action. The theory of reasoned action (TRA) proposed by Fishbein and Ajzen [7] in the social psychology literature defines relationships among beliefs, attitudes, norms, intentions, and behavior. Attitude toward a behavior is determined by beliefs about the consequences of that behavior and the affective evaluation of those consequences. Beliefs are defined as the individual's subjective probability that performance of a given behavior will result in a given consequence. This approach represents an information processing view of attitude formation and change the states that external stimuli influence attitudes only through changes in the person's belief structure. Intentions are determined also by subjective norms, which in turn are determined by an individual's normative beliefs and motivation to comply with perceived norms. This approach seeks to understand the dynamics of human decision making in the context of accepting and resisting a technology, illustrated in Figure 3.

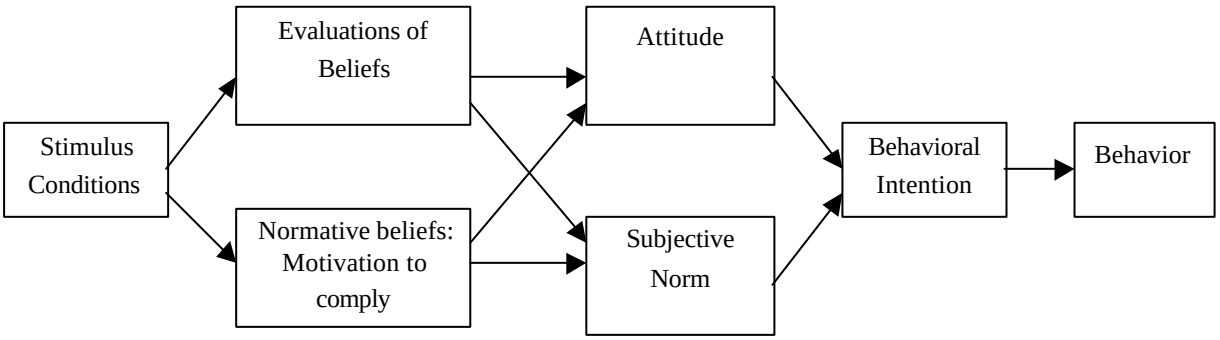

Figure 3: Theory of Reasoned Action of E-Commerce

Technology Acceptance Model (TAM). Technology Acceptance Model (TAM) of Davis [5] is the most widely cited, demonstrated in Figure 4. The goal of TAM is to predict the system acceptance and diagnosis the design problems before users experience the system. TAM predicts that user acceptance of any systems is determined by two factors: (1) perceived usefulness and (2) perceived ease of use. Perceived usefulness (PU) is defined as the degree to which a person believes that use of the system will enhance his or her performance. Perceived ease of use (PEOU) is defined as the degree to which a person believes that use of the system will be free from efforts. There are some differences between TAM and TRA. Davis and his colleagues drop the context driven factors: subjective norm construct. They held that there is direct path from perceived usefulness to intention without the mediation effects of attitude. They explain that even though an employee may dislike a system, that employee may still use the system if it is perceived to increase job performance. Another divergence is the direct effect of PEOU on PU. That means, when faced with two systems that offer identical functionality, a user should find the easier one to be more useful.

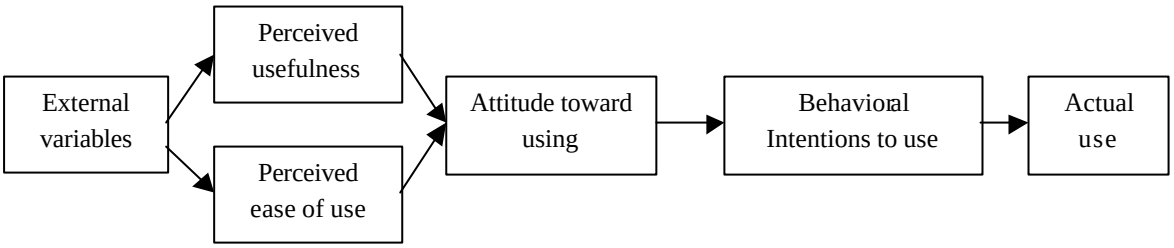

Figure 4: Technology Acceptance Model of E-Commerce

Theoretical approaches to the design of acceptable technology. We review literature that explores use and implementation of technology and inform the design and development of e-commerce to ensure or at least to increase the acceptance of any resulting artifact.

The sociotechnical systems perspective has become influential in the analysis of the organizational impact of technology. A fundamental tenet of sociotechnical systems thinking is that a technology on its own (technical capability) has little meaning for the purposes of organizational analysis. Technology is comprehensible only in terms of the context in which it is embedded and the organizational goals or transformations that it serves or enables.

Sociotechnical system theory has given birth to a framework for technology design that emphasizes holistic job satisfaction and user participation throughout the development process such as the analysis of all stakeholders, the formation of planning groups to oversee the design, and the performance of prototyping exercises. The intention of such a design process is to avoid unpleasant side effects in working practices and to ensure as much a social solution as a technical solution. Sociotechnical systems approaches have been pivotal in shifting technology design away from just financial and technical concerns manifest in traditional software development models, such as the waterfall model, toward a more user-centered perspective.

Human-Computer interaction (HCI) and the usability engineering. Adressing more traditional human factors concerns of workstation and interface design, researchers have long sought to influence the development of a more user-centered technology. HCI research has moved from its original concern with hardware ergonomics and screen design to the point where the complete range of user issues are of interest.

HCI research has concentrated heavily on the concept of usability, both its definition and its measurement. Most HCI researchers assume that the more usable a technology is made, the greater its chances of proving itself acceptable to the users. Thus, researchers recommend the techniques similar to those of sociotechnical theorists, such as user participation, rapid prototyping of interfaces, and use of focus group in trying to design more usable systems. This approach blurs the distinctions between many of the social science and engineering research tradition that have an interest in developing more humanly acceptable systems.

The usability (traditionally, it is equivalent to "user-friendly", "ease of use", and certain interface features such as windows, icons, menus, and pointers) of an application refers to the effectiveness, efficiency, and

satisfaction with which specific users who are performing specific tasks in specific environments can use an application. The two major characteristics of usability engineering are prototyping and redesign in seeking to maximize the usability throughout the whole product development process.

DESIGN OBJECTIVES

Based on a value proposition to purchasing via the internet, Keeney [10] generates and organizes the fundamental objectives and means objectives that customers value most by interviewing people. In the following Figure 5, all the objectives that relate to the interface design are listed.

Means objectives related to Internet Commerce	Fundamental objectives related to Internet Commerce
Assure System Security Maximize fraud protection Prevent fraud Maximize security of transaction Discourage hacking Minimize the unauthorized use of credit card Maximize ease of use Make access easy Make search process easy Simplify finding desired product Have many search possibilities Maximize transaction speed Maximize product information Maximize information about promotion Maximize available product information Be able to feel product Be able to see product Be able to try product on Be able to test product Maximize the accuracy of information Maximize accuracy of transaction Minimize product errors Minimize shipping errors Minimize charging errors Enhance comparison shopping Provide comparison shopping Maximize ease of comparison shopping Maximize speed of comparison shopping Make better purchase choices Minimize likelihood of disappointment Maximize the confidence Maximize product variety Maximize product selection Have broad choice of products Offer personal interaction Provide human customer support Provide opportunity for personal interaction	Overall objective Maximize customer satisfaction Maximize product quality Maximize product value Ensure quality of product Maximize functionality of purchased item Minimize cost Minimize product cost Minimize shipping cost Minimize internet cost Minimize travel cost Minimize time to receive product Minimize delivery time Minimize shipping time Maximize convenience Maximize purchasing convenience Maximize time flexibility in purchasing Provide quality after-sale service Assure an easy return process Minimize effort of shopping Maximize ease of finding product Minimize time spent Minimize purchase time Minimize processing time Minimize payment time Minimize queuing time Minimize time to find the product Minimize communication time Minimize search time Minimize time to order product Minimize time to gather information Minimize time to select a product Maximize privacy Avoid electronic mailing lists Maximize shopping enjoyment Making shopping a social event Minimize worry Inspire customers Minimize disappointment Maximize customer confidence

Figure 5: List of Fundamental and Mean Objectives of E-Commerce Customers

The listed objectives are the basis for web interface design. It will be necessary to tailor the meaning of each objective to the specific product and situation. Thus a set of primary and means objectives can be selected to represent the value that customers want by potential customers. A sample of customers should be interviewed to prioritize the objectives and value tradeoffs. Such balanced objectives and priorities can be used to guide the subsequent design consideration.

DESIGN DIMENSIONS

Miles et al. [12] hold that the increased use of the internet to purchase and sell products represents a significant departure from the standard information retrieval and communication tasks. E-commerce is different from many other internet applications since the primary goal of an e-commerce web site provider is to facilitate economic actions, not to provide information. Electronic commerce is a separate task-domain, and the software systems that support it should be designed from the perspective of its objectives and its constraints.

There are a substantial variety of technologies that provide some specific advice for information retrieval tasks, such as standard hierarchically arranged web pages, electronic sales assistants, product databases, and auction mechanisms. But no clear picture exists as to how each kind of technology support the user's task. Here, we will focus on the buyer's objectives and values in the setting of business-to-consumer e-commerce.

Many researchers study the tasks involved in e-commerce from a marketing perspective. Watson et al. [21] address the issue of how to attract more customers to a web site. Leong et al. [11] have contrasted how web managers perceived the effectiveness of e-commerce relative to more traditional media. The O'Keefe and McEachern [15] model contains five decision processes: need recognition; information search; evaluation; purchase; after purchase evaluation, and they emphasize that e-commerce systems need to be designed to support these processes. Miles et al. [12] adopt Holsapple and Ehinston's decision-making model in terms of stages of design (finding the alternative solutions), intelligence (acquiring information) and choice (selecting between the alternatives). They describe it as (1) search for products, (2) management of search criteria, and (3) comparison of products. Once a user has identified a need, he then engages in a process of search for products that match a set of more or less specific criteria in his mind. Criteria management occurs when the buyer encounters information that prompts him to alter his search criteria. As user identifies potential purchases, he needs to compare them with each other.

These activities are goal-driven ones in buyers' behavior. The precedence of activities will be determined by the availability of on-screen information prompting an activity. Customers' decision-making activities are not an algorithm, but interleaved activities with multiple searches, criteria and comparison management.

The design dimensions can be grouped into four categories shown in Table 1: (1) front-end, (2) criteria management, (3) comparison support, and (4) market place. The front-end dimensions concern interface features that help users locate the products. The criteria management dimensions describe mechanisms and information provided to support matching products to search criteria. The comparison support dimensions refer to those aspects of an interface that allow different products to be compared. Finally, the market place dimensions are those that refer to the economic assumptions underlying a technology.

Miles et al. [12] regard web-based e-commerce systems as decision support systems. They do not attempt to make decisions for buyers, but instead some offer advice (e.g., Electronic Sales Assistants), and others attempt to reduce the load of maintaining multiple products in a memory for comparison.

E-commerce environment flexibly combines a database of products with a variety of mechanisms for presenting those products. E-commerce systems tend to be committed to one particular structure for product representation and one particular mechanism for the presentation of product collections. The presentation mechanisms would take advantage of different media such as text, picture, 3D model, and feature record. The type of presentation and navigation mechanism might depend on the objectives of the buyer (research, management of criteria and product comparison), the type of product (visually or technically rich) and the goals of seller (maximize number of items sold or price per item). Whatever consolidation does take place, it is important that the usability of the designs is considered from the perspective of the buyer. Moreover, it will often be essential that support is provided for the search process, for the management of product criteria, and for product comparison.

What makes a web site usable or how to make a cool site depends on what users/customers are trying to accomplish. Are they surfing? Doing research? Buying products? Downloading software? And it also relies on the organization's goals for creating the web site. Is the

site aimed at marketing a product/service? Making information available to employees, stakeholders, and customers? Spool et al. [19] have summarized the designer' dos and don' ts, illustrated in Table 2. Users like the sites the best that had content interesting and relevant to them. When users dislike a site, their reasons usually related to some significant difficulty in using it [19].

Table 1: Design dimensions and value range of human-machine web interfaces for e-commerce

Design dimensions	Value range
Front-end	
Site metaphor:	Web, search engine
Navigational structure:	X level hierarchy, network, sequence, word based search, criteria-based search, email communication, combinations of these methods
Criteria management support	
Product representation:	Name, text, tabulated text, image, 3D image, combination of these types
Product information provision:	Text independent of products, text for products, separate database
Comparison support	
Site scope:	Within seller, across sellers, NA
Comparison tool:	None, value bars, tables, graphics plots.
Marketplace	
Negotiation method:	NA, none, external contact (e.g., phone), user specified algorithm
Control of marketplace:	Seller, buyer, third party, distributed
Maintenance of marketplace:	Manual., database, seller submitted, agent-based
Ratio of buyers to sellers:	(x/y =1 to > 1 million).

Table 2. Web design practical principles and interpretations

Principles	Interpretation
1. Graphic Design neither helps nor hurts	Graphics may be important for making users more willing to return to the site or selling products, but it does not help users retrieve information from a site.
2. Text Links are vital	The better users could predict where a link would lead, the more successful they were in finding information.
3. Navigation and content are inseparable	This is called shell strategy, a technique that lets developers design a navigational structure and hierarchy first, then just plug the content into it. For example, a firm has one department working on the overall look and feel of the site, including the homepage, navigation bars, style sheets, and templates for different types of interactions. Other departments are responsible for creating the content.
4. Information retrieval is different that surfing	When users surf, they are just browsing, clicking whatever looks most interesting or cool, and content may not be the driving force in coolness. When looking for information, users are much more focused. They tend to click on the link most likely to yield the information they are hunting for. The kinds of things designers put on web sites to attract surfing users proved to be distractions during information retrieval tasks.
5. Navigation is invisible when it' s working	But when there' s problem, users can get completely stuck. In fact, navigation problems frequently caused users to give up since users do not have the domain knowledge they needed to navigate the site or the site structure did not meet users' expectations. A well-defined structure provides users with an obvious, clear model of the information space such as frame, table of content, hierarchical maps, and links.
6. Within-site searching (built-in search engine) helps users to find information within the site	The search engine helps but often users have two types of problems with on-site searches: (1) they do not understand the scope of the search; (2) they have trouble interpreting the search results.
7. The comparison is important	Users handle comparisons by remembering, writing things down, printing, opening multiple windows, or make query from the database

DESIGN TECHNIQUES

Originally, the web is not designed to support EC sites and there is no simple way to integrate a web server with a database system containing product, pricing, and promotional data with transactional systems for processing orders and with payment systems for handling credit card purchases and settlements. To succeed in e-commerce, customers need to be able to submit order information and receive responses to inquiries. Database application server (e.g., Oracle) provides a variety of methods for creating web pages that interact with a database.

In a static web page, tags and text are fixed at the time the page is created. Each time a static page is accessed, it will display the same information. So static web page is appropriate for displaying the information that does not change often. In a dynamic (interactive) web page, the page content varies according to user inputs and/or database queries. Thus, the content of web pages can vary from one user to the next and from one time to the next. The ability to respond to these requests has created a new system of commerce [20].

Regardless of whether a web page is static or dynamic, the language used to create it is the same, called HyperText Makeup Language (HTML). Besides standard HTML, other makeup languages include Virtual Reality Model Language (VRML) for creating three-dimensional worlds and the Extensible Makeup Language (XML).

HTML is created by Tim Berners-Lee when he first conceived of the world wide web in 1989. Today, many of the tags in HTML 4.0 deal with graphic presentation. It is easier for web site designers to control the quality of the layout and visual aesthetics of their web pages.

Currently, the technologies supporting interactive web pages can be grouped into four basic categories: (1) HTML forms, (2) Server Side Includes, (3) Active Components, and (4) VBScript or JavaScript. HTML forms, which are enhanced HTML documents designed to collect user inputs and send them to a web server. HTML forms allow users to input data using text boxes, option buttons, and lists (e.g., combo box). When the form is submitted to the web server, a program running on the web server processes the form inputs and dynamically composes a web page reply. This program uses the common gateway interface (CGI) protocol, a standard application programming interface (API). CGI provides a way for software developers and application programmers to integrate web servers with various back-end programs and data sources. The problem with using CGI-based servicing programs is that each form submitted to a web server starts its own copy of the servicing program. A busy server is likely to run out of memory when it serves many forms simultaneously.

The second approach uses a technology called Server Side Includes (SSIs). An SSI is a command that is sent to a web server from within a static web page. An SSI can display many outputs, ranging from simple web page hit counters and 'current time' displays, to page contents tailored to the type of browser the user has, to database and file information.

The third approach downloads compiled executable programs stored on a web server to a local web browser and runs them on the local computer. The program interacts with the user and sends and retrieves data from other servers as needed, such as Java (Applet) and ActiveX. The advantage of this approach is that more complex and rich graphic user interfaces (GUI) can be created and user inputs are validated and responded to from the local Java or ActiveX program rather than a remote web server. They also make it possible for processing to be distributed between the desktop and the server.

The final approach allows uncompiled code in languages such as JavaScript or VBScript to be typed into the HTML document along with the static HTML text. Special tags indicate to the user's browser that this text is code, and if the user's browser has the capability of recognizing and interpreting the code, the code is run by the browser. Javascript can control the objects, content, and interactions within the browser. It cannot draw graphics or directly access the network. Java has no control over the browser but can obviously do graphics and networking. JavaScript has the following functions such as client-side validation, client-side calculation, client-side lookup databases, providing interactive feedback, manipulating Java applets or activeX objects within a page. The more complex user interfaces are possible with this approach. JavaScript can be used in any browser, but VBScript can only be used in Internet Explorer. Both JavaScript and VBScript can be used to construct server-side scripting in its Active Server page (ASP) technology, in which specialized tags and variables are used to embed the scripting code directly within the HTML code. Whenever an HTML page containing the intermingled script and HTML code is accessed, the server first execute the script code within the page and then sends the resulting page back to the browser. In this way the content of the HTML page are dynamically generated. They provide the means to perform relational (SQL) database updates and queries.

HTML forms are the most widely used, but their network traffic and server processing requirements are demanding. Virtual reality is a term that usually refers to computer-generated or enhanced 3D environments that can be manipulated by the end user. VRML files are text files containing special tags that define 3D scenes from more primitive objects (such as cubes, cones, cylinders, and the like). VRML also has the capability to animate a scene changing the location and shape of objects in response to user or system actions.

The web is a fast-moving environment, especially from a software standpoint. The problem with HTML is that it is a set of tags that deal with document structure, content, and display. This makes it difficult for web designers and webmasters to create and maintain the multiple pages found at most EC web sites. It is also difficult for software agents to either index or find specific content on the web.

In XML, there are no fixed tags. Instead, the web designer or author is free to create his or her own tags, which is why the makeup language is called extensible. XML is display-device independent, and its documents can be used with any display device. Documents composed of XML can also be more easily understood and manipulated by other software programs.

CONCLUSION

This article is about the review of the theory of web interface designs. It involves different design perspectives, design objectives, design dimensions, and design techniques. Good web design not only provides rich information but also has a human touch. So customers can use the web sites in the way that the designers intended. It provides a summary of some ways to evaluate and improve the usability of web sites for information-finding tasks: web site navigation, links, graphic design, page layout, and user acceptance and satisfaction.

Based on the above review, an in-depth case study for objective – design dimension connection will provide much insight about specific relationships between both. It will provide a useful guideline for web interface design to serve customers well.

The theoretical perspectives from IT use literature can be used to direct the model building in e-commerce and measurement development to test the relationships. Such test also facilitates the comparison of traditional IT use model and e-commerce model.

The next logical question needs to be addressed it how to choose appropriate techniques for different e-commerce web design requirements. So the potential of web design technology can be exploited to fully serve customers. It also facilitates managers' decision in choosing right technologies as a platform to meet their business needs.

The connections among design perspectives, objectives, design dimensions, and techniques can be explored with empirical examination in a new context of e-commerce/business. It will refine and enrich the IT use theory in this totally new environment.

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