Design of Web-based Support Systems

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Abstract

Web-based Support Systems (WSS) can be viewed as a multidisciplinary research area that focuses on supporting human activities in specific domains or fields based on computer science, information technology, and Web technology. There are many open problems for this newly identified research domain. How to design and develop such systems is one that remains a challenge. This article aims to study some issues on the development of Web-based support systems.

1 Introduction

Web-based Support Systems (WSS) is a domain of study on how to provide assistance to various human activities with the Web as a user interface [20]. It can be viewed as a multidisciplinary research involving the integration of domain specific studies and other disciplines such as computer science, information systems, and Web technology.

There is a sufficient evidence showing a strong trend for studies of computerized support systems especially on Web platforms. Research on information retrieval support systems [21, 22], research support systems [23], teaching and learning support systems [4], decision support systems [12], computerized medical support systems [15], and knowledge management support systems[8] are just some representatives of them. Investigations of WSS in a wide context may result in many new research topics and more effective systems.

Many types of WSS have been considered recently by many researchers [12, 20, 21]. An example of such systems is Web-based Decision Support Systems (WDSS) [12]. Recently, two workshops aimed to exchange research on the topics of WSS were held in Halifax, Canada and Beijing, China in 2003 and 2004 respectively. Papers published in the proceedings cover a variety of Web-based support systems [18, 19].

This paper will focus on one of the important research topics of WSS: the study on how to develop and implement Web-based support systems. The organization of this paper is as follows. We will introduce the concept of Web-based support systems in the next section. Section 3 will discuss issues of developing WSS. Finally, we conclude this paper in Section 4.

2 Evolution from Computerized Support Systems to Web-based Support Systems

Computer scientists have been expecting to develop a fully automated computer system for decades. It is hoped that the system can have the same or even a higher level of intelligence as human beings. However, the technologies we have mastered are limited. We can only design and develop systems that have some abilities to assist, support, and aid us for various activities. Research proves that it is almost impossible to replace human intelligence with computer systems, at least within the foreseeable future [13]. With this restriction, we have to lower our expectations of our goals.

A particular computerized support system with specific domain knowledge provides support to a specific field. The most popular and successful example is decision support systems (DSS) [16]. DSS can be viewed as a hybrid product of two domains of studies: management science and computer science. The same principle applies to other types of computerized support systems. For example, a medical support system or a medical expert system is the product of the union between medical science and computer science. Research support systems are the combination of research methodology and computer science. Computer aided design (CAD) systems are hybrid of engineering design techniques and computer science. They are examples of computerized support systems that fulfill partial and more practical goals.

In general, a specific support system aims to support activities and operations of the specific field. It is noted that various support systems have been studied for a long time. Schematically, suppose $\mathcal{A}$ is a specific domain, a support system for domain $\mathcal{A}$ can be termed as an $\mathcal{A}$ support system. It was found that the majority of support systems are business and management oriented [20].

The Web provides new media for information storing, presenting, gathering, sharing, processing and usage. The impacts of the Web can be felt in almost all aspects of life. Moving systems online is a trend. Web technology provides plenty of benefits to support systems. First, it provides a distributed infrastructure for information processing. Next, it delivers timely, secure information and tools with user friendly interface such as Internet Explorer and Netscape.

Application domain	Technology		
	Computer technology	Web technology	...
Decision making	DSS	WDSS	...
Business activities	BSS	WBSS	...
Data mining	DMSS	WDMSS	...
Research	RSS	WRSS	...
Information retrieval	IRSS	WIRSS	...
Learning	LSS	WLSS	...
Medical application	MSS	WMSS	...
Knowledge management	KMSS	WKMSS	...
...	...	...	...

$\mathcal{A}$ (a specific domain) + support systems $= \mathcal{A}$ support systems

Web $+ \mathcal{A} +$ support systems $=$ Web-based $\mathcal{A}$ support systems

Table 1. Two dimensional view of WSS

In addition, there is no restriction on time or geographic locations. One can access Web-based systems at any time, any place. Users can control and retrieve results remotely and instantly.

WSS is a natural evolution of computerized support systems. There are two important features of WSS. They can be understood as extensions of existing research in two dimensions, as shown in Table 1. In the application dimension, represented by the rows in the table, WSS cover support systems in many different domains. They can also be viewed as natural extensions of decision support systems. In the technology dimension, represented by columns in the table, WSS use the Web as a new platform for the delivery of support. Along the application dimension, the lessons and experiences from DSS can be easily applied to other domains. Along the technology dimension, the new advances in technology can lead to further innovations in support systems.

3 Issues on the Designing and Development of WSS

Web-based systems, especially larger systems, are complex. Many larger and high performance systems have been successfully developed in various organizations. However, it is not unusual to hear stories of failures. The primary causes of failures are flawed design and development processes and poor management of development efforts [7]. There are some common issues on the designing and development of WSS. Web Engineering uses scientific, engineering and management principles as well as systematic approaches to successfully develop, deploy and maintain high quality Web-based systems and applications [3].

WSS is a special type of Web-based system. The failures of Web systems are similar to software crises in 1970's. However, there is a major difference between Web-based systems and traditional software. One of the solutions for software engineering approach is to try to freeze the user requirements. The understanding of user requirements is considered to be the first step of most design models. It is unfortunately a fact that WSS as well any Web-related systems bear the nature of evolution. Not only the requirements but also the information content keeps changing. The scalability and maintainability are two important concerns of development [7]. Some other issues include accessibility, security, interface, and personalization.

This article does not intend to propose a new design model for WSS nor to provide a silver bullet to solve all WSS design problems. It is aimed to examine some critical issues as well as design principles. Considering these issues does not guarantee a successful system, ignoring them without careful attention will result in failure.

3.1 Design Criteria

To set design criteria is one of the important issues for any system design. Although the following set of criteria [10] was proposed for a special type of Web-based system, we can generalize it easily. It is basically the questions we should ask before designing a system.

- To whom is the system made for and for what purpose? How does the system support searching or manipulating information effectively? How does the system support different kinds of users?
- What are the levels of services in terms of versatility, adequacy, and functionality? What are the levels of tools in terms of versatility, adequacy, and functionality?
- What is the level of communication possibilities among interest groups? What is the level of possibilities to give feedback? What is the level of the system in its entirety?

3.2 Reliability

System reliability and security is a key issue of any system design and has been studied for decades [5]. One does not only seek for the correctness but also robustness of a system. There is no exception for Web-based Support systems. The recent study on recovery-oriented computing [2] sheds light on designing more reliable systems in a simpler way. The approaches are well-suited for Web-based support system design. The basic idea of recovery-oriented

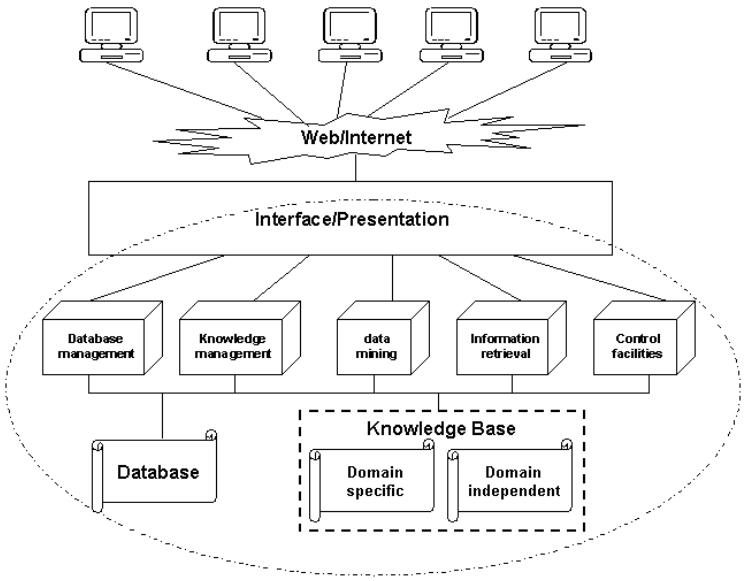

Figure 1. An Architecture of Web-based Support Systems [20]

computing is that we should pay more attention on reducing the time for recovery from failures instead of trying to design a fail-safe system. It is more productive to build systems that recover fast than targeting systems that never fail. Microreboot is considered a technique for cheap recovery. A system is designed into components. In general, a small subset of components is often responsible for a global system failure [2]. Recovery of a failure is to restart only those parts of a system that trigger the observed failure. Another technique is the undo/redo mechanism. Many system problems caused by human errors such as accidently deleting data. Undo proxies and rewindable storage could be used to quickly restore a prior snapshot of all system state.

3.3 Security

Security is a key issue of the design of Web-based support system. With protection measures at network level, we still face attacks at the application levels [14]. Modifying HTML forms and SQL queries at the client side are some feasible vulnerabilities. Corss-Site scripting (XSS) is an even dangerous one. XSS is a special kind of attack that users may submit malicious HTML with JavaScrip or other scripts to dynamic Web applications [14]. Any inputs from a browser should be sanitized before storing to prevent such attacks. It is crucial to protect Web-based support systems against unauthorized access or modifications of information, and against denial of service to authorized users [6]. It is evaluated that various access control models may be used for Web-based applications and their suitability for supporting such systems are accessed. A detailed review can be found in [6]. It is possible to diagnose security holes of WSS with a system such as Web Application Vulnerability and Error Scanner (WSVES) [9].

3.4 Data and Knowledge Management

WSS are data-intensive systems [1]. A database of WSS is a data collection of heterogeneous nature. Some data are highly structured such as the ones from legacy systems and they are normally stored in relational or object-oriented database systems. Others are semi-structured data in Web format such as XML files. However, there are a large amounts of unstructured data. In addition, there is more multimedia data appeared on the Web. Processing of online databases is a challenge for designers and developers.

Structured, unstructured, and semi-structured data need to be processed in different ways. SQL types of queries can be applied to structured data. When one comes to unstructured or semi-structured data, there are generally two solutions on how to query. One simple solution is to convert the unstructured data into structured ones and thus structured query languages can be used. Another solution is to construct a new type of query that is suitable for the new type of data such as XQuery [17]. The WSS also involves may types of queries such as scheduled queries, ad-hoc queries, information seeking queries and activity support queries. Much attention has be paid to related studies on different query techniques.

With the evolutionary nature of Web systems, to allow real-time data access and updating is important. Some data latency problems could be resolved if dynamic data collection is applied. The data of WSS may be distributed over a network. Various data formats may be adopted by different subsystems. Data warehouse or data mart techniques can be used to resolve the inconsistency problems. Multi-dimensional database features could be used for accessing aggregated information. Agents and grid computing tech-

niques are good candidates for such problems.

3.5 WSS Infrastructure

A (thin) clint/server structure, as shown in Figure 1, is one of possible structures for WSS [20]. The users, including decision makers and information seekers, are clients on the top layer. They access the system with browsers via the Web. The interface that is designed on the server side will be presented on the clients' side by browsers 24 hours a day, 7 days a week . The lower layers and components encapsulated by the oval dotted line are very similar to conventional computerized support systems. In other words, a Web-based support system is a support system with the Web as the interface.

Various kinds of networks such as the Internet, intranet and extranet will play an important role in the WSS infrastructure. Web browsers are intermediates to access a WSS. WSS are fully accessible, open, and dynamic systems. We have to make sure the information is fully and friendly delivered to different types of users. There is intensive interactive human involvement. Interface design is another key issue of WSS design. General principles of designing a Web page apply here.

No matter what kind of data we use, it is only the carrier of information. Our utmost goal is to employ information and knowledge to support human activities and extend the physical limitations of information processing. Data mining, knowledge discovery and knowledge management techniques are the natural choices.

4 Concluding Remarks

We reiterate the concept of Web-based support systems. WSS is a natural extension of existing studies. A practical solution to fully automatic systems is to develop particular support systems for different domains. With the introduction of the Web, these computerized support systems could go online. It may extend to another level if a new technology comes alive. Some issues on design and development of WSS are discussed in this paper. The evolutionary nature of WSS makes the design and development even harder. Technologies of Web engineering can be used for the design. Security, reliability and data management are some of the major concerns. Normally WSS are extended from computerized support systems, although integration with legacy systems remains a challenge. Business process improvement and business process reengineering approaches could be involved.

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