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WEB-BASED SUPPORT SYSTEMS FOR INFORMATION RETRIEVAL

KAMLESH KUMAR[1], ASHUTOSH KUMAR BHATT[2] AND AMARJEET SINGH[3]

[1]Department of Computer Applications, Jai Arihant Academic Institute, Haldwani (Nainital)
[2]Department of Computer Science, Birla Institute of Applied Sciences, Bhimtal, Distt Nainital
[3]Rajarshi Tandon Open University, Allahabad, U.P., India
*Corresponding Author: Email- kpadaliya@gmail.com

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Abstract- We view Web-based Support Systems (WSS) 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. Research on WSS is motivated by the challenges and opportunities of the Internet and the Web. The recent advancements of computer and Web technologies make the implementation of WSS feasible. This paper presents the fundamental issues of WSS, a framework of WSS, and research on WSS. We also present preliminary studies on two examples of WSS, Web-based research support systems (WRSS) and Web-based information retrieval support systems (WIRSS).
Keywords- Web-based systems, information retrieval, Web technologies

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Introduction

The advances in computer technologies have affected everybody's daily life. Computers support and assist almost every single human activity. Traditional decision support systems (DSS) focus on computerized support for making decisions with respect to managerial problems. Other good examples are computer aided software engineering (CASE) and computer aided design (CAD). With the introduction of Web technology, one may reconsider the existing methods and re-design or modify existing systems to meet new challenges. The Web is used both as a universal interface and as the underlying infrastructure for Intelligent Web Information Systems. There is an emerging and fast growing interest in computerized support systems in many other domains such as information retrieval support systems, research support systems, teaching and learning support systems, computerized medical support systems, knowledge management support systems, and many more. The recent development of the Web generates further momentum to the design and implementation of support systems.

Many types of Web-based Support System (WSS) have been studied recently by researchers. It is argued that the time to treat Web-based support systems as a new and separate sub-area of Web intelligence is coming based on the observations of existing studies [21].

We first discuss the historical view of WSS. A section that presents the framework and some design issues of WSS follows. We present preliminary studies on two examples of WSS, Web-based research support systems (WRSS) and Web-based information retrieval support systems (WIRSS).

Historical View of Web Based Support Systems

The WSS is a natural evolution of studies on various computerized support systems. An ultimate goal of computer scientists is to build fully automated computer systems that have the same or even a higher level of intelligence as human beings. It is hoped that these systems can replace human beings to perform various activities, either simple or complex. However, we can only study, design and develop systems that have some abilities to assist, support, and aid us for various activities due to the limited technologies we have mastered. Research in artificial intelligence proves that it is almost impossible to replace human intelligence with computer systems, at least within the foreseeable future. With this restriction, we have to lower our expectation to implement systems that can fulfil more

practical goals. We classify computer systems that support human activities as computerized support systems [26].

The study of computerized support systems involves many disciplines of research. The most popular and successful example is DSS. Turban et al. summarize DSS as "computer-based information systems that combine models and data in an attempt to solve non-structured problems with extensive user involvement through a friendly user interface" after discussing various definitions. DSS can be viewed as a hybrid product of two domains of studies [13]. It is an approach or methodology for supporting decision making. It uses interactive, flexible, adaptable computer-based information systems specifically developed for supporting the solution to a specific non-structural management problem. DSS are derived from management science and computer science. The same principle applies to other types of support systems. For instance, a medical support system or a medical expert system is the product of the marriage between medical science and computer science. Research support systems are the combination of research methodology and computer science. In general, a specific support system aims to support activities and operations of the specific domain.

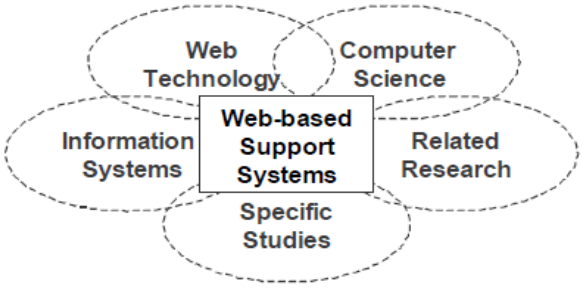

Fig. 1- Web Based Support System

Web-based Support Systems

The World Wide Web provides a new medium for storing, presenting, gathering, sharing, processing, and using information. The impacts of the Web can be felt in most aspects of our life. The impacts are twofold: Web technology provides us with more opportunities in terms of information availability, accessibility, and flexibility. However, more challenges are in front of us. We have to find the right information and tools from largely available resources. We have to learn to use the existing tools that keep changing all the time [3] [6].

The study of WSS aims to take the opportunities of the Web, to meet the challenges of the Web, and to extend the human physical limitations of information processing. We define WSS as a multidisciplinary research field that focuses on supporting human activities in specific domains based on computer science, information technology, and Web technology. One of the goals is to find out how applications and adaptations of existing methodologies on Web platforms benefit our decision making and other various activities. The following are some potential benefits of Web technology,

- The Web provides a distributed infrastructure for information processing.
- The Web delivers timely, secure information and tools with a user friendly interface.
- The Web has no time or geographic restrictions. Users can access systems at any time and any place.
- Users can control and retrieve results remotely and instantly.

Table 1- Two Dimensional view of WSS

Application domain	Technology	
	Computer technology	*Web technology*
Decision making	DSS	WDSS
Business application	BSS	WBSS
Information retrieval	IRSS	WIRSS
Scientific research	RSS	WRSS
Teaching	TSS	WTSS
Medical application	MSS	WMSS
Knowledge management	KMSS	WKMSS
Data mining	DMSS	WDMSS
…	…	…

A Two Dimensional View of WSS

Web-based Support Systems have two important features that can be understood as extensions of existing research in two dimensions, as shown in Table 1. In the application dimension, A WSS covers support systems in different domains. They can be viewed as natural extensions of decision support systems. In the technology dimension, WSS uses the Web as a new platform for the delivery of support. Along the application dimension, the lessons and experiences from DSS can be applied to other domains. Along the technology dimension, new advances in technology can lead to further innovations in support systems. The two-dimensional view of WSS provides a simple classification. Schematically, suppose A is a specific domain, a computerized support system for the domain can be termed as an A support system.

Based on such a scheme, we used one of the most popular search engines, Google (http://www.google.com), to find evidence of various existing support systems. Decision support system(s), business support system(s), negotiation support system(s), and medical support system(s) are amongst the highest returned hits. Technical oriented support systems had not been paid attention to by researchers. Therefore, we should investigate more on the technical oriented support systems such as support for data mining, research, and learning. Although the advantages of applying Web technology to support systems are sufficient, researchers have not paid enough attention to the concept of Web-based support systems. It is clear to see from the search results that the number of hits for each type of Web-based support systems is dramatically lower than its computerized support system counterpart. For instance, the hits of "Medical support system" and "Medical support systems" are around 1,000. However, there were none when we changed the phrase to "Web-based medical support system" or "Web-based medical support systems" in 2003. By comparing the number of hits from 2003 to 2011 respectively, one can observe that there is a growing interest in Web-based support systems. Due to the coverage of Google databases, the search results may not always be consistent. However, the general trend is shown as increasing.

The Architecture Of Web-Based Support Systems

Interface, functionality, and databases are some of the components that are needed to be considered when we design a system. The architecture of WSS can be viewed as a (thin) client/server structure as shown in Figure 2. The users, including decision makers and information seekers, are clients on the top layer. They access the system with browsers via the Web and Internet. The interface that is designed on the server side will be presented on the client's side by browsers. 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 can be viewed as a support system with the Web and Internet as the interface.

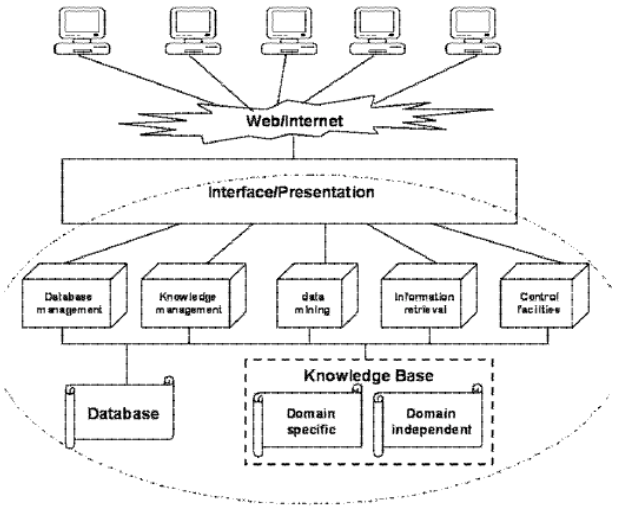

Fig. 2- An Architecture of Web Based System

The architecture shown in Figure 2 is presented from a usage point of view and is logical but not physical. In practice, data and control components may not necessarily sit physically on the same point of the network, which is one of the major differences between WSS and traditional computerized support systems. System components may be spread all over the network. Users of the systems are located globally. Agent, grid computing, and Web services play important roles in WSS implementation.

The data layer comprises two components. A database is a basic component in any modern system. WSS is not an exception. Another major component is the knowledge base. The knowledge base stores rules, principles, and guidelines used in supporting activities. We intend to divide the knowledge base into two parts: a domain-specific knowledge base and a domain in dependent knowledge base. The former is the knowledge specific to the domain that is supported. The latter involves general knowledge for all support systems.

Knowledge management, data management, information retrieval, data mining, and other control facilities form the management layer. These serve as middleware for the three-tier client/server architecture and as the intermediaries between the interface and data layers. Reasoning, inference, and agent technologies play important roles on this layer. The separation between the management of data and user profiles results in a secure and standardized system. To take advantage of Web technology, these processes are distributed over the Internet to form a virtual server. In fact, databases and knowledge bases on the lower tier are also distributed. The WSS can be classified into three levels. The first level is support for personal activities. Personal research activities such as search, retrieval, reading, and writing are supported. The second level is organizational support, such as research support on an institutional level. The top level is the network level. The collaborations between organizations or decision making by a group of people like in group decision support systems fall in this level. The group-decision support room may be a virtual room on the Web.

WSS Examples

Web-based Research Support Systems

As new technologies evolve and existing technologies expand, scientists must adjust accordingly and make full use of these emerging tools when carrying out research. Scientists face many challenges in using Web-based information resources, such as information overload, misinformation, fees, poorly designed navigation, retrieval, and browsing tools; effectively, supporting scientists to meet such challenges is an important issue. Many computerized systems have been implemented to support various research activities. The study of Web-based Research Support Systems (WRSS) is trying to provide a common framework for such systems. Similar to what we discussed above, WRSS is also interdisciplinary, involving at least three domains of studies: research methodologies, computer science, and the Web.

Many computerized systems, although not designed specifically for research support, have been used by scientists in different stages of research. The WRSS aim at pooling together all these isolated efforts and unintegrated systems with a common goal of research support. Research activities can be broadly classified into two levels—the institutional level and the individual level. The institutional level deals with the management of research and research projects in an institution. The individual level is the actual research process of a scientist. A research process model at the individual level may include the following phases: idea generating, problem definition, procedure design and planning, observation and experimentation, data analysis, results interpretation and explanation, and communication and dissemination. It is possible to combine several phases into one phase or to divide one phase into more detailed steps. The division between phases is not clear cut. Moreover, the research process does not follow a rigid sequencing of the phases. Iteration of different phrases may be necessary [1][2]. To support a large spectrum of research activities, the WRSS must be flexible and have much functionality. We summarize some basic functionality in this section.

The first component is profile management, which deals with profiles of users of WRSS, i.e., scientists. Different classes of profiles may exist, such as research interest, personal libraries, address books, Web bookmarks, and many more. The profile management module collects, organizes, and stores all relevant information for a scientist. Resource management is the second functionality of WRSS. Many types of resources exist for supporting research, such as human resources, tool resources, and information/ knowledge resources. Database, knowledge base, information retrieval, and agent technologies can be used. Web search engines can be used for retrieval. The third component is data/knowledge management. Typically, research involves the collection and pro-

cessing of a large amount of data. The WRSS must have a module to record the useful data, which gathers information and knowledge during the entire research process. The module must contain some data/knowledge operations and retrieval facilities.

The profile, resource, and data management components form a solid basis of WRSS. A research support system consists of many sub-systems to support different activities. They share common data and knowledge bases [9]. We list some specific supporting functionality: exploring support, retrieval support, reading support, analysing support, and writing support. As a specific type of WSS, the WRSS assist scientists to improve their research quality and productivity. The feasibility of such systems is based on the assumption that relatively systematic approach exists in scientific research. Furthermore, a general research process can be established, consisting of several steps or phases, such as idea generation, exploration, problem definition, procedure design and planning, observation and experimentation, data analysis, results interpretation, and communication. A number of activities are involved in each of these phases [18].

Web-based Information Retrieval Support Systems

Each support sub-system of WRSS has its special feature, as described above. Information retrieval support is the one that has been paid attention by some researchers. Web-based Information retrieval support systems (WIRSS) are designed with the objective to provide the necessary utilities, tools, and languages that support a user to perform various tasks in finding useful information and knowledge. We summarize the WIRSS in this section.

Information retrieval support systems, Web browsers, and Web search engines extend the basic search functionalities of data retrieval systems exemplified by a database system. They provide basic functionalities to assist a user or scientist in the context of libraries and in the early stage of the Web. A scientist may have to perform many different tasks when finding useful information. The new tasks include understanding, analysis, organization, and discovery in addition to the conventional tasks of searching and browsing. It is discussed in literature that WIRSS is actually a natural evolution from retrieval systems. The WIRSS attempt to resolve the problems of information retrieval systems by providing more supporting functionalities. A WIRSS provides models, languages, utilities, and tools to assist a user in investigating, analysing, understanding, and organizing a document collection and search results. These tools allow the user to explore both semantic and structural information of each individual document, as well as the entire collection [24].

We can classify WIRSS models into three related types. Documents in a document collection serve as the raw data of WIRSS. The document models deal with representations and interpretations of documents and the document collection. They allow multiple representations of documents. Granular computing plays an important role in the construction of document models. The retrieval model deals with the search functionality. They provide languages and tools to assist a user in performing tasks such as searching and browsing. WIRSS should provide multi-strategy retrieval. A user can choose different retrieval models with respect to different document models. The presentation models deal with the representation and interpretations of results from the search. They allow a user to view and arrange search results as well as various document models. The same results can be viewed in different ways by using distinct presentation models. Moreover, a user can analyse and compare results from different retrieval models [25]. A single document model, a retrieval model, or presentation model may not be suitable for different types of users. Therefore, the WIRSS must support multiple models as well as provide tools for users to manage various models.

A WIRSS focuses on the supporting functionalities of information retrieval. Yet, existing information retrieval systems focus only on the search and browsing functionalities. The WIRSS are more flexible and combine the functionalities of IRS, Web browser, and Web search engines. It is expected that current IRS should be extended to support more user tasks. A WIRSS is based on a different design philosophy that emphasizes the supporting functionality of the system instead of the specific search and browsing functionality. In the process of finding useful information, a user plays an active role in a WIRSS by using the utilities, tools, and languages provided by the system. The components of a WIRSS also include data management, model management, knowledge-based management, and user interface subsystems.

Concluding Remarks

The emerging interdisciplinary study of Web-based support systems is motivated by the challenges and opportunities of the Web. It focuses on the theories, technologies, and tools for the design and implementation of Web based systems that support various human activities. The research of Web based support systems is a natural evolution and extension of existing research.

The evolution of the application dimension is the extension of decision support systems to computerized support systems. With the emergence of Web technology and Web intelligence, various Web -based support systems are extended from a single machine—a single user computerized support system. The research on Web-based support systems can be classified into a few categories. There are four types of existing research, namely, WSS for specific domains, Web-based applications, techniques that are related to WSS and design, and the development of WSS that can be classified as WSS research.

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