CUPTRSS: A Web-based Research Support System

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Abstract

Research Support Systems (RSS) provide research organizations and scientists with information and facility for improving their research capacity, quality and productivity. Application of Web Intelligence technologies in developing the Web-based Research Support System (WRSS) will make such systems more effective and convenient. This paper analyzes research support services and proposes a Web-based intelligent system to provide integrated research support. A prototype system, CUPTRSS, is discussed, which will be implemented at Chongqing University of Posts and Telecommunications (CUPT).

1. Introduction

With the never ending growth of the Internet and ever expanding of information on the Web, we have arrived at a new information age. The Web provides a new media for gathering, storing, processing, presenting, sharing, and using information. The impacts of the Web can be felt in almost all aspects of life. To meet the challenges and take advantages of the opportunities offered by the Web, a subfield of computer science, called Web Intelligence (WI), has been emerged recently. There is fast growing interest in Web intelligence research [6, 16].

According to Yao *et al.* [15],

> "*Web Intelligence (WI) exploits Artificial Intelligence (AI) and advanced Information Technology (IT) on the Web and Internet*."

The goals of WI research is to study, based on artificial intelligence and information technology, theories, methodologies, technologies, and algorithms for the design and implementation of Intelligent Web Information Systems (IWIS). Many types of IWIS are needed to serve different groups of users and purposes.

In this paper, we investigate and examine a special type of IWIS called Web-based Research Support Systems (WRSS) [10, 14]. WRSS could be viewed as a concrete research area of Web Intelligence. The objective is to build new and effective tools for research institutions, researchers and scientists in order to support their research activities. Such tools will assist researchers to improve their research quality and productivity.

The design and the implementation of viable Research Support Systems (RSS) depend on a clear understanding of research activities and process. Research activities can be broadly classified into two levels, the institutional level and the individual level. The institutional level activities deal with the management of research and research projects in an institution. The individual level is the the actual research precess of a scientist. A good support system at institutional level will maximize the efficiency of research activity and guarantee conditions where research staff can concentrate on research. At the individual level, the system assists researchers at every phase in the research process [14]. The support at institutional level is closely related to Decision Support Systems (DSS), and the support at individual level is concerned with the integration of existing software systems and tools [14].

The study of Web-based research support systems on its own will lead to new theories, technologies and tools for supporting scientific research in the Web age. To illustrate the basic ideas, we discuss in detail a prototype system, CUPTRSS, which will be implemented at Chongqing University of Posts and Telecommunications (CUPT). The initial feedback from the research community in CUPT on the proposed system is positive and encouraging.

2. Motivations and Related Studies

In the management context, decision support systems (DSS) have been studied extensively to support and improve

decision making for managers [11]. To a large extent, DSS apply existing computer technologies to build systems that support management decision making in an organization. The development of computer science affects the design and implementation of DSS, as new computer technologies have been constantly added to DSS. For example, the development of the Web leads to Web-based decision support systems [8]. By applying the basic ideas of DSS to the context of research management and research process, one may consider the notion of research support systems (RSS). Tang considered RSS at the institutional level by focused on research management and administration tasks [10]. Yao proposed a framework of RSS at the individual level by focusing on the actual research activities of a researcher [14]. The combination of the two levels of support produces a complete model of RSS. Furthermore, the development of RSS on the Web results in Web-based research support systems (WRSS).

The notion of research support systems has been used by many organizations and research institutions. There is typically a research office at a university or a research institution that provides supports to research activities. At the information age, every community runs a Web site to provide important information and support in different scales. Some systems are called Research Support Systems and some are called Research Management Systems (RMS). By querying with the search engine Google with exact phrase "research support system" in February 2003, we obtained 515 hits. It returned 48 hits with exact phrase "research and development system" at the same time.

From the Web search results, it is found that many organizations and research institutions adopt some kind of research support systems. Some of examples are presented below:

- The Research and Development Support System at the Defense Threat Reduction Agency's (DTRA) Center for Monitoring Research (CMR) (http://www.cmr.gov/) provides a broad range of support to the nuclear explosion monitoring R&D community.
- The Chinese Natural Language Processing (CNLP) platform (http://www.nlp.org.cn/), developed and maintained by Software Division of Institute of Computing Technology, Chinese Academy of Sciences, is providing sharing resources for the research on natural language processing.
- The Research Support Libraries Programme (RSLP) in United Kingdom (http://www.rslp.ac.uk/) aims to facilitate the best possible arrangements for research support in UK libraries. "The programme has been 'managed', and has attempted to take a holistic view of library and archive activity throughout the UK."
- National Institute of Health (NIH, United States) has planned 3 NIH-wide information system projects (http://www.nih.gov/), they are CRIS (Clinical Research Information System), eRA (Electronic Research Administration) and NBRSS (Business and Research Support System).
- DCU Genius (http://rss.dcu.ie/GeniusSearch/genius.asp) is a research support system of Dublin City University in Ireland that contains comprehensive information on research staff at the university, including details of consultancies and other research outputs, publications etc.
- InforShare (http://infoshare.mednet.ucla.edu/infosys.htm) is a Research Support System in University of California at Los Angeles (UCLA). It integrates resources researchers need to conduct research such as a database of research equipment, a database of UCLA research databases, a database of grant funding information, faculty research interests, and grant application and financial systems.

Although research support systems have been widely used, there is still a lack of systematic study of such systems. Furthermore, most of systems focus on the management and administration of research activities at the institutional level.

Existing studies on individual level support focus on some specific tasks of research activities. For example, search/retrieval, reading and writing may be considered as three basic activities. Support systems for such activities have been studied by many authors. As an illustration, we searched the Google in August 2003 and found the following results:

Exact Search Phrase	Number of Hits
search support system	114
search support systems	21
retrieval support system	141
retrieval support systems	121
reading support system	120
reading support systems	8
writing support system	92
writing support systems	18

A careful examination of the returned Web pages reveals several useful observations. Different types of support systems have long been considered in many contexts. The recent advances in digital library and Web show the necessity of search/retrieval, and reading support. Many studies concentrate on the support of a particular research activity relatively independent to each other. For example, Web-based information retrieval support systems (WIRSS) assist retrieval related activities, such as browsing, searching, organization, and utilization of information [12, 13] on the

Web platform. WIRSS provide models, languages, utilities, and tools to assist a scientist or researcher in exploring, searching, analyzing, 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. There is clearly a need to integrate and study those systems in a unified model. A recently proposed framework of Web-based research support systems (WIRSS) attempts to address this problem. A brief description of this framework will be provided in the next section.

3. A Model of Research Support Systems

Based on the results of related studies reviewed in the last section, we propose a model of research support systems by considering the two levels of support. For simplicity, we used university in the discussion. A university research support system services two group of people, university research management staff and individual researchers. It in fact represents two types of research support services. The former provides administrative support and guidance on all matters related to the research effort. The latter provides support to the full range of research activities in order to meet the needs of research.

3.1. Research Support for Management Staff

Research management provides administrative support and guidance on all matters related to the research effort. According to a survey conducted by Association of Commonwealth Universities in 2001, there are four research management models [9]:

Model A: One Central Office or One Stop Shop One office administers grants and deals with industrial liaison and commercialization. Some offices are more comprehensive than others even dealing with financial management of awards.

Model B: Multiple Central Offices Two or more nonfinancial offices are involved in the main functions of research management. The most commonly involved offices are industrial liaison, technology transfer that make contact with businesses and deals with commercialization.

Model C: No research office The research management functions are carried out in the office of senior management or in another administrative office.

Model D: Partial research office The central research office carries out only part of the process, most commonly grant administration.

Model A and B count for 78% from the respondents. With a half of the remaining universities fall into Model C and D category are from Africa and Asia. The survey shows that over the past 10 years there has been considerable movement towards centralized structures for research management [9]. Even though there are different research management strategies in different research communities, the research management services are concentrated in 4 areas, as shown in table 1.

We may conclude from the above discussion that there are two types of services in research management: (1) To provide various information and guidelines related to research activities; (2) To deal with administrative transaction and collaborate with both of researchers and grand sponsors. To support research managers to cope with the research management, an integrated, web-based management system, which combines Office Automation (OA) with the function of a Management Information System (MIS), is needed. Although individual researcher has his/her way of doing research, we can also roughly divide the procedure into three stages from management supporting of views:

Survey and proposal investigating the interested academic field, assessing its state and finding the issues to be solved, making choice on topics to research and preparing the proposal

Research and development planning and designing how to do in research project, collecting and analyzing relative information and data, developing related technologies, making simulation and testing the results;

Summarizing and evaluation making conclusion of the project, evaluating the results, presenting publications and figuring out future research issues.

It is obvious that research information, research environment and research collaboration are three critical factors leading to successful research. Research outcomes such as publication, commercialization, etc are also important to both researchers and funding agencies. Figure 1 shows the research activities in three stages from management perspective. A Research Support System should provide both managers and researchers with services, including information services, sharing resources and collaborative work support. In addition, it should be easily accessible.

In general, a WRSS should fulfill the needs of a research office such as,

- To help researchers effectively and efficiently identify funding opportunities, prepare grants proposals and contracts;
- To provides researchers with information retrieval support that help them find their interested information efficiently;

	Responsibilities	Provision
Comprehensive administration	Gather and disseminate research related information Help researchers to build and sustain partnerships with industry, government, universities, public and private agencies Maintain archives Fulfill research plan,policies and strategy Provide research training Monitor and promote ethical practices in research	Policies and strategies structure Planning report Training courses Research ethics Scientific and technological archives
Project management	Provide information on funding opportunities Organize proposal and application for projects Negotiate contracts Supervise progress of projects Organize result evaluation	Knowledge of funding opportunities Advice on proposal Annual management report
Result management	R&D statistics Intellectual property protection and management Technology transfer Publication/Dissemination Seminar sponsor	Marketing intelligence Identification and exploitation intellectual property Annual R&D statistic report Publication
Financial Management	Administration of research funds and grants Producing certified financial acquittance for individual grants and contracts Outlay control	Project outlay report Financial final accounts report

Table 1. Research Management Responsibilities and Provisions

- To provide public resources sharing, such as data, computing capacity, programming and testing environment, experiment condition, etc.
- To help research managers effectively deal with administrative affairs

Therefore a WRSS could be designed as an integrated system which consists of 4 subsystems as shown in Figure 2. Research management subsystem provides research management support services for research managers. Information Retrieval Support subsystem provides information support services. Resource Sharing Support subsystem provides public research resources information and environment. Collaborative Research Support subsystem provides a public platform to support collaborative work.

The system consists of three layers, namely infrastructure, application system and user access control. The WRSS is established on campus network and interconnected with Internet. It is a distributed system that connects to the Research Support Office, the Finance Department, the Library, the Laboratory & Equipment Management Office, the Network Center and Academic Departments. Each unit operates and maintains related database. And it deploys the "one-stop shop" model, namely all users access to the system and are served through a unique portal.

In fact, many universities have constructed various computer management information systems, such as Office Automation system, Research Management System, Financial Management System, Asset Management System, Digital Library, Human Resource Management System, etc. These systems are usually separated in different departments or offices and are valuable in establishing the integrated Research Support Systems.

3.2. Research Support for Individual Researchers

For the individual level support, we briefly summarize the framework recently proposed by Yao [14].

Research is a highly complex and subtle human activity, which may be difficult to formulate formally. By adopting Graziano and Raulin's model [4], we can model research procedures into seven phases, namely, Idea generating, Problem definition, Observation/experimentation, Data analysis, Results interpretation phase and Communication phases.

Idea-generating phase. The objective is to identify a topic

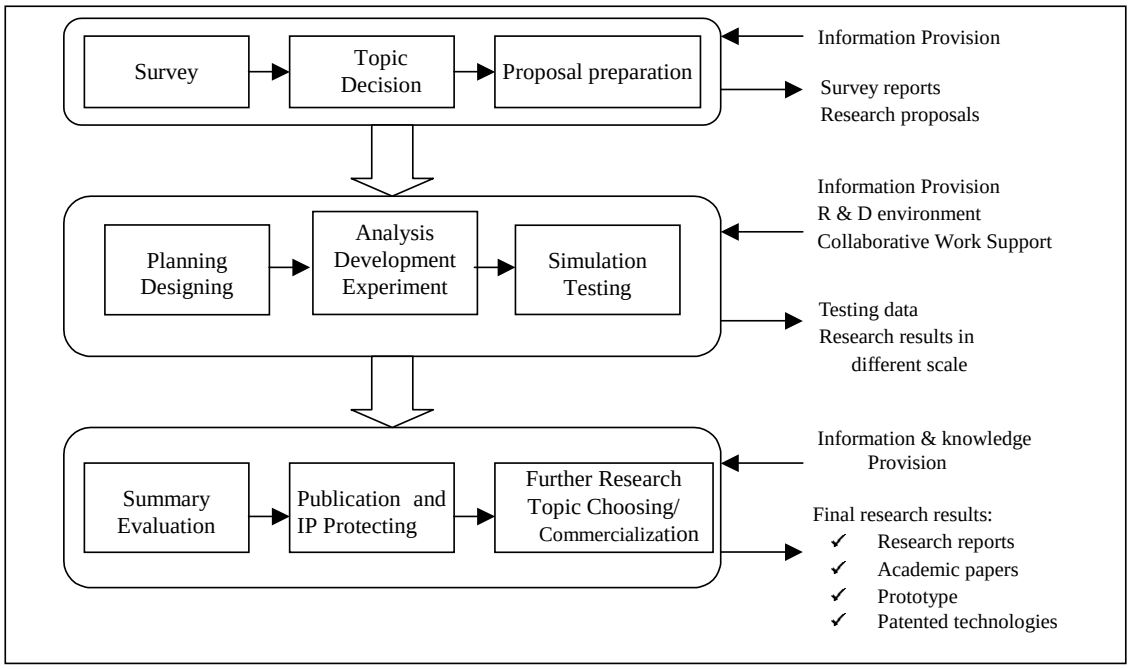

Figure 1. Management Support to Research Activities

of interest to study. Initial ideas can emerge from vague thoughts and in very non-scientific ways. Literature search and reading also play an important role in this phase.

Problem-definition phase. The objective of this phase is to precisely and clearly define and formulate vague and general ideas generated in the previous phase. Problem definition involves careful conceptualization and abstraction. The success in problem definition increases the probability of a successful research project.

Procedure-design/planning phase. The objective is to make a workable research plan by considering all issues involved, such as expected findings and results, available tools and methodologies, experiments, system implementation, time and resource constraints, and so on. This phase deals with planning and organizing research at strategic level.

Observation/experimentation phase. The objective is to observe real world phenomenon, collect data, and carry out experiments. Depending on the nature of the research disciplines, various tools and equipment, as well as different methods, can be used.

Data-analysis phase. The objective is to make sense out of the data collected. One extracts potentially useful information, abstraction, findings, and knowledge from data.

Results-interpretation phase. The objective is to build rational models and theories that explain the results from the data-analysis phase. The connections to other concepts and existing studies may also be established.

Communication phase. The objective is to present the research results to the research community. Communication can be done in either a formal or an informal manner. Books and scientific journals are the traditional communication media. Web publication is a new means of communication. Oral presentation at a conference, or discussion with colleagues, is an interactive means of communication.

To assist researchers in each of the above phases, one needs to consider the following specific supporting functionalities:

- **Exploring support**. In the early stage of research, a scientist may have a vague idea and may not be aware of the works of fellow researchers. Exploration thus plays an important role. There are many means of exploration, such as browsing databases, libraries, and the Web. If the Web is used for browsing, the historical data can be tracked. The collected data can be analyzed using machine learning and data mining tools to provide a scientist useful information and hints. Currently, Web browsers are a useful exploration tool. Their functions need to be expanded for providing support to research.

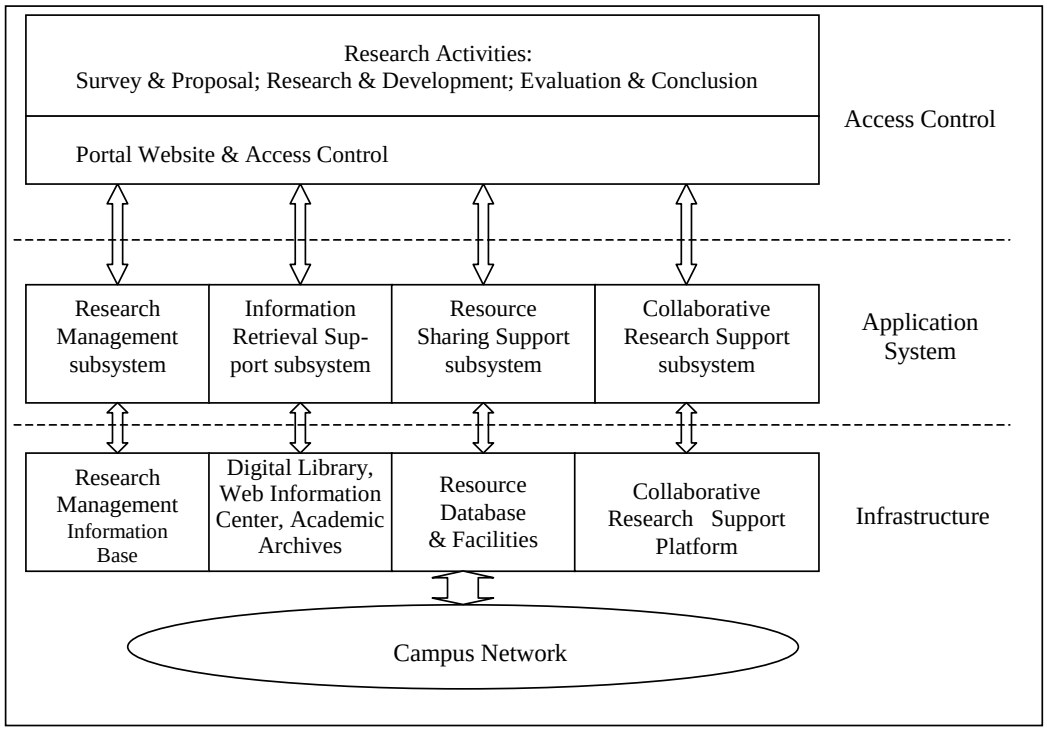

Figure 2. An Architecture of Web-based Research Support Systems

- **Retrieval support**. Once a scientist forms relatively solid ideas, it is necessary to search literature to find relevant information. Retrieval support assists retrieval related activities, such as browsing, searching, organization, and utilization of information [13, 14, 12]. A more detailed discussion on retrieval support will be given in the next section.
- **Reading support**. Reading critically and extensively is important, especially in the preparation stage [2, 5]. The advances in digital libraries and electronic publications make the reading support a necessity [3]. Software packages exist so that a reader can add book marks, make notes, link different parts of an article, and make logical connections of different articles. A reading support system needs to assist a reader in actively finding relevant materials, as well as constructing cognitive maps of the materials read. Reading support systems can be combined with exploring and retrieval support systems. Machine learning and text mining methods can be used to assist a reader by learning from the reading history. Agent technology can be used to actively look for useful information and periodically inform scientists with new information. On-line dictionaries may also be useful in reading support.
- **Analyzing support**. Successful analyzing support depends on tool management. It is necessary to help a scientist find the right tool for a particular problem in analyzing data. In addition, the system should also assist a scientist in using a tool. An explanation feature may be needed, which answers the question why a particular tool is used. If the functions of tools are described as plain text, information retrieval systems can be used to find the right tool. Computer graphics and visualization may be useful in analyzing support.
- **Writing support**. There are many writing support software tools, such as word-processor and typesetting software. Many packages come with additional functions, such as spelling-checking, grammar-checking, and various other agents. A writing support system should also contain some functions mentioned in the retrieval support systems. For example, a writing support system can find relevant articles based on the text written by a scientist and suggest possible references.

A research support system for individual research consists of many sub-systems to support different activities. The sub-systems share common data and knowledge bases. As one can not have a clear classification of research activities, it is difficult to have a clear classification of different types of support sub-systems.

4 A Prototype System: CUPTRSS

To support research and its activities at Chongqing University of Posts and Telecommunications (CUPT), China,

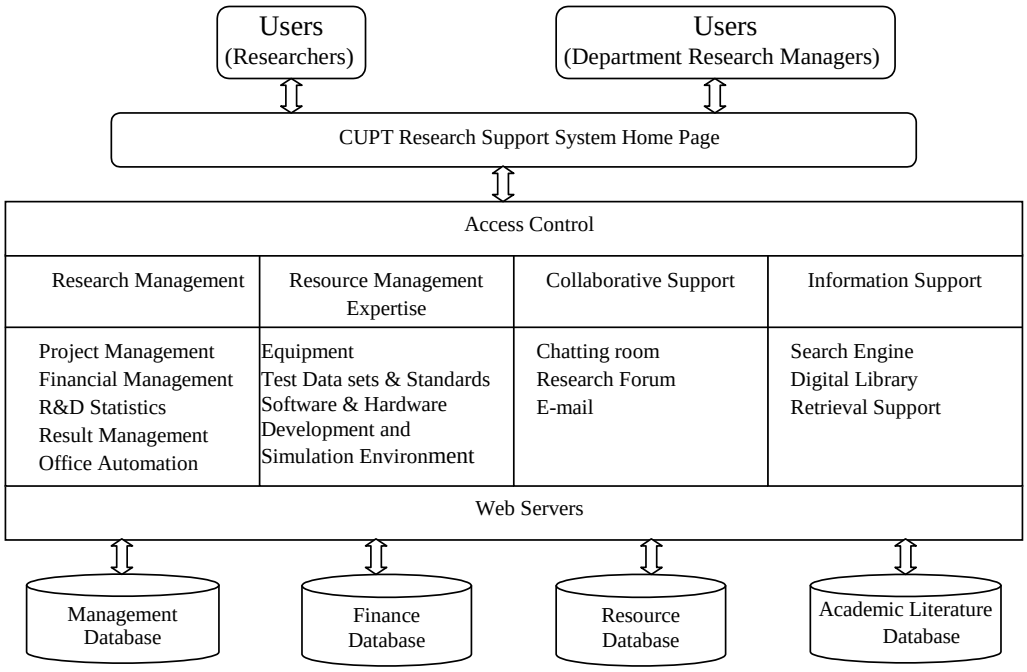

Figure 3. CUPT Research support System

we design and implement a prototype system for web-based research support. The system is maintained by the Office of Science and Technology of CUPT. It aims at providing researchers with accurate and timely information, improving research management and integrating public research resources at the university. It is also aimed to implement the frame we introduced in previous section. The current design of the system is mainly for management support. The system is also acts as test bed or platform for further research in WI related technologies. The structure of the system is shown in Figure 3. We adopt multi-layered architecture. The top layer is different users of this systems. The homepage represents layers of presentation and business logic. Under these two layers are access control layer and databases. The users access to the system through the unique portal, namely CUPTRSS homepage. There is an authentication module to manage the access control. Users, databases as well as web servers are distributed in different offices and departments.

The main function of the system includes:

Research management It is a combination of an Office Automation (OA) system and a Management Information System (MIS) for supporting research managers in terms of dealing with administrative transactions and providing relative services. It includes project management, contract management, financial management, result management, intellectual property, policy and strategy, research archives management and research and development statistics.

Research resource management This is an management subsystem that mainly focuses on research resources including personnel, data, software and hardware. It provides an online platform for instruments, simulation hardware and software. Acquisition and supply, human resource and expertise database are also included. All resources can be shared by different departments.

Information Support It includes collection and dissemination of information about funding opportunities, project guidelines and procedures, science & technologies news and marketing information. It provides information retrieval support including a Chinese Bibliography search system. A web-based intelligent search engine employing fuzzy, rough etc soft computing technologies is also the function of this module.

Collaborative work support It includes some subsystems such as a research forum for posting research papers in order to get comments and feedback from peers, a research chatting room for exchanging research ideas and discussion with other researchers, and many others.

The CUPTRSS is an ongoing project and used while research and development are going on. An open platform is adopted for future improvement and adding new functionalities as the new needs appeared as time going.

5 Conclusion and Future Work

Developing Research Support Systems is a very important research topic in the domain of Web Intelligence. RSS especially WRSS support research activities for researchers and research offices in universities. They also aim to promote research and related activities in an institution. Web-based technologies make the WRSS easy to use and access. We present a model for Web-based research support systems. WRSS provide two level of support, namely institute level for management staff and individual level for researchers. We also present a prototyped WRSS implemented at CUPT. Its main function is to server the needs in the research office of CUPT. It may also support research activities for some researchers. There are some other issues remain unsolved such as how to merge the goals of researchers and management staff. Future work include fine tune the system and enhance it functionality.

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