Intelligent Library System for Academic Knowledge Exchange

Salah S. Al-Majeed
School of Engineering
Nazarbayev University
Astana, Kazakhstan
salah.almajeed@nu.edu.kz

Martin Fleury, Udo Kruschwitz, John Woods
School of Computer Science and Electronic Engineering
University of Essex
Colchester, United Kingdom
{fleum, udo, woodjt} @essex.ac.uk

***Abstract*—This paper proposes an Intelligent Library System (ILS) framework that upgrades the traditional, book-based library to meet the interests of an emerging IT-aware generation. The library will remain as the information center of the university but will also become the base for knowledge exchange using cutting-edge technology As described in the paper, high-bandwidth wireless technology, social networks, and integrated databases can all facilitate the role of the library, which is to act as a centralized resource in support of research and learning. The framework consists of three sub-systems: electronic bookshelves (for ease of access and management of the book stock); virtual white space (for discussion of information found within the library and, by extension to the whole of the academic environment); and a social network with an integrated innovation database (to disseminate new ideas). The paper shows how these sub-systems can be arranged to support the ILS.**

Keywords—electronic bookshelf; interactive whiteboard; RFID; 60 GHz WLAN; social network

I. INTRODUCTION

The traditional library service is faced with a wide variety of demands from current users, especially from researchers and students, and the emerging generation in general, which is more at home with information technology than it is to the world of printed books. At the same time, librarians are highly motivated to meet these on-going changes through the employment of novel technologies and IT methods.

This paper proposes a framework for an Intelligent Library System (ILS), which will provide a library with an integrated database incorporating three core sub-systems: 'Electronic Bookshelves', for automating access to the bookshelves; 'Virtual White Space', for the discussion of information found in the library; and 'Innovation and Social Network Database (ISNB)', for disseminating and storing new ideas and concepts, each of which is described in Section II. The benefits of the ILS arise from utilising: the knowledge that exists within a library, the usage patterns (e.g. from exploiting patterns that emerge from library users accessing the books); and the application of advanced wireless technology within the library. Some of the proposed functionality could be achieved by existing wireless LAN systems such as IEEE 802.11n. However, by employing the emerging IEEE 802.11ad standard for indoor 60 GHz wireless [1] [2], ILS hopes to future-proof its development by enabling the low-latency transfer of high-bandwidth multimedia, such as from digital document archives, and high-definition (HD) video. It also intends to exploit such technologies because in themselves they can act as engines for innovation and growth. The paper now goes on to describe in more detail the individual sub-systems of the framework, followed by innovatory features that are brought to bear.

II. ILS SUB-SYSTEMS

The ILS framework, as mentioned in Section I, incorporates three core sub-systems, as illustrated in Fig. 1. The following Sections delineate the main features of the sub-systems.

A. Electronic Bookshelves

The first sub-system is called 'Electronic Bookshelves'. It is a challenging task to go through the library shelves looking for a book, which might just contain the knowledge for which we are looking for, even if we have the options of previewing the books on the library's website. In addition, the heavy daily tasks of managing the borrowing and return of books, as well as subsequently shelving those books, demands a considerable effort from library staff, an effort that could be directed to better use. As far as the authors are aware, Electronic Bookshelves is a novel idea based upon cutting-edge wireless technology, namely the combination of a high-speed 60 GHz wireless network [2] with RFID (Radio Frequency IDentification) [3]. In this way, support is given to a wide range of new library applications. When combined with search algorithms employing semantic and matching techniques, this sub-system will make possible: virtual browsing of the bookshelves; access to book content; and give additional information about books related to the topic in which the user (e.g. student or researcher) is interested. Thus, ambient wireless applications will power the Electronic Bookshelves and register common interests with other users of the library, enabling group working and project collaboration.

In constructing "knowledge sources" from "data", the challenge is to turn data collections into usable knowledge. Meeting this challenge results in an 'Electronic Bookshelves' knowledge base. This knowledge base will not be static but evolve over time in a continuous learning cycle. Furthermore, there is a need to provide methods and technologies to tap into these knowledge sources to navigate, search or access them in various ways. It should also be possible to update the knowledge accordingly instead of simply accessing it.

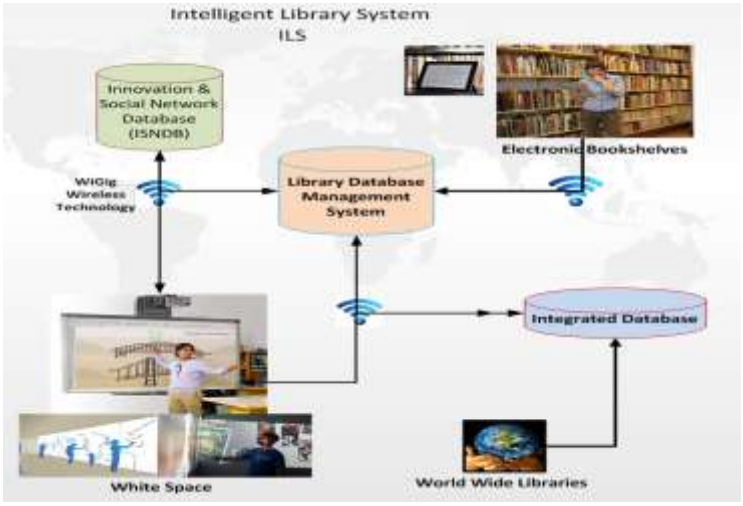

Fig. 1. Sub-systems of ILS.

For the librarians this system will, of course, give a better overview of the current state of the library and provide easier management.

B. Virtual White Space

The second sub-system is called 'Virtual White Space' or more succinctly 'White Space'. This will be a space where users can use Interactive Whiteboards (IWBs) to create and save novel ideas, as identified in Fig. 1. IWBs can in some implementations allow participants to interact as (virtual) avatars within a 3D space [4]. They provide a solution for discussion meetings and educational applications but can also be highly useful for developing ideas. IWBs have emerged as educational tools that are able to deliver a wide range of computer applications to the classroom or across the Internet, where they help to enhance learning systems [5–6]. According to the authors in [7], IWBs have been used in collaborative modeling as part of a visualization and logic approach. A prompt visualization of a problem can be very helpful in supporting explanations of a complex subject. These types of visualization can be provided for by a digital whiteboard. Furthermore, this interactive learning tool allows users (students or researchers) to "play" with keywords and provide a more enjoyable way to explore complex problems, and produce innovative solutions. Within the White Space the IWB will be supported by 60 GHz radio for multimedia wireless communication and use of semantic and matching algorithms.

C. Innovation and Social Network Database

An Innovation and Social Network Database (ISNDB) is the third sub-system. Data will already be exchanged between users of Electronic Bookshelves, so that a database will be attached to that sub-system. 'White Spaces' has its own database for storage of the ideas emerging from IWB discussions. Nonetheless, technology innovation focuses on designing and developing new products, services, ideas and principles using creative methods and best practices, whereby the ISNDB, the third sub-system, comes into play to support both the other sub-systems, providing coverage of major innovations in technology, in the past, present, and those intended for the future. ISNDB is at the heart of the ILS framework, as it will be able to extract different types of data from the Electronic Bookshelves and White Space users, in addition to what is available through suggestions emerging from social networks.

III. SUPPORT FOR INNOVATION

The ILS framework goes far beyond the traditional facilities usually provided by a library in which individuals work in isolation and find it difficult to work on a project as part of a team. Teaching can become project-led, which shadows the way commercial companies undertake a task. For example, it follows the practice of technologically-oriented universities such as Eindhoven University in the Netherlands, which is sponsored by Philips Electronics.

A. Adaptive Information Retrieval

Adaptive information retrieval [8] covers areas such as search, browsing and navigation over document collections ranging from enterprise search applications to digital libraries. The fundamental idea is to turn unstructured or partially structured data into usable knowledge structures. A range of adaptive algorithms are possible, some of them biologically inspired, that make use of knowledge extracted from documents, from log data, and from click-through information.

What makes a digital library context particularly appealing is the fact that one has access to a range of different input sources. First of all these are structured records that represent metadata which comes with every single publication (author, title, keywords, UDC classification etc). Then one has access to the full text in a library where most books are available in electronic form. In the first instance, this can be made available using open source software, such as Apache Solr [9], to make this easily information accessible and searchable using keyword search or a faceted search.

In addition, one can also make use of all additional usage data that can be recorded [10] such as information about what people borrow, what they search for (as recorded in the search logs or in the White Space discussions). This will allow additional structures to be imposed on the document collection that allows somebody, for example, to link closely related books. It will also allow the library content to become searchable in a user-oriented fashion, i.e. based on what the users of the library actually do rather than. An application of that would be to make book recommendations similar to the way a company such as Amazon already does. A further advantage of such an approach is that the database can learn relations over time but also forget links as they become out of date.

B. Indoor Wireless Technology

Wireless transmission systems allow flexibility in communication and networking between different ILS applications and end users. Under the pressure of a highly competitive open market the number of mobile applications is increasing, targeted at specific areas, providing more flexible services, improved multimedia interfaces, and enhancing data management. Furthermore, some applications can utilize several different wireless technologies simultaneously. The selection of the appropriate wireless technology depends on the number of the users, the types of application, data quantities, and the use of streaming. Streaming within ILS implies that real-time access is needed but requires error resilience and/or forward error correction in a hostile wireless environment to reduce retransmissions.

The ILS framework intends to exploit 60 GHz wireless technology [2], which is highly directional but supports sufficient bandwidth even for transfer of uncompressed high definition video. For example, standardization efforts are underway as IEEE 802.11ad, as well as a number of other initiatives [1], though the implementation of a tri-band (2.4, 5, and 60 GHz) commercial system may be several years into the future. The framework also intends, in its Electronic Shelves component, to use near-field communication (NFC), based on recent smart-phone NFC interfaces. There is additional interest in exploiting Ultra-Wideband (UWB)-based communication with RFIDs, as UWB is short-range but is not noise-limited (as is NFC). RFIDs are more familiar when employed as merchandising tags but can also be used within library books as a way of identifying which books are being browsed. For example, a user can gain information about a book by using NFC to the RFID to extract the book's id and hence use the id to connect to online information. Connecting high-bandwidth wireless systems may also lead to the use of an optical network [11], as copper-based networks do not have sufficient bandwidth.

The introduction of such systems will stimulate: the development of traffic modeling within the ILS system, autonomic management systems (requiring computational intelligence) for the library, assessment of quality-of-experience and quality-of-service of its users, and novel applications of wireless-based multimedia, all of which can lead to original research. Furthermore, experience with these advanced wireless systems can lead to technological spin-offs, which in turn act as an engine of growth.

IV. OTHER LIBRARY SYSTEMS

One approach to re-evaluating the role of the academic library is via technological innovation. For example, the work in [12] was motivated by the dissatisfaction of library users with mobile devices with library search software created for PCs. Using information about the location of local libraries, a search algorithm was created that firstly searched for related books in the nearest library and then searched for books in nearby libraries. The author recorded a high level of satisfaction with the trial software. Key-word search was based on an algorithm based on collective intelligence. More information on the extension of library services to mobile devices can be found in [13].

[14] is one of many reports in the literature that discuss the role of Radio Frequency ID (RFID) tags for the management of books (in this case Shenzhen Library in China). Not only can this technology provide security but it can enable intelligent collection management by allowing the book shelves to be scanned, which in turns aids readers. NFC, mentioned in our paper is a close relative of RFID tags.

However, in [15] a future library is planned (for 2016/17 in the University of Technology (UTS), Sydney, Australia) that is not just about book storage and technology (though an RFID management system is planned). After questionnaires and consultation, the librarians plan "an increasing focus on digital and physical spaces, on personalised services and on applications that assist clients to discover information resources in intuitive ways." Much of the book collection itself will be stored away from the main library space, freeing up room for collaborative learning, research support, and social activities. In that sense, the UTS library is more radical than our proposal, though it does not appear to invoke social networking and white boards for the learning interactions. However, books will still be available through virtual book shelves.

The future general library, Library 2.0, is considered in [16]. The authors consider that there will be a constant need to be responsive to the changing needs of library users, rather than the static role some librarians have become accustomed to taking. In fact, the model of [16] is a commercial one, in which the library is a product that should respond to its customers' needs. For example, users of the library should be able to call impromptu book discussion groups or customize the library web pages. Ways should also be sought to reach out to remote users. For example, the *Writely* word processor software also enables collaboration, as more than one writer can work on the same text. (*Google Docs* now offers similar features to *Writely* and can be accessed from mobile devices.)

Collaboration in a virtual space can be taken further via *Second Life* type Multi-User Virtual Environment (MUVE). In [17], the advantages and disadvantages of a MUVE for fostering learning and collaboration in a library setting are discussed. Further discussion about collaborative environments within libraries can be found in [18].

V. CONCLUSION

ILS represents a way forward in the application of IT and e-Learning to the traditional library. The proposed framework can be cloned with all its elements (as an integrated system) or just the selected subsystem can be replicated in another institution. The Electronic Bookshelves will enable an improved learning experience for students. The Virtual White Space is an efficient tool for the development of novel research ideas. What is quite different about the ILS system is unique blend of software search techniques with the innovatory technology. Moreover, the approach of ILS is not one of individual students working in isolation but collaborative work based around projects. To this end the various sub-components set up the infrastructure to allow that to happen. White Spaces and Social Networks are both enablers for collaboration. The integrated databases, though organized in a structured way, will access as a large logging device for the investigations that take place. The concept is in accord with the current generation's constant use of pervasive electronic media, which is so different from previous generations. To make libraries relevant for the upcoming generation a radical framework of the type outlined is necessary. Future work will refine the planning of the framework to bring its vision closer to fruition.

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