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Architecture Design and Implementation of RFID Based Academic Library

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Abstract: Increasing demand for information sources in academic libraries obliges responsible managers to implement progressive technologies such as web services interfaces, RSS feeds, RFID and other modern identification technologies to streamline service operations and enhance customer services. Implementation of Barcode Technology in library operations markedly improved the efficiency of libraries and the quality of services. However, an exploitation of RFID technology brings new opportunities how to improve customer services and solve many different types of problems in libraries. This study focuses on the development and adoption of RFID technology along with applying business process management tools in the faculty library system of the Technical University of Kosice.

Key words: RFID, management, diagrams, Information Library System, Slovakia

INTRODUCTION

The main role of any library is to provide high quality of services to reader for utilization of available sources including the internet that allows users to interact and collaborate with each other according to web 2.0 technology. Library 2.0 presents user-centered concept which enables clients to have real time interaction with library. Driving access to knowledge using these tools is all about driving users to the web platform; making them aware of new tools which offer faster and reliable services in information seeking such as: wikis, blogs, RSS (Really Simple Syndication), web personalization and others (Ezeani and Eke, 2010; Aguolu and Aguolu, 2002).

In like manner, applications of automated information technology in libraries connect new ideas and technologies with library services. Equally, implementation of RFID in libraries generally leads to productivity enhancement through queue reduction at the checkout counter, improved customer service and less repetitive strain injuries of library staff (Cavoukian, 2004; Engels, 2006). Libraries started to use RFID systems to substitute barcode systems in the late 1990s (Mulla and Chandrashekara, 2006). According to Derakhshan *et al.* (2007) and Hongying *et al.* (2008), RFID has significant technology advantages over bar code identification systems and has been gradually adopted and deployed in a wide range of applications. During the last decade, a number of practical and theoretical approaches related to implementation of Radio Frequency Identification (RFID) Systems into libraries have been published. Especially, the studies by Smart (2004), Coyle (2005), Bansode and Desale (2009), Ching and Tai (2009) and Boss (2003) can be highlighted. In generally, RFID is a highly advantageous technology compared to barcodes even though it has to be said that implementation of Barcode Technology in library operations significantly improved the efficiency and the quality of libraries services. In generally, applications of RFID in a library systems are focused on elimination of flows emerged by using traditional paper cards or the bar code labels (Ilie-Zudor *et al.*, 2011). As known RFID tags embedded in books enable faster reading of library items but other possibilities to automate library processes in a library are more or less uncovered. Moreover, their exploitation often brings into light new possibilities how to improve customer services and how to solve many different types of problems in libraries. The intention in this study is to present the approaches and development experiences of small academic library.

METHODOLOGICAL FRAMEWORK

Since, in this project researchers had an ambition to establish process-based library services, researchers decided to apply modern business process management tools based on the process classification framework, process modelling and other related approaches. Because utilization of business process modelling methodologies varies depending on a particular purpose or activity, firstly it was necessary to select a suitable modelling technique. One of the possible techniques usable for making such models is based on IDEF (Integration Definition) modelling languages. There are several types of IDEF methods (Ross, 1985; Ang and Gay, 1993; Colquhoun and Baines, 1991). The most familiar one is

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IDEF0 (Integration Definition for Function Modelling) which offers, apart from other functions, integration of information systems; business processes or software engineering analysis (Whitman *et al*., 1998; Presley *et al*., 1995). The business content analysis of the designed library brought us to a decision to apply modified IDEF0 modelling technique. Its tools were applied at the conceptual stage of the project. Subsequently, development and adoption of RFID technology for library process automation was performed. During that stage it was necessary to develop specific software packages to adopt standard RFID components for intended use to be compatible with the Library Information System.

RESEARCH MOTIVATION

When applying modern business management concepts in an academic institution, it is important to take under consideration ultimate objectives of the organization and basic business rules such as providing maximum outcome with given resources or quantification of customers demands and others. The certain problem is that not everyone agrees with the position of university as business company. Moreover, most faculties do not agree with the point to define students as customers since, it refers to assumption that customer is always right (Michael *et al*., 1994).

On the other hand it is obvious that educational institutions should have to be competitive that means to be student-oriented rather than discipline-oriented. One of the conditions for achieving such goals is to provide students and teachers high quality library services. Moreover, university library systems might be respected as a core institution activity because scholarly processes are changing rapidly in learning and research. In accordance with this contention, researchers have embarked on a project to modernize the specialized department library.

There were also several additional motivations behind this initiative. Primarily, it was a generally known fact that information searching approaches used by students for at least one decade were markedly developed. Therefore, library users including students are implicitly expecting workflow-related systems for searching and discovery. Predominant feature of the workflow-related systems, against content-related systems is process view. According to Mesquita *et al*. (2002), in the content view, users' goals are not task-related but content-related which means that users need only to find some information by whichever means available in the application. In the process view, the focus is on tasks that clients need to perform when using the application.

RESEARCH DESCRIPTION

Implementation of BPM tools: In order to describe the approaches to development of the academic library, firstly researchers can focus on the business process management concept development. At the initial stage we have decided to apply the business process modelling technique based on modified IDEF0 Method that was standardized by NIST Publication (1993). Process mapping by this technique begins with the description of the system as a whole at the highest level of abstraction and then by decomposition of this model to describe each of the sub-systems within the system hierarchy. Accordingly, researchers divided process into the three basic classes of diagrams (Modrak, 2007):

- System diagram
- Sequence flow diagrams-describing content of top-level processes
- State transition diagrams-describing content of sub-processes

A generic example of the system diagram decomposition into sequence flow diagrams is shown in Fig. 1. The purpose of system diagram is to model the structure of top-level processes performed by an organization at highest level of abstraction. Subsequently, relations between top-level processes and the library environment are specified. The environment is represented in the system diagram by external entities with which the library communicates while their content is not a subject of analysis in the following steps of the process mapping (Modrak, 2008). External entities usually represent the initial sources (suppliers) of sequence flows or end customers. Figure 2a shows the system diagram describing real model of the academic library system named Library of Manufacturing Technologies and Management (LMTM). Library system in this diagram is represented by five autonomous Library Processes (LP) that are also called as parent processes with accordance to Business Process Management Notation (BPMN) modelling and reference guide (White and Miers, 2008). These are:

- LP 1 Acquisition of library fond units
- LP 2 Data structure definition of library documents
- LP 3 Cataloguing
- LP 4 Providing of library services
- LP 5 Revision of library fond

Three of them-library processes 3-5 are automated through library information system CLAVIUS. The Library

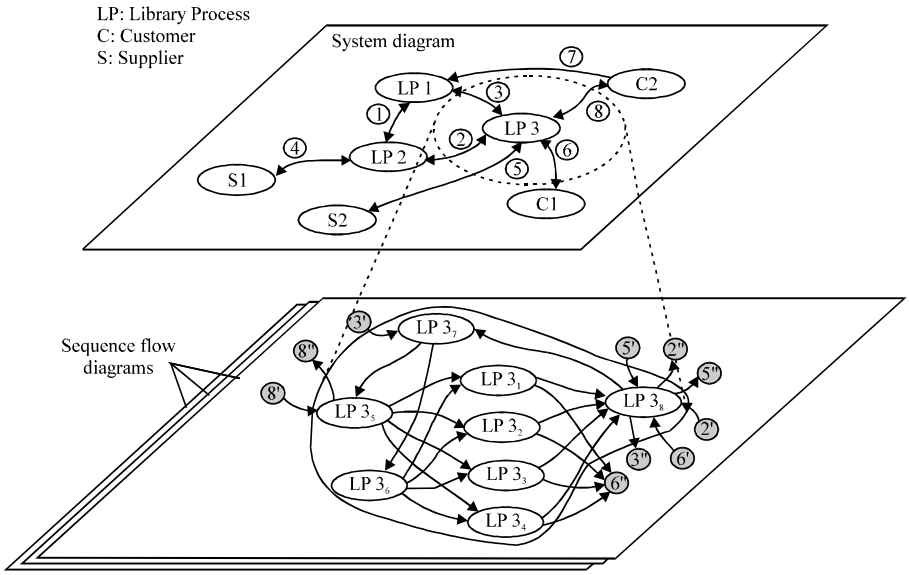

Fig. 1: Generic model of the relationship between system diagram and sequence flow diagrams

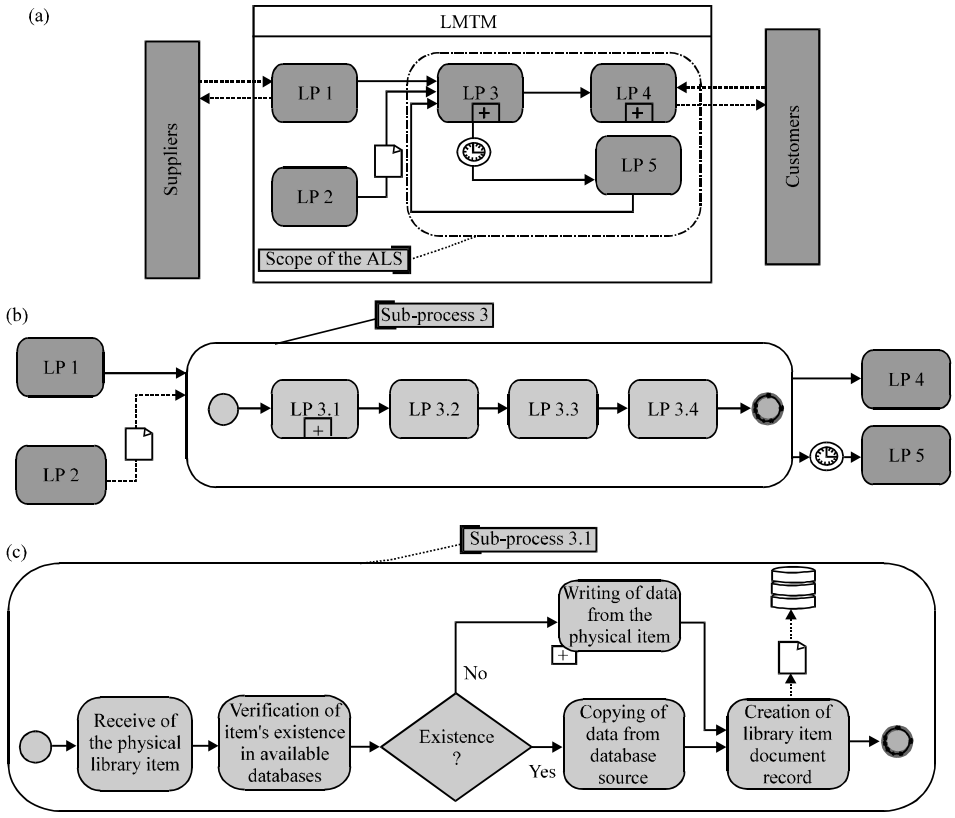

Fig. 2: a) System diagram; b) Sequence flow diagram of the LP 3 and c) State transition diagram of the library process 3.1

Information System (LIS) is also able to manage library process 1 but in this time we didn't capitalize its all functions. Speaking about the LIS, only few basic characteristics are perhaps needful to summarize. Automated library system CLAVIUS has been developed in 1998 by the company LANius. Core application of the

library information system works on the Windows Operating Systems and interacts with SQL database and web server. Its main advantage that affected the selection process is that library system CLAVIUS has a potential to cope with radio frequency identification technology. This potential has been in the project fully utilised and presents a key innovative element in the LMTM automation processes.

The external environment of LMTM consists of library suppliers (book vendors) and customers who are students and teachers of the faculty. Figure 2b describes structure of the library process 3 that represents second level of diagram processing. This structure consists of the following workflow steps:

- LP 3.1 Data dictionary management
- LP 3.2 RFID tags printing
- LP 3.3 Tagging of library units
- LP 3.4 Moving of library units into shelving storage

Due to the reality that library process 3.1 is the most compounded from sub-processes depicted in above diagram, further content of the process is shown the Fig. 2c. The purpose of this procedure is data transformation of physical library item (a book, magazine, CD or video) to the library automation system. Its first step is automated verification whether given unit is already present in the database system of the National Library and in databases of CLAVIUS. If so, relevant data are copied and applied for creation of the Library Item Document Record (LIDR). Library item document record can be generated in five search results formats:

- Elementary document record
- ISBD (International Standard Bibliographic Description)
- UNIMARC (Universal Machine-Readable Catalogue
- Citation
- MARC21-format that provide the protocol by which computers exchange use and interpret bibliographic information. Its data elements make up the foundation of most library catalogues used today (Taylor, 2005)

The client's viewpoint on the autonomous library processes tells that LP 4 process can be considered as the most decisive one. Its decomposition is shown in the Fig. 3. In this process the following important workflow sequences can be identified:

- Client registration
- Searching of library documents and identification of availability by clients either through internet or touch terminal
- Checking item availability at Google Books from elementary catalogue card format
- Sending the order to the librarian through Library Information System
- Change of book availability to state out now in the automated library system
- Consolidation of physical library items by librarian for clients
- Feedback announcement to client by e-mail (in case if needed)
- Reading of client's RFID card
- Linking of client's RFID card number with library document RFID number into automated Library Information System

The library process 5: Revision of library fond can be very effectively carried out by use of portable RFID reader/writer. Gathered data from RFID readers regarding a presence of the books are automatically compared against all registered items.

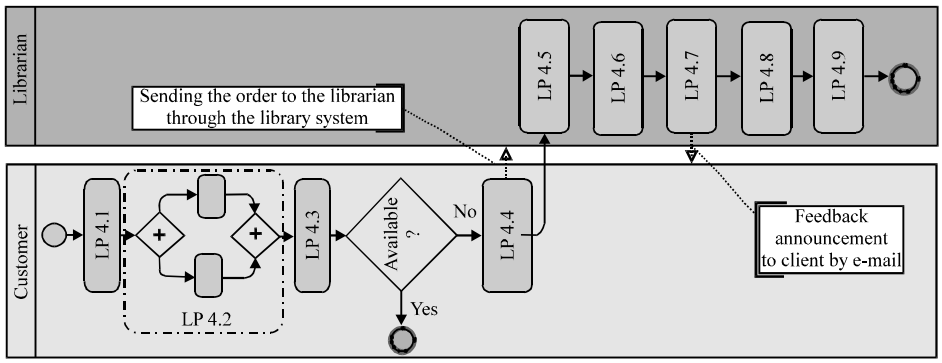

Fig. 3: Sequence flow diagram of the library process 4

Description of the technical configuration: As usual, minimum equipment requirements for implementation of commercial software products are always defined by the software vendors. The aim was to technically equip the library to respect sustainable development's principles. Hardware conception of LMTM library system is connected with chosen software platforms like MS Windows server, Linux and applications running on these operating systems as IIS (Internet Information Services), MySQL, CLAVIUS Software and proprietary RFID Software. The core of the hardware is application server which operates CLAVIUS Software.

Library document records are stored in MySQL database server. Finally, web server is used in this concept to serve clients by providing access to the Database and Library Document Reservation System. In order to enhance the security of stored library document records, the database server is connected to the application server directly by separate LAN connection. This information connection flows exclusively through the second network card of application server with just one open port used for communication furthermore secured by password.

In case of electricity power failure, servers are supplied by UPS up to 1 h running time. After that time, automatic and safe shut down is initiated. When the electric power is again on, all servers turn automatically on. Above mentioned systems and BIOS configuration ensures that no data will be lost by power failures. Beside this, data stored on the hard disks are either mirrored by use of RAID1 mode or parity is shared on all disks in RAID5 mode. This hardware configuration of disks enables hot plug-in and plug-out of defective disks and reduces server off time during the maintenance. Firewall is also inherent part of this configuration. Technical configuration of LMTM is shown in the Fig. 4. Beside the servers itself, hardware configuration includes intranet switch, touch terminal for easy access of client to the Library Information System, RFID printer and wireless barcode/RFID reader used for fond revision. Finally RFID readers/writers supplement the whole configuration. As it is obvious RFID readers work in various frequencies, radiation powers and are using different communication protocols and ciphers. In this case the library RFID readers operate on 13.56 MHz band. The reason why this technology was used originates from the following reasons:

- Students and teachers identification cards operate on this frequency
- Tags on this frequency operate up to 10 cm so no accidental tag reads can occur
- This frequency readers and tags are widely spread and are quite cheap
- This readers are already described in ISO/IEC 14443-4 (2008)
- Proprietary software development could be easier carried out by the staff due to familiarity with 13.56 MHz RFID technology

Accessibility and structure of the physical library fond: The content of a physical library fond of the Library of Manufacturing Technologies and Management is accessible from the internet (http://www.kniznica.tk) or from a local network by use of touch terminal by clicking on the logo of the library. An initial library page contains two main options for simple searching by Author or by Subject. When clicking on the selected item from the menu a cataloguing card of the relevant document will become visible. Further information generated from the LIS includes location and availability of the given document in our library and Google books together with cover page with possibility to get link to the amazon.com. It has to be mentioned that there is a difference in the number of documents in the Slovak and the English version. Besides the mentioned option for searching of

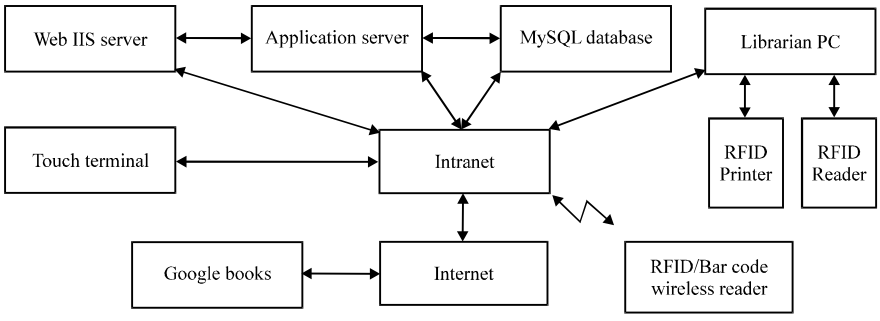

Fig. 4: Technical configuration of LMTM

Table 1: Basic categories and subcategories of LMTM documents

Category	UDC
Manufacturing management	
Production management	005/338.3
Mfg systems design	022.3/338.3
Design of experiments	519.242
Organization design	331.103.22
Enterprise process modeling	519.876.2
Marketing	339.138
Project management	005.8
Quality management	005.6
General management	005
Macroeconomics	330.101.541
Microeconomics	330.101.542
Environment science	
Occupational safety and health	331.45
Recycling technologies	502.174.1
Renewable energy sources	502.174.3
Waste management	658.567.5
Ergonomics	331.101.1
Environmental engineering	628.39
Environmental protection	502
Informatics and information technologies	
Radio frequency identification RFID	621.396
Simulation of systems	519.876.5
Optimization	005.591.1
Antennas	621.396.67
Programming languages	004.43
Database systems	004.65
Operations systems	004.451
Systems engineering	004.41
Artificial intelligence	004.8
Manufacturing technologies	
Mechanical engineering and machinery	621
Mechanics of materials	621.01/531
Industrial engineering	338.45/005.336.1
History of technology	62"71"
Material sciences	620.1
Logistics	
Manufacturing logistics	355.41
Supply chain management	346.544

library documents, there is also another given option to access the library items by A-Z index. The A-Z index is available from the initial page by clicking the author or subject without specifying any author or subject. The content structure of the physical library fond titles was strictly adjusted to a curriculum of the Manufacturing Management Study Program that is a branch of Manufacturing Engineering. Accordingly, book and another document titles has been divided in the library classification system into five basic categories that include: Manufacturing Management, Environmentalism, Informatics and Information Technology, Manufacturing Technology and Logistics. These categories consist from subcategories that are classified according to The Universal Decimal Classification (UDC). The subcategories along with UDCs are shown in Table 1.

DISCUSSION

It is no doubt that RFID applications in library management systems can improve operational performance and utilisation of library information resources. Since, there is no need for line of sight, RFID reader allows identifying items with short read range requirements. Moreover, effective RFID application makes a library more users friendly. Prevalent RFID installations as security systems help librarians in reducing antisocial behaviour of clients. Other effects can be achieved in a number of different ways depending on main RFID implementation objectives. In the presented solution, students and teachers have comfortable online access to the library fond either through internet or through the touch terminal (Fig. 4) that is situated on public accessible place. All information regarding fond and news can be updated in real time. Clients are not discouraged to utilize library services due to waste of their time.

Adoption of new technology into new function areas is frequently accompanying with unexpected hurdles like in this case. Applied software product doesn't count with the possibility that student or/and teacher card ID could be coupled with yet existing institution database information and automatically used for direct data entry into library registration sheet. In order to automate the process of registration to employ existing institution database information it was necessary to gain access to the University database. This administration process took approximately two months and according to our opinion, obstacles were caused by typical behaviour of administration workers to solve in routine tasks. Another bottleneck during implementation was problem with supplier quality services of RFID components. For instance, the same supplier that delivered us RFID printer, subsequently delivered us tags but with not compatible frequency with printer. The explanation of this inconvenience is that given distributor was not technically educated in the area of RFID technology.

CONCLUSION

Overall, researchers are convinced that RFID application in libraries, similarly as in warehouse management, provides a platform for improving of customer satisfaction and gradual technical enhancement (Modrak *et al*., 2010). Even though an initial investment seem to be generally higher (in compare with barcode), the experience proved that this solution makes financial savings of operation costs. Savings of initial costs in the case have been achieved mainly thanks to decision to design and implement the workflow solution solely by the internal team. Considering the ubiquity of the barcode in every-day applications companies tend to prefer this type of identification against RFID. This case proved that in given specific conditions the barcode reading would be at

least twice slower and manual identification would be couple of times slower than RFID. Assuming that the growth rate in the use of RFID in libraries around the world rapidly increases, RFID can be seen as a significant tool that enables library managers to optimize and maximize the effectiveness of library services. Accordingly, RFID technology has a potential to become a disruptive technology also in this realm. In other worlds it means that RFID may help library managers to identify new sources of growth (Christensen and Raynor, 2003).

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