The Electronic Library

Mixed approach in creating a university union catalogue

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Received 5 February 2014
Revised 2 June 2014
4 September 2014
Accepted 17 September 2014

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Abstract

Purpose – The purpose of this paper is to present the software architecture of the university's union catalogue in Novi Sad, Serbia. The university's union catalogue would comprise the collections of 14 academic libraries.

Design/methodology/approach – The basis of this paper is a case study of developing a software solution for the union catalogue of the University of Novi Sad in Serbia. The solution principles of object-oriented modelling are applied to describe the software architecture. Specifically, the unified modeling language (UML) component and sequence diagrams are used. The database model is described by using a physical data model.

Findings – Through the research of related papers and, taking into consideration the problem of creating a university union catalogue, it is concluded that the best approach is to combine the idea of a virtual and a physical union catalogue. Records are stored in one physical union catalogue, while the holdings data are stored in the local library management systems (LMSs) organized in the form of virtual union catalogues. Because academic libraries often use LMSs from different vendors, interoperable communication between those LMSs and the union catalogue is provided through the usage of standard library protocols for information retrieval (Search and Retrieve URL [SRU], SRU Record Update and NISO Circulation Interchange Protocol [NCIP]).

Research limitations/implications – The development of a union catalogue for the University of Novi Sad is in its test phase, and, at this moment, only a software solution supporting the functionalities of a union catalogue has been created.

Practical implications – By introducing a university union catalogue, students would be able to search the collections of all the university libraries by using a single portal. Their results would indicate whether a book is available and from which library it is available to borrow.

Originality/value – Originality of this software architecture lies in the usage of standard library protocols. The described architecture enables the addition of new members to the university union catalogue, regardless of which LMS the library uses.

Keywords Union catalogue, SRU, SRU record update, NCIP, Software architecture, BISIS

Paper type Research paper

1. Introduction

The availability of information provided via the Internet, as well as the possibility to exchange information between libraries which use library management systems (LMSs) from different vendors, became one of the main prerequisites for successful management of a library. Modern Web users are accustomed to using search engines, such as Google or Yahoo, which provide them with the possibility of a centralised search

The work is supported by Ministry of Education and Science of the Republic of Serbia, through project no. III47003: "Infrastructure for technology enhanced learning in Serbia".

The Electronic Library
Vol. 33 No. 6, 2015
pp. 970-989

0264-0473
DOI 10.1108/EL-02-2014-0026

service (comScore, 2014). Furthermore, research studies have shown that university students prefer using Web search engines over all other electronic information services, such as online public access catalogues (OPACs) or bibliographic databases, to obtain information. Griffiths and Brophy (2005) determined that Google is the first choice for 45 per cent of students compared with using the OPAC, which is a first choice for just 10 per cent of students. Google is their preferred choice because it is an easy-to-use tool that does not require specialized skills in comparison to an OPAC (Fast and Campbell, 2004). However, Brophy and Bawden (2005) stated that these two kinds of resources are complementary and both have their advantages and drawbacks. Their research shows that Google is superior in coverage and accessibility, while library databases provide more quality results.

To exploit student Google search trends, libraries should provide their users with a more comprehensive search engine with an easy-to-use interface. The idea of using a single OPAC to search the collection of a lone library seems to be of less importance. Consequently, organising multiple library collections into a union catalogue takes precedence as a way to bring together more information into a single place. The existence of a union catalogue is a requirement for developing a modern library OPAC that has functionalities similar to Google.

The aim of this paper is to describe the software architecture of a union catalogue at the University of Novi Sad in Serbia. In this paper, we present one software solution, supporting a union catalogue that would consist of bibliographic records from all the libraries at the university searchable using a single OPAC. Once implemented, students could very easily and quickly obtain information about which library possesses a particular book and what the status of an item is; that is, whether a specific library has the item and whether it is available for borrowing.

The presented software architecture of a university union catalogue does not follow any of the existing practices in creating union catalogues. The architecture is based on a combination of physical and virtual union catalogues. Combining all the good features of virtual and physical union catalogues in the architecture of the university union catalogue is the main contribution of this paper. Additionally, the University of Novi Sad comprises 15 libraries that use different LMSs, so the main idea was to enable interoperability among them using open standards, such as Search and Retrieve URL (SRU), SRU Record Update and NISO Circulation Interchange Protocol (NCIP).

The paper is presented in nine sections. A brief description of the organization of University of Novi Sad academic libraries is given in the Section 2. In Section 3, the application of a combination of two different approaches – physical and virtual union catalogues – to create a software solution for a union catalogue is described. Bearing in mind that a union catalogue requires the exchange of information among libraries, a short description of protocols used for search and retrieval of bibliographic records, as well as a description of a protocol used for the exchange of user data, is given in the fourth section. A software architecture model for the university union catalogue and the benefits of this type of architecture are presented in Section 5. A brief overview of the university union catalogue's implementation is given in the Section 6 and Section 7 explains the possible problems that may arise during the creation of a union catalogue. Concluding remarks, as well as some plans for future work, are presented in the final two sections.

2. Overview of academic libraries at the University of Novi Sad

The University of Novi Sad is located in Novi Sad, which is the largest city of the Serbian province of Vojvodina. Founded in 1960, it is the second largest university among the eight state universities in Serbia. Today, the university comprises 14 faculties with campuses located in four different cities in Vojvodina: Novi Sad, Subotica, Zrenjanin and Sombor. The majority of the faculties are situated inside the university campus in Novi Sad. Approximately 40,000 students study at the University of Novi Sad and about 7,500 new students enrol in the university each year.

Each faculty inside the university has its own library and there is an additional central university library. The faculty libraries are financially supported by the faculties and they are under their patronage. Each library has its own policy and creates its policy independently of the other libraries. Therefore, libraries are free to choose any LMS they prefer and they manage their own collections according to their internal rules. Currently, these libraries use the BISIS (2007), COBISS (2014), UNESCO (2011) and Pergam LMSs. Pergam is an in-house solution developed in the 1990s; however, its development has been discontinued. The information about LMSs used and that about the size of the library collection are presented in Table I.

Faculty libraries are not grouped into a consortium, but there is an agreement within the university that enables students from different faculties to borrow books from other faculty libraries. In that case, information about those loans is stored in the LMS of that particular library and it is not visible to the other libraries. Most of the libraries have OPACs and, by using the OPAC of one particular library, students can get information on whether the library possesses a book and whether that book is available for borrowing. There is no union catalogue containing the collections of all the libraries. This means that students, to check whether a book is held at one of the 15 university libraries, must make as many searches as there are libraries at the university and, for each search, they must use the OPAC of that particular library. Communication amongst the libraries is not supported by any modern electronic library services, such as interlibrary loans or direct consortia borrowing, that might support interlibrary cooperation at the university. A first step to achieve automated communication amongst

Table I.
The libraries of the University of Novi Sad, LMSs and collection size

Library	LMS	Collection size
Academy of Arts in Novi Sad	COBISS	24,000
Faculty of Medicine in Novi Sad	COBISS	46,000
Faculty of Philosophy in Novi Sad	COBISS	250,000
Faculty of Agriculture in Novi Sad	BISIS	33,000
Faculty of Law in Novi Sad	Pergam	75,000
Faculty of Technology in Novi Sad	WINISIS	16,000
Faculty of Economics in Novi Sad	BISIS	45,000
Faculty of Technical Sciences in Novi Sad	BISIS	48,000
Faculty of Sciences in Novi Sad	BISIS	78,000
Faculty of Civil Engineering in Subotica	BISIS	11,000
Technical Faculty in Zrenjanin	BISIS	6,000
Faculty of Sport and Physical Education in Novi Sad	BISIS	8,000
Faculty of Education in Sombor	BISIS	40,000
Teachers' Training Faculty in Hungarian in Subotica	BISIS	20,000
Central Library	BISIS	12,000

the libraries is to provide a centralized search of all the libraries' collections; that is, it is necessary to create a union catalogue for all the university libraries.

3. Related work

A union catalogue enables a search of the multiple libraries or library collections (Lynch, 1997). Cousins (1999) said that there are two approaches that could be applied to create a union catalogue. The first approach relates to the creation of a physical union catalogue physically containing all bibliographic records. Precisely, there is one single repository used to store all bibliographic records created by the participating libraries. The development of information and communication technology caused the emergence of the second approach in creating union catalogues. That approach is based on a federated search of all the collections organized as a virtual union catalogue. A virtual union catalogue is responsible for showing bibliographic records resulting from a search, while records are still stored in the LMSs of the participating libraries. During the federated search, it is necessary to establish communication with all the participating libraries and to make parallel searching possible for all their collections. Taking into account that a single bibliographic record could be found in more than one library, one of the tasks of a virtual union catalogue is to deal with duplicate bibliographic records by showing the user the different bibliographic records. Also, if one record exists in numerous libraries, information about the libraries which have that record will be included in the search result. Besides these two approaches, Gatenby (2002) recognized a third approach in creating a union catalogue. That approach is based on distributed data with a centralized index. This means that data are located within local databases, but a centralized index is created by harvesting metadata from those databases. The central index is updated periodically.

All of these approaches have their advantages and disadvantages, which have been the subject matter of many previous research studies (Lynch, 1997; Cousins, 1999; Dovey, 2000; Gatenby, 2002; Hider, 2004). According to most of the authors, physical union catalogues are faster because all records are stored in one place and there is no need to perform parallel searches as is the case for virtual catalogues. The response time for obtaining results during parallel searches will permanently increase with the addition of new libraries into a virtual union catalogue.

Both approaches have issues with managing duplicate records. In the case of virtual catalogues, one record may be found in more than one library, so detection of duplicates must be done when search results are presented. Therefore, the creation of appropriate algorithms for duplicate detection is necessary. In the case of physical catalogues, records are stored in one database, so creation of duplicate records must be prevented when a new record is added or an existing record is updated. Therefore, some kind of quality control mechanism must be performed during the process of adding or updating records.

Furthermore, based on existing research studies, one consistent index and the authority control of physical catalogues provides better recall and greater precision, but there must be an agreement on cataloguing rules and a single indexing policy. To achieve this with virtual catalogues, all participating libraries must provide uniform indexes and search functions, which is not always an easy task. This can lead to inconsistency of search results from virtual catalogues. Alternatively, virtual catalogues are less politically difficult to establish than physical ones because each

participating library has its own policy of cataloguing. To decrease inconsistency and keep their own policy, libraries may organize their collections as a virtual catalogue with a centralized index. In addition, research studies indicated that maintainability costs of virtual union catalogues are lower in comparison with the costs of maintaining physical catalogues. Also, virtual catalogues are more scalable because it is easier to join a new library to a virtual catalogue than to merge its data into an existing database.

The first union catalogues emerged in the 1970s (Cannell and Guy, 2001). One well-known and the largest physical union catalogue is the catalogue of the Online Computer Libraries Center (OCLC), today known as WorldCat (OCLC, 2015). WorldCat enables the search of many libraries at once for an item and then locates it in a nearby library. Currently, almost 70,000 libraries expose the richness of their collections to the worldwide library community using WorldCat. End users can search WorldCat using its OPAC, but they can also use major search engines, such as Google or Yahoo, to search. Nilges (2006) described the Open WorldCat service that can also be used to search WorldCat.

Similar trends followed in the UK, where the Consortium of University Research Libraries (CURL) was founded. CURL was established in 1983 and the database was located at the University of Manchester (Cousins, 1997). This consortium created a physical union catalogue, COPAC, making it possible to search through over 70 academic, national and special libraries (COPAC, 2015). The Summit is another example of a physical union catalogue of academic libraries. The Summit union catalogue was formed by merging the union catalogues Orbis and Cascade managed by the universities of Oregon and Washington. Chmelir (2005) described the Cascade union catalogue and reported on the improvement in resource sharing made by using Summit. Today, Summit comprises the local catalogues of 37 universities and colleges in Oregon, Washington and Idaho (Summit, 2014).

In addition, many national libraries created their own physical union catalogues at the state level. For instance, the National Library of Australia created, under the project Libraries Australia, 2015), its own physical union catalogue which records the location details of over 45 million items held in most academic, research, national, state, public and special Australian libraries. Missingham and Boston (2005) described the research undertaken to assess the needs of Australian citizens for access to library collections, as well as the technical architecture of the new search service for this national infrastructure. The National Library of Denmark also applied a similar approach in creating its union catalogue named DanBib. DanBib contains all items published in Denmark and all items found in the stock of the Danish public libraries (Petersen and Lose, 2006).

One of the problems that may occur during the development of physical union catalogues regards merging data from local databases into one central database. Merging data requires identification of possible duplicate bibliographic records beforehand. This problem cannot be solved uniquely and depends on local data and policies in the local libraries. One possible strategy for identifying duplicate records is using a crowdsourcing approach described by Morishima *et al.* (2014). Chand and Chauhan (2008) described the workflow of the development for the INFLIBNET union catalogue comprising more than 150 university libraries in India. They discussed the steps taken to collect raw data, merge it and make it available via the union catalogue. Also, Visakhi and Hasan (2013) described the development of the union catalogue of the

agricultural libraries in India in partnership with OCLC. To integrate bibliographic records from the 12 libraries with WorldCat, they used an automated OCLC service for batch uploading. Additional obstacles in creating physical union catalogues may arise from technical aspects of implementing catalogues (e.g. different library software, absence of appropriate standards) or from library management (e.g. lack of trained library staff, lack of readiness to contribute to a union catalogue). Chelak and Azadeh (2010) discussed obstacles regarding the development of union catalogues in Iran.

In addition, physical union catalogues encounter issues with obtaining the circulation data of a particular item. Namely, union catalogues should provide single access points to all the collections of the member libraries and the information about the availability of an item is of vital importance to the end-user, but that information is often deemed private. One approach to solve this problem is that a physical union catalogue stores just basic data about an item and provides the user with links to local systems in order to obtain the circulation status. The consortium of Academic Libraries of Catalonia has a physical union catalogue that uses this approach. Anglada (1999) described this union catalogue and the way circulation data are obtained. WorldCat also uses the same approach. Some union catalogues solve this problem by using the Z39.50 protocol to obtain dynamic holding information. In this way, the end-user just uses the OPAC of the union catalogue, and there is no need to go to the local OPACs. For instance, DanBib supports the "danZIG" profile for implementing the Z39.50 protocol (Petersen and Lose, 2006). That profile contains instructions for bibliographic search and retrieval, holdings search and retrieval, ordering and interlibrary loan. The holdings' data are exchanged in a format conforming to the ZIG holdings XML schema. A few years ago, Petersen *et al.* (2009) discussed the experience gained through the usage of that profile for the purpose of the DanBib catalogue. A similar approach is used by the National Library of Australia which also uses the Z39.50 protocol as an option to obtain the circulation status of items (Missingham and Boston, 2005). However, this option is possible only if the library supports the Z39.50 protocol.

With the advent of new communication protocols (e.g. Z39.50, SRU, OAI-PMH), a number of libraries formed virtual union catalogues. For example, under the umbrella of the eLib programme (eLib, 2001), several virtual union catalogues were created. Some of these are Search25 (M25 Consortium of Academic Libraries, 2015) that is a virtual catalogue of 57 academic libraries in London and Cairns (Cairns, 2012) that comprises the collections of 45 Australian libraries. Furthermore, today, a number of academic libraries have grouped into consortiums and have their collections organized as virtual union catalogues. OhioLINK is one of the largest virtual catalogues comprising the collections of 89 libraries of Ohio's colleges and universities (Kohl, 1998). The library collections of Florida's universities are exposed through the virtual union catalogue managed by the Florida Center for Library Automation (FLVC, 2015). Hong Kong university libraries grouped their dissertation and theses collections by making an in-house search engine. That search engine requires that all participating libraries use the same LMS – a limitation for this solution – and it does not use any standard library communication protocols (Wong and Li, 2009), so a lack of interoperability is another disadvantage of this solution. Unlike the approach presented by Wong and Li (2009), Sarkar and Mukhopadhyay (2012) described a prototype union catalogue of electronic theses and dissertations on health and medicine through the application of the OAI-PMH protocol for metadata harvesting. By using this approach, they created a

virtual union catalogue that acts as a single-window search interface to facilitate retrieval of data on a global scale. Virtual union catalogues may be an acceptable solution for some national libraries too. The National Library of Singapore gathered 11 libraries and formed a virtual catalogue that is a base for "e-interlibrary loan[s]" (Chellapandi *et al.*, 2010).

Taking into consideration that both virtual and physical catalogues have disadvantages, some libraries decided to chose a mixed approach in creating a union catalogue based on distributed data with a centralized index. The Affiliated College Libraries of Bangalore University applied this approach in creating their union catalogue. They used SRU/W for search and retrieval, and OAI-PMH for harvesting metadata (Konnur and Mohan, 2006). In addition, there is a software solution ELIN that supports this approach technically. The ELIN service is provided to any academic library on a subscription basis (Mayfield *et al.*, 2008).

However, any final decision on an approach to be used to create a union catalogue must be determined by the libraries. Every approach has its advantages and drawbacks, so libraries, according to their collections, needs and users, must decide which approach they will use.

4. Protocols for bibliographic data exchange

During the process of creating a union catalogue, no matter whether it means the creation of a physical or a virtual union catalogue, it is necessary to provide the exchange of data. In the case of a physical union catalogue, it is necessary to provide participating libraries with the mechanism of sending records to a union catalogue. In the case of a virtual union catalogue, there should exist a mechanism to search the collections of all of the participating libraries. Also, there should exist a way to obtain information about the availability of a single item in the participating libraries.

In the process of bibliographic data exchange, it is necessary to provide interoperability and make that communication independent of concrete implementation of library systems. Taking into account that the main task of this paper is to describe the technical side of the union catalogue, in the following sections, short overviews are given of some protocols that may be used for the purpose of interoperable communication.

4.1 Search and Retrieve URL

The Z39.50 protocol (Z39.50, 2004) is one of the most used protocols for the exchange of bibliographic records in the past 20 years. However, it is noted that it has some drawbacks beyond all of its advantages and, because of that, Z39.50 protocol users have started up many different initiatives to make Z39.50 more useful for a larger number of users. One of the projects that aims to reduce the complexity of the Z39.50 protocol, but still incorporates its basic functionalities, is the SRU standard (SRU, 2013).

The SRU standard tries to keep functionalities defined by the Z39.50 standard, but it enables their implementation by using up-to-date technologies. Similar to the Z39.50 protocol, the SRU protocol also requires that there are client and server applications communicating through the HTTP protocol. The client application (client) sends its requests to the server application (server) in the form of the HTTP GET and HTTP POST methods or in the form of an XML document encapsulated in a SOAP message.

Exchange of messages as an XML document is one of the advantages of the SRU protocol in comparison to Z39.50.

Requests that clients can send to a server are defined through the services. Unlike the Z39.50 standard that defines 15 services, the SRU standard defines just 3 services, primarily because it was noticed that only a few services defined in the Z39.50 standard are actually used in practice. The services defined by the SRU standard are as follows:

- *SearchRetrieve*: A service responsible for search and retrieval data using the CQL query language.
- *Scan*: A service for a given search index that returns all values which could be found for that index.
- *Explain*: A service that returns information about elements of standards that some server supports.

In this paper, we used just the *SearchRetrieve* service, and its application is described in Section 5. However, more details about those services can be found on the official site of the SRU standard (SRU, 2013).

4.2 SRU Record Update

SRU Record Update (SRU, 2007) is a protocol enabling remote clients to store records in a database. This protocol provides a mechanism for the creation, replacement and deletion of records. This protocol is mainly used for the creation of a union catalogue, local history databases, book review databases and so forth (Thewlis and Gatenby, 2010).

The protocol defines two operations, the *Update* and the *Explain* operations. The *Update* operation is responsible for creating, updating and deleting records. Records that are going to be created or updated can be sent in the form of XML documents and then XML schema that describes the XML documents must be stated. In the case of deleting a record from some repository, it is only necessary to state a record identifier as a parameter of the *Update* operation. The *Explain* operation retrieves information about elements of the standard that are available. A server does not have to implement all elements defined by a standard.

Application of this protocol in the architecture of the university's union catalogue is also described in Section 5. The operation *Update* is used to send records to the union catalogue.

4.3 NISO Circulation Interchange Protocol

By development of the Z39.50 protocol for search and retrieval of bibliographic data, as well as the ISO ILL (ISO 10,160/ISO 10,161) protocol for interlibrary loan, it is possible to locate electronic resources, as well as to send and track requests for the exchange of bibliographic resources. However, libraries had a new requirement related to the exchange data about users who use those resources. In response to that requirement, the NCIP (i.e. the Z39.83 protocol) for exchange data about users was created and standardised. The protocol defines services and messages (exchanged between applications) to perform the functions necessary to lend and borrow items, and to provide controlled access to electronic resources. Application areas of this protocol regard:

- *Direct consortia borrowing*: Users of one library can request and borrow items from another library within a consortium.
- *Circulation/interlibrary loan interaction*: Exchange of circulation data between interlibrary loan (ILL) applications and circulation application.
- *Self-service circulation*: Users can check out or check in desired items without assistance from agency staff.

The XML language is used for describing structures of services and messages for exchange. XML schema describes the structure of messages and is also part of the standard. Messages are exchanged through the HTTP, HTTPS and TCP/IP protocols.

This protocol is relatively new and it is still not widespread. The protocol is free to download from the official site of the NCIP protocol (NCIP, 2015). In this paper, just a few NCIP services (*Lookup Item*, *Accept Item* and *Update Item*) are used to exchange data about items between the union catalogue and the participating libraries.

5. Software architecture of the university's union catalogue

The software that supports the university's union catalogue was developed inside the project BISIS. As a part of this project, LMS BISIS was developed and is used in many of the libraries at the university. LMS BISIS is an integrated software solution fully meeting the demands of the libraries, and it provides modules for cataloguing, circulation, reporting and acquisition (Tešendić *et al.*, 2009; Boberić and Surla, 2009; Dimić and Surla, 2009; Milosavljević and Tešendić, 2010).

The software architecture of the university's union catalogue does not follow any of the described approaches in creating union catalogues, but it is based on a combination of virtual and physical union catalogues. Bibliographic records of all of the libraries will be stored in the physical union catalogue to ensure a better response time and that better recall and precision is achieved.

Considering that every library, which is a member of the union catalogue, has its own policy for creating holding and user data, it was decided that the data be organised in the form of a virtual union catalogue and that every library stores the data in their local LMS. This solution is more acceptable because libraries do not have to change their organisation and working policies that is one of the advantages of virtual catalogues.

In addition, the consideration that the libraries use systems from different vendors had to be taken into consideration, so it was necessary to provide interoperable communication between the libraries and the union catalogue. To provide interoperability among different systems, the main idea is to create a system whose architecture is flexible and modular, and that is the reason why we chose open standards, such as SRU, SRU Record Update and NCIP, to support communication amongst the systems. In this architecture, the university OPAC and other participating libraries, as well as other systems, may use the SRU protocol to search the union catalogue. The SRU Record Update protocol is used in the case when a participating library wants to create a new record or update an existing record in the union catalogue. All records in the union catalogue are stored in the MARC21 format. The NCIP protocol is used to get circulation data about single items from a particular library.

The software architecture of the university's union catalogue is shown as a unified modeling language (UML) component diagram in Figure 1. In that diagram, three components and their interfaces used for communication are shown. A component

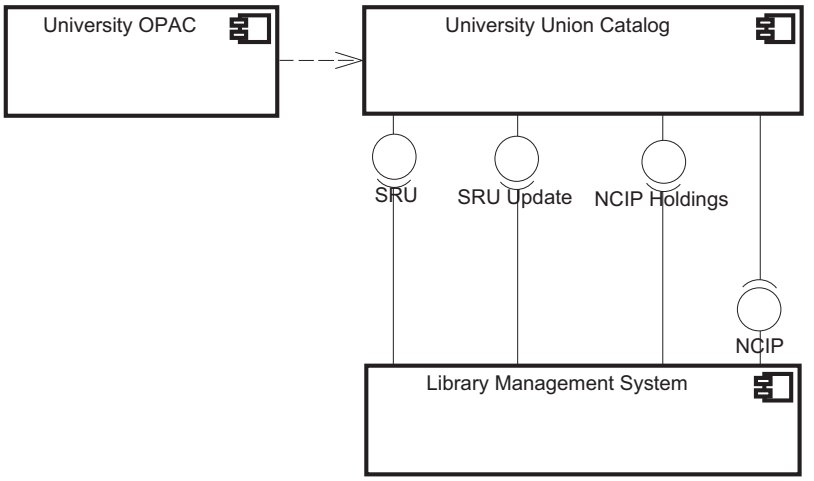

Figure 1.
Architecture of the university's union catalogue

University OPAC enables users to search the university union catalogue. A component *Library Management System* (referred to as *LMS component* forthwith) represents the local LMS of a participating library. Recall that the participating libraries may use software from different vendors. A component *University Union Catalogue* (referred to as *UUC component* forthwith) occupies a focal point in this architecture. Its task is to manage bibliographic records in the union catalogue.

With the aim to achieve interoperability, the components UUC and LMS communicate through standard protocols. For the purpose of that communication, several interfaces were implemented and a description of the particular interfaces are presented in Figure 1.

5.1 Interfaces for exchanging records

For exchanging bibliographic records between the UUC and LMS components (Figure 1), two interfaces are provided: SRU and SRU Update. The UUC component provides the interface SRU for implementing the *SearchRetrieve* service and it presents a server
side of the communication through the SRU protocol. When a library wants to search the union catalogue, than its LMS creates a CQL query and, using a *SearchRetrieve* service defined by the SRU protocol, sends that query to the UUC component. If there are records that correspond to that query, the UUC component will return those records in the form of an XML document in accordance with the MARC21 bibliographic format.

The UUC component also provides an SRU Update interface that implements an *Update* operation and it is a server side of the communication through the SRU Record Update protocol. This interface is used in the situation where a library, through its LMS, wants to send a record to the union catalogue. In that case, the LMS component creates a bibliographic record in the form of an XML document in accordance with the MARC21 format. Using the *Update* operation defined in the SRU Record Update protocol, the LMS component sends it to the UUC component. The UUC component is responsible for storing and indexing that record and, during

that process, it automatically assigns a unique record identifier to the record. If the record is successfully saved in the union catalogue, component UUC will return the unique record identifier to the LMS component, and that component will locally store the identifier and connect it with its copies. Every record in the union catalogue has its own unique record identifier. This identifier is assigned to the record when it is created for the first time and it cannot be changed. Operation *Update* may be used also when a record is going to be updated and, in that case, it is necessary that the LMS component sends a record, as well as its identifier, to correctly identify the record in the union catalogue to be updated.

5.2 Interfaces for exchanging holdings data

One of the main functions of the union catalogue is to provide information on whether a book has available items and in which library they can be found. However, that information strongly depends on the subsystem for circulation in a particular library and is stored in the LMS of that library. That was the reason why we chose to organise holdings data in the form of a virtual catalogue. Considering the fact that bibliographic records are stored in the unique physical catalogue and that their items can be found in the LMSs of participating libraries, it is necessary to provide a way to identify which items belong to one record. It is necessary to provide communication between the physical and virtual union catalogues to get information about items relating to records from physical catalogues.

Copies of the same book, related to one bibliographic record, can be found in many libraries. If information about items connected to a record is needed, a union catalogue must send a message which contains a record identifier to the LMS components of the participating libraries that have that specific record. LMS components responding to that message will return information about items that belong to that record. This task cannot be accomplished by using protocols for bibliographic record exchange.

To overcome that problem, the NCIP protocol was used in the architecture of the university's union catalogue. NCIP services provide detailed information on an item according to its identifier. Because the protocol does not define services that will provide information about items according to only a record identifier, we took advantage of several NCIP services to obtain that functionality. Two interfaces, NCIP and NCIP Holdings (shown in the Figure 1), were implemented. The LMS component implements the NCIP interface, while the UUC component implements the NCIP Holdings interface.

Interface NCIP is used to obtain holdings data of a concrete record stored in the union catalogue. Recall that holdings data are stored in the local library systems. The communication among the components responsible for obtaining holdings data is presented in Figure 2 using a UML sequence diagram. When one searches the union catalogue using an OPAC, the UUC component returns the appropriate record(s) from the physical union catalogue together with information on which libraries the items in the records are found. Selecting one of the libraries, the UUC component sends a request to the NCIP interface belonging to a selected library and obtains information about the availability of the record's items in that library. The NCIP interface implements the *Lookup Item* service (defined by the NCIP protocol) that serves to obtain information about the record's item according to the item

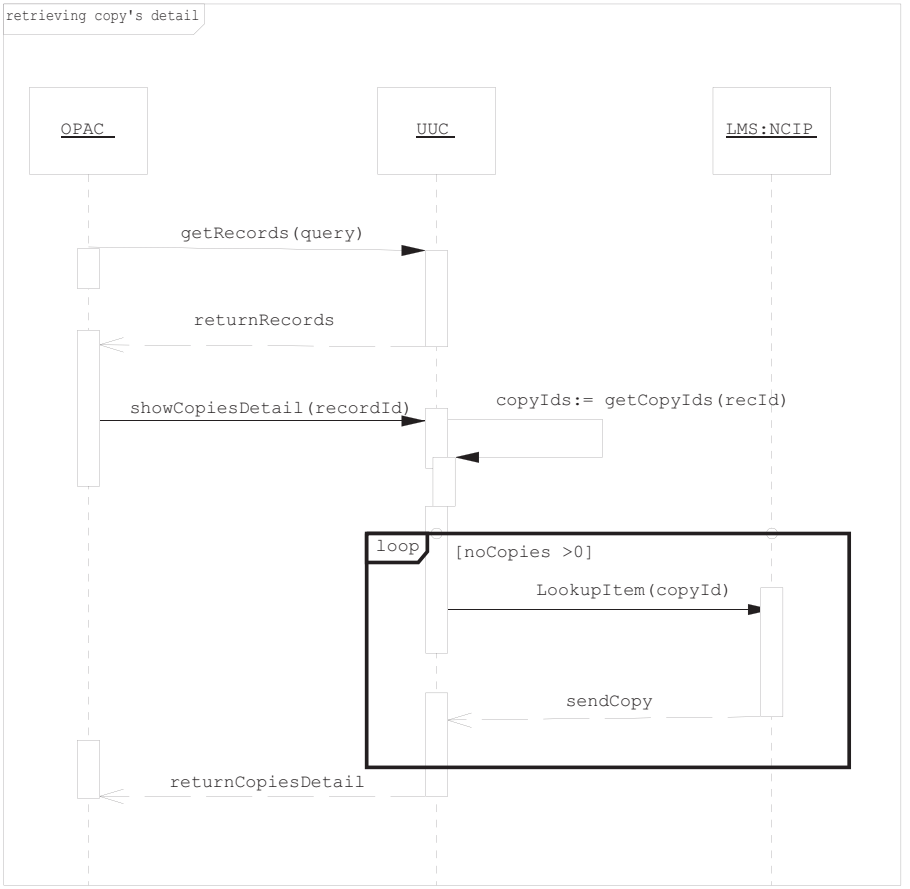

Figure 2.
Retrieving an item's detail

identifier. This means that the UUC component, before sending a request on availability to the NCIP interface, must know the item identifier it wants to get information about. Namely, besides the record identifiers, single-item identifiers must also be stored in the physical catalogue. Furthermore, it means that when a library wants to save a record in the union catalogue, it must send item identifiers relating to that record as well.

It was already mentioned that records are sent to the UUC component using the SRU Update interface, but this interface is used only to send records, not items. The NCIP Holdings interface, that implements services *Accept Item* and *Update Item* (defined by the NCIP protocol), is used for sending items. The main purpose of those services is to exchange information about users and publications in the process of direct consortia borrowing. However, in the architecture of the university's union catalogue, those services are used by LMSs to send item identifiers of a concrete record to the UUC component. Communication between the UUC and LMS components when a new record is stored in the union catalogue is presented in Figure 3 using a UML sequence diagram. As part of the request to *Accept Item*, as

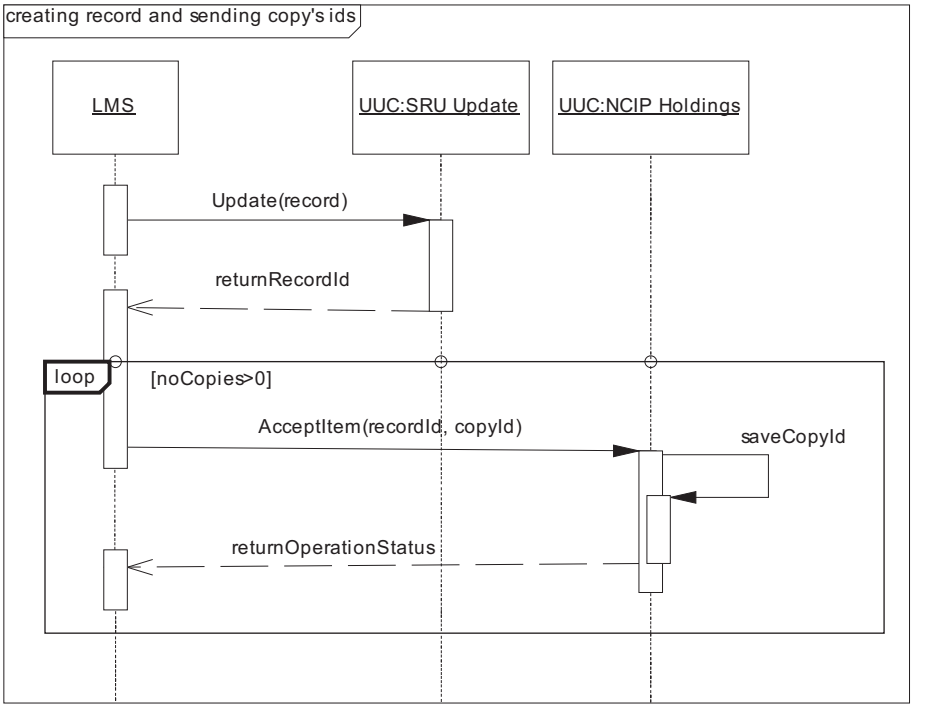

Figure 3.
Creating a new record and sending its copy IDs

well as to *Update Item*, the LMS sends a record identifier and an item identifier. The UUC component stores those identifiers and returns an acknowledgement message. In this way, the physical union catalogue has all the record identifiers and all the item identifiers. Those item identifiers are used by the NCIP interface to get information about the availability of an item in a library.

As previously mentioned, this architecture and the organisation of the holdings data exchange is created because the NCIP protocol does not have services that would (based on the record's identifier) return information about all of its items. If such a service existed, the architecture of the union catalogue would be more elegant and simpler. Developers of the eXtensible Catalog project (eXtensible Catalog, 2015) also recognised the need for such a service. They are developing open-source software for libraries and the NCIP Toolkit is one of the software components developed within that project. The NCIP Toolkit is based on the NCIP protocol and interacts with other LMSs for exchanging circulation data. The NCIP Toolkit developers have designed the *Look Up Item Set* service that is a non-standard NCIP service, and it requests data about items according to the provided list of record identifiers (eXtensible Catalog, 2011). Usage and implementation of that service would significantly simplify the proposed architecture of the university's union catalogue, but that service is not yet standardised and, in our architecture, we tried to propose a solution that would be based on a combination of standard NCIP services (*Lookup Item*, *Accept Item* and *Update Item*) and accomplishes the same task. In the case of the standardisation of the *Look Up Item Set* service, we

would replace our services and would get a less complex architecture for the university's union catalogue.

6. Software implementation

A brief description of the implementation of the UUC component is given in this section. The UUC component is implemented in the Java programming language using open-source solutions.

The UUC component is responsible for record management and records are stored in the relational database whose model is presented in Figure 4. The table *Record* contains bibliographic records in XML format and records are identified by the *idRec*. Data about participating libraries are stored in the table *Library*. Besides the basic information about the library, the *Library* table contains information about the URL address at which the NCIP interface is located and used for obtaining holdings data from that library. Every library has its own item identifiers that may not to be unique at the level of a union catalogue. Those item identifiers, together with the library identifier to which items belong, are stored in the table *Item*. That is, in order to identify an item, it is necessary to have information about its local identifier (*idItem*), the identifier of the library (*idLib*) to which the item belongs, and the identifier of the records (*idRec*).

For the purpose of efficient records retrieval, all records are indexed by using the search engine Lucene (2014). Lucene is software for indexing and retrieving data (Information Retrieval Library). It is a free, open-source tool implemented in Java. In the implementation of the university's union catalogue, it is applied using a similar idea for indexing records, as it was applied in the library management system BISIS (Milosavljević *et al.*, 2010). The process of record indexing is realised in such a way that all records are saved in a database, while the index contains only information relevant to the search. It means that when the search is performed, first, it looks into the index and, if records exist which match the query, those records are retrieved from the database and returned to the user of the system.

Interfaces SRU and SRU Update, described in the previous section, are implemented as XML Web services using the Apache Axis library (Apache Software Foundation, 2012), while the interfaces NCIP and NCIP Holdings use the HTTP protocol for data

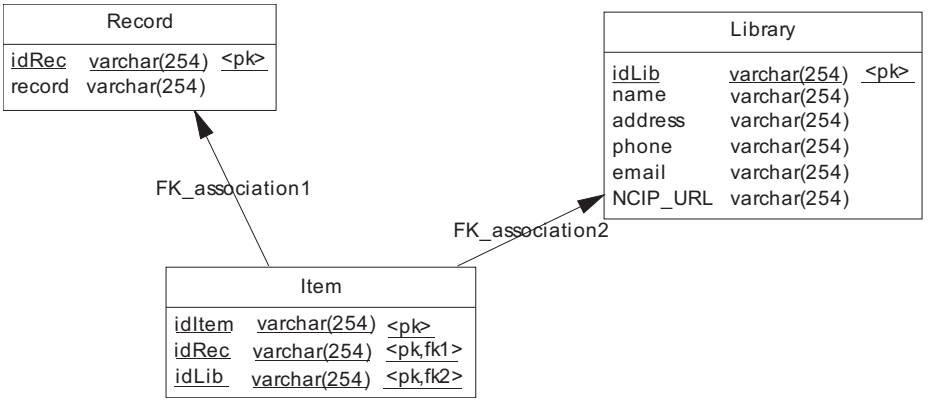

Figure 4.
The UUC component database model

exchange. This type of communication, together with the use of standard protocols, enables interoperability between the UUC component and the LMSs from different vendors. If a library wants to participate in the university's union catalogue, it is only necessary to implement the NCIP interface described in the previous section and to know how to use the services of the UUC component.

7. Challenges of establishing the university's union catalogue

The development of a union catalogue at the University of Novi Sad is in its first phase and, at this moment, is only a software solution supporting the functionalities of a union catalogue. The software is an in-house solution developed as a part of project BISIS. Inside of the project, the LMS BISIS is also developed and used in several libraries at the university.

The proposed software solution for a union catalogue is verified based on the library of the Faculty of Sciences. This library houses five different book collections (those of mathematics, physics, chemistry, biology and geography), and uses LMS BISIS and the UNIMARC format for cataloguing records. Each collection belongs to a specific department of the faculty and they were stored in separate local catalogues. The first step, to test the usability of the proposed software solution, was to merge all the collections into a single one. All the bibliographic records were automatically converted into the MARC21 format (Rudić and Surla, 2009) and stored in a centralized union catalogue. After merging the data, about 3 per cent of the duplicate records were found in the database. During data import into a centralized union catalogue, every record was given a new record number and information about mapping the old record numbers to the new ones was stored in an external file.

The number of duplicates is low due to the fact that the collections are disparate and most of the duplicates relate to literature that is common to all departments (topics from sociology, psychology, pedagogy, etc.). These duplicate records must be processed manually. Inside LMS BISIS, there is a tool for comparing and merging records that will be used for that purpose when a union catalogue is established. This tool works in such a manner that it considers two records being duplicates if they have the same value for ISBN, title, author, publisher and year of publication. After the tool finds duplicate records, the librarian must decide which record is of better quality and then, automatically, all item identifiers will be added to that selected record. Also, this tool updates an external file which contains mapping between an old record number and the new one. After the process of merging collections is completed, the record numbers stored in the local LMS must be updated. In LMS BISIS, this process is done automatically on the level of database management.

The problem of merging data and finding duplicate records will also be present when it comes to data import from other libraries to the union catalogue. In that case, the number of duplicate records will be greater, but not significantly. Fortunately, faculty libraries of the University of Novi Sad possess collections that cover specific subjects depending on the faculty library where they are located and, because of that, there will be little overlap among collections. For example, the library of the Faculty of Technical Science possesses only about 1,000 mathematics books (books with the UDC number starting with 51), while the library of the Faculty of Sciences has about 15,000 mathematics books. It is expected that at least 50 per cent of the mathematics books from the library of the Faculty of Technical Science will be found in the collection of the library of the Faculty of Sciences. However, this is still not a large number of duplicate records that must be processed manually. This estimate was calculated for only the

mathematics books, but we expect to get similar results for common topics found in other libraries because the libraries have disparate collections. Most of the faculty libraries also use LMS BISIS and the UNIMARC format, and the experience gained through this pilot project will be useful.

The next challenge that must be addressed is to achieve an agreement and policies among the libraries related to privileges and rights to store and exchange data in the union catalogue. This issue does not relate to the technical aspects of the software and the librarians will be those who must make the final decision. At this moment, the union catalogue system allows any library to update the union catalogue.

Currently, most of the faculty libraries use the UNIMARC format (or some local variation of UNIMARC) for cataloguing and, in this proposed solution for a union catalogue, records are stored in MARC21. This means that the local LMSs must be adjusted to send records to a union catalogue in the MARC21 format. For libraries that use LMS BISIS, this will not be a problem because this LMS supports cataloguing in this format and the librarians made the decision to start cataloguing in MARC21 after a union catalogue is established (Dimić and Surla, 2009). Other libraries may continue using their current format, but that requires conversion of their records into MARC21 before sending records to a union catalogue.

The union catalogue consists of 15 small libraries which have effective and close cooperation and they use similar cataloguing rules so the quality of records should be on a similar level. In the initial phase of using a union catalogue, all members of a union catalogue will have the same privileges regarding adding to and updating records from the union catalogue. The software solution for a union catalogue is designed in such a way that a librarian must decide whether a new record will be created in a central union catalogue or an existing one will be updated. A librarian is responsible for searching the catalogue and verifying that such a publication is not already in the catalogue. This method is error prone, so implementation of a duplicate control mechanism in the future is desirable.

It is uncertain how well this union catalogue solution will work, and the only way it can truly be tested is to release it and wait for responses. Currently, this software works just in the test environment and there is no real measurable results regarding response time, performance issues and so forth. Real measurable results may be expected soon after more libraries join their collections to this union catalogue.

8. Results

The main aim of this paper is to describe a software architecture of a union catalogue that uses a physical catalogue to store bibliographic data and a virtual catalogue to share holdings data. This combination has some benefits.

First, bibliographic records of all libraries are stored in the single physical union catalogue by which better response time, better recall and better precision are achieved. Next, every library that is a member of a union catalogue has its own policy for creating holdings data and user data. This proposed software solution does not require that libraries change their organisation and working policies because holdings data remain in the local LMS.

In addition, software for a union catalogue is based on standard library protocols for communication and enables interoperability with LMSs from different vendors. The only prerequisite for libraries to participate in the union catalogue is that they must use LMSs that have implementation of standard services described in the previous sections. Currently, three different LMSs are in use at the university. If a new library wants to join

the union catalogue or an existing library wants to change their LMS, the software of the union catalogue will remain the same.

This advantage enables easy joining of other libraries into the union catalogue. For example, libraries from private faculties or high schools in Novi Sad could be easily included in the union catalogue, too. Also, this software solution for a union catalogue can be used by any group of libraries that want to create a union catalogue.

Furthermore, the software solution uses the SRU service for searching a union catalogue, which means that any outside system can search the catalogue easily. Other systems, like virtual catalogues at the state level, could use this service as an access point to the union catalogue of the University of Novi Sad. For example, a virtual catalogue of Serbian universities could be one of those systems, if such a catalogue were to exist in the future.

By establishing a union catalogue at the University of Novi Sad, students will have the possibility to search all collections at the university using a single OPAC and easily retrieve information about available books. This union catalogue will be the first step in the realization of direct consortia borrowing at the university level.

9. Conclusion

In this paper, the proposal of the software architecture for a union catalogue of the University of Novi Sad in Serbia is presented. Two different approaches for implementing union catalogues are recognised and we described some examples of union catalogues based on those approaches in this paper. The first approach is based on the federated search where all the collections are organized as a virtual union catalogue, while the second approach is based on the idea of creating one physical union catalogue that will physically contain all the bibliographic records. In this paper, to implement a software solution for the university's union catalogue, we applied a combination of those two approaches. The main idea is to store all bibliographic records in a physical union catalogue, while holdings and users data will be organised in the form of a virtual union catalogue and every library stores its data in their local LMS.

Libraries participating in the university's union catalogue use LMSs from different vendors and, because of that, it is necessary to provide interoperability between a union catalogue and the LMSs of the participating libraries. In the architecture of the university's union catalogue, interoperability is achieved by using standard protocols for the exchange of bibliographic data, such as SRU, SRU Record Update and NCIP. The SRU and SRU Record Update protocols are used for searching and creating records. Those records are stored in the MARC21 format. The NCIP protocol is used to get information about item availability in a particular library.

This software solution enables a centralised search of all the collections of the faculty libraries of the University of Novi Sad, and it presents a base for the realization of direct consortia borrowing. In the future, we are planning to implement support for this process inside the LMS BISIS. Also, by adding some additional functionalities, that would provide ILL, libraries could be able to exchange ISO ILL requests by using the university's union catalogue system.

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