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Professional paper

IMPROVING AND OPTIMIZING PUBLIC LIBRARY SERVICES USING SMART TECHNOLOGIES

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Abstract

The potential application of smart technologies in libraries should be perceived first as a strategy and, secondly as a software solution. The emphasis should be on improving services and strengthening the library's and target groups' relationships. Also, smart technologies should provide better working conditions and optimize business processes. Implementing smart technologies represents a strategic approach to improving library operations, and the main goal is to improve the quality of services provided. The new approach should encourage activities such as promotion of libraries, communication with existing and potential users and maintenance of good business relations with associates and business partners. The implementation of smart technologies shortens the time required for searching and locating publications, monitoring the book collection, and the movement of users through the library. To improve efficiency, it is necessary to carry out a strategic implementation of smart infrastructure in the library environment. Thus, the modern way of communicating with library service users involves using information systems, and technologies and integrating computer and mobile applications.

The paper will present smart technologies that can significantly optimize business processes within the library and improve communication and interaction with users of library services.

Keywords: *smart technologies, library services, integrated library systems (ILS), optimization of business processes*

Introduction

Public libraries play an important role in providing equal access to information, information literacy and lifelong learning for all citizens. Modern trends and technologies are widely present in library activity, and services, such as library web presentation, electronic catalogue, database or access to the digitized library collection, should not represent modernization but should be an integral part of library business. Due to major changes in

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lifestyle and habits, users of library services have less and less time to search the library collection in the library building, so it is necessary to ensure adequate access to the library collection and online resources. The best and most efficient way to enable this is through the library's web presentation and online catalogue for searching the book collection. In this regard, one of the most important processes in the automation of every library is keeping adequate records of the needs and habits of users of library services. In addition, librarians must accept the modernization of the library business not as a danger and threat to their daily activities, but as a necessary way to improve library activity.

Due to the complexity of applying modern technologies, many public libraries have not fully utilized the advantages of library business automation and other technologies offered on the market, primarily due to the costs incurred in the process of implementing and maintaining modern information systems. On the other hand, libraries have the opportunity to take advantage of advanced technologies thanks to the development of mobile and smart technologies. Current technological trends represent great potential for libraries that can optimize library operations by applying smart technologies. By implementing smart technologies in integrated library systems, operations can be significantly improved, even with limited financial resources. The long-term success of the library is only possible if the users are satisfied with the quality of the services provided, and it is necessary to collect information from different sources in real-time and store them in a single database in order to form a unique picture of the users' needs and their habits. It is necessary to use modern technologies and tools such as mobile and smart technologies to obtain relevant information about users to improve communication with them.

Libraries as knowledge hubs

By following international standards and official guidelines, libraries are obliged to provide users of library services with unhindered access to information and to actively participate in the improvement of the services they provide, and they can only achieve this based on their habits and needs. One of the ways to improve the quality of library services is by applying smart technologies in libraries. In particular, to enable users to access the resources and services provided by the library in digital form. Libraries are moving to a new way of executing business processes thanks to the benefits offered by modern technologies. Activities of librarians are now less based on the use of physical objects, such as books, magazines and long library materials, because the focus is increasingly directed towards virtual ones, i.e. digital resources, such as e-books, digital materials, online courses, digital journals, and more [1]. The main operating principle of modern libraries is based on the paradigm that information circulates from the library to the user, but also from the user to the library [2]. Modern libraries become places where librarians and users of library services acquire modern knowledge and skills, formal or informal [3].

Electronic business in libraries

Improving existing and developing new technologies opens up opportunities for libraries of all types and sizes to get closer to users of library services and to improve business processes by implementing these technologies [4]. Optimizing business processes is very important in the process of improving the functioning of modern libraries. To provide better services, the



library must first take into account the characteristics of users' needs that change over time, and then, using available tools, find the best way to satisfy their needs [5]. The modernization of library information systems has undergone several transformations in the last few decades, from systems that could only be used within the institution, through systems that were used via the Internet, to today's systems that are used on mobile devices and those that are used in the "cloud" [6]. Some of these systems are commercial and some are available for free use.

With the development of various technologies and the increase in media capacity, the technique of organizing and searching library material has changed and accelerated. In the last few decades, libraries have been using computers to optimize storage, searching, exchanging catalogue information about library units, finding library materials in remote locations, inventorying, interlibrary loan services, procurement, as well as other actions necessary for the flawless functioning of library services [7]. The interest of libraries in the application of computer technologies stems primarily from the need to improve the process of circulation of library materials, which until the advent of computer systems was based on manual data entry, which resulted in long-term and error-prone record keeping of issued and returned publications [8].

In the second half of the twentieth century, the global network became the basis for the functioning of library services. A library information system has appeared that integrates all the services provided by the library and unites them into one integrated library system. The importance and role of these systems are reflected not only in increasing the efficiency of the work of librarians but also in the establishment of standards that have a significant impact on the further development of library activities [9]. Afterwards, online databases emerged that made it much easier for users to search the book collection [10]. In addition to the aforementioned changes, there were also changes that, thanks to technological progress, greatly facilitated the performance of daily activities, such as acquisition planning, sorting of book materials, digitization, classification of the library collection and others. The newest trend is the implementation of "Big data" technologies into library operations [11].

Implementation of smart technologies in library business

The library business, together with information and communication technologies, is in a period of rapid changes and constant development. The application of models based on smart technologies in library business requires changes in organizational processes, but also a change in business strategy [12]. Smart libraries represent a concept that is inspired by the research of suitable spaces and is a smart space developed in a library environment. Regardless of the wide distribution in the professional literature, the difference between the terms smart and intelligent buildings is still not clearly defined [13]. Smart spaces are defined as environments that support stationary and mobile infrastructure that can connect to the Internet [14]. Smart libraries can also be defined as intelligent environments equipped with a wide range of hardware and software equipment: readers, sensors, cameras, motion detectors and other equipment [15].

In addition to the use of sensors used to regulate temperature, humidity, lighting and other living conditions inside the building, today many examples of the implementation of smart technologies can be found in libraries such as [16] [17]:

- smart cards,
- smart shelves,



- self-service stations,
- systems for automatic sorting of publications,
- monitoring of the book collection using RFID (Radio Frequency IDentification),
- digitization of written material,
- systems for audio/video conferences,
- library virtualization,
- promotional activities etc.

The main goal of implementing smart technologies in libraries is to increase efficiency in working with users, improve services, reduce business costs, and more. Automation and the use of self-service stations can greatly help in achieving the stated goals in libraries of all types and sizes with the involvement of adequate financial resources [18]. In combination with RFID technologies, these services offer additional security in the preservation of publications and other types of media found in the library collection, and at the same time improve circulation and inventory processes, which opens up the possibility of allocation of financial and human resources [19] [20].

This means that librarians get more time to carry out other professional tasks. The key question here is whether the library provides adequate resources to its users. One way to examine this is to compare the number of users who visit the library with the number of publications issued. However, the problem is how to record those publications that are not allowed to be taken out of the library, and no record is kept of their use. That problem can be solved by implementing smart shelf sensors that will register the use of each publication and thus provide more precise insight into the needs of users of library services [21]. Smart technologies can also be applied in other business segments, such as monitoring the movement of users within the library to gain a better insight into the use of space, controlling access to special departments such as special collections and conservation and restoration departments, or controlling free seats in reading rooms.

RFID technologies

Currently, RFID technologies represent the standard in the field of application of information and communication technologies in business, and they find practical application in transport and logistics activities, improvement of productivity and safety [22]. In the initial stages of implementation, RFID technology was primarily used in libraries to prevent the theft of books and non-book materials. Unlike electromechanical and barcode systems, the RFID system does not focus exclusively on the security aspect but is a tracking system that combines security with more efficient tracking of library material throughout the library, including easier and faster loading and unloading of shelves, and management of inventory and other book and non-book materials [23]. It is a combination of technologies based on radio frequencies and microchips. Information contained on microchips in RFID tags attached to library materials is read using radio frequency technology, regardless of the position or alignment of the object (the technology does not require visual contact between the tag and the reader as with barcode technology) and the distance from the tag to the reader is not a critical factor. Security gates at the exit of the building can be up to two meters wide, as the tags can be read at a distance of up to one meter on each side [24].

The RFID system consists of three subsystems (Figure 4):



- An RF subsystem that performs identification and transactions via wireless communication,
- a library subsystem consisting of computers that host applications that store, process and analyze data collected by the RF subsystem (so that this data can be applied in the decision-making process).
- library intranet, which connects all subsystems of the organization for information-sharing purposes [24].

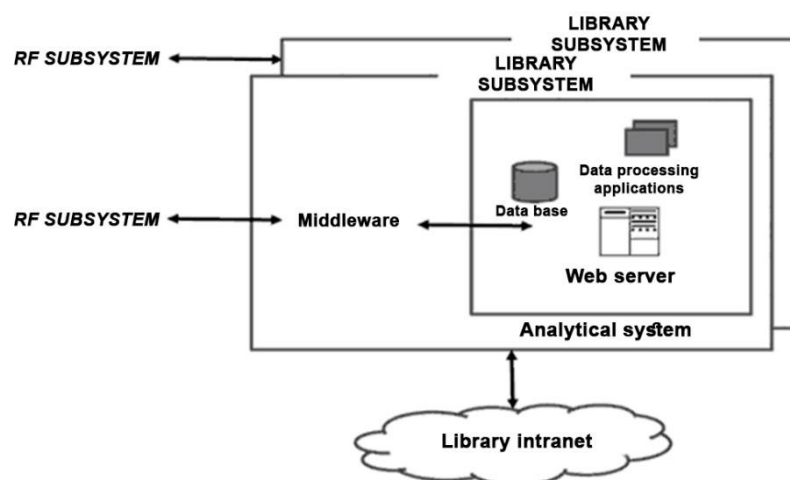


Figure 1: Architecture of the RFID system

In most RFID systems, the RF subsystem is supported by the library subsystem if it consists of middleware, analytical systems and network services [25]. The library subsystem consists of a computer system and programs used to read the data stored on the RFID tag. In addition to the components that manage the readers and antennas, there are intermediary programs that forward the data to the servers that host the databases and applications for their processing [26].

The advantages and features of the RFID system that are characteristic of library business are:

- **Automatic check-in/check-out.** The use of RFID reduces the time required to perform operations in the process of circulation of library materials. The most significant time savings can be attributed to the fact that information can be read from RFID tags much faster than from barcodes and that multiple items from the shelf can be read at the same time. Enables multiple publications to be checked in/checked out with a single scan [24].
- **Easy log-in/log-out.** Users are allowed to log in or out of the system themselves and to charge or return one or more publications at a time, which significantly shortens the entire process.
- **High level of reliability.** RFID tag readers are extremely reliable. Library RFID systems in practice show a high degree of reliability when reading tags. With well-adjusted RFID systems, there are no false warnings, as was the case with bar-code technology, because the system records the publication status on the RFID tag itself. This is achieved by assigning the "theft" bit and depending on the publication status it

is activated and deactivated on the tag itself. If a publication is not properly borrowed or attempted to be stolen, the sensor will register a "theft" bit at the output and activate an alarm to alert the library staff.

- **Quick inventory.** A specific advantage of the RFID system is its reliability when scanning publications on the shelves, without the need to physically touch or move them. A hand-held tag reader can be moved quite quickly along the shelves and thus collect data on all the publications on the shelves. Using wireless technologies, it is possible not only to inventory the publications on the shelves but also to identify publications that do not belong in that location by comparing the current location with the actual location where the publication should be located.
- **Automatic sorting of book material.** Another feature of the RFID system that has proven to be useful in the library business is the ability to automatically sort publications into categories, which makes it much easier to place returned publications on the shelves. This operation requires a sorter that, based on the RFID tag, sends the publication to a specific basket so that employees spend less time on individual placement of publications and finding the appropriate shelf [27].
- **Longevity of tags.** RFID tags last significantly longer than barcodes because they do not need to be touched when scanned, nor do they need to be on the cover of a publication when read.

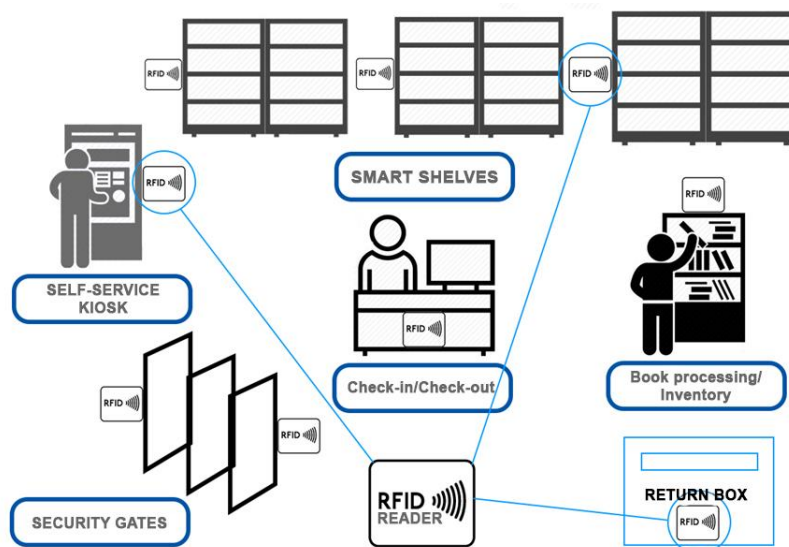


Figure 2: Library services developed using smart technologies

QR technologies

Although the implementation of QR codes is still underutilized in public libraries, their use is increasing as librarians become aware of the potential that QR codes provide in promoting library services and connecting with users. Libraries can use QR codes when creating materials for promotional and marketing activities. Their advantage is that they can be generated in electronic and printed form, and the result is that the printed material acquires a digital dimension. Users who find that the information generated by the QR code may be important to others can share it with friends via mobile device, social media, email or print.



However, one should be careful when choosing a strategy for implementing QR codes because excessive use can lead to users losing interest in using them if the generated content does not meet their expectations or takes too much time [28]. The application of QR codes can contribute to the improvement of relations with clients, but before introducing these technologies into the library environment, it is necessary to check the attitude of users towards new technologies and familiarize them with the possibilities they provide so that the strategy can be adapted to their needs and expectations in time [29].

Some of the advantages of this technology compared to bar-code technology are:

- A QR code occupies a smaller area,
- more information can be placed on the QR code,
- it is compatible with smart devices,
- simple way to create and read content,
- can be read when a piece of code is damaged,
- it can be used for different purposes and on different types of materials (paper, plastic, fabrics or in digital form).



Figure 3: The QR code example

Due to their functionality and mobility, QR codes provide the possibility of connecting physical spaces with electronic resources, facilitating communication and access to information for those who use mobile devices. It can be as simple as using a QR code to connect the user to a specific library service, resource, or information or placing a QR code that connects them to a form for booking seats in the reading room [28].

NFC technologies

This technology represents a form of short-range radiofrequency technologies, wireless communication and contactless smart card technologies. They provide an active reading of data from a distance or close proximity [30]. Communication between two devices can be realized by their mutual contact or by bringing them near each other.

The advantage of NFC technology over QR technology is that QR codes can only be read, while devices that support NFC technologies can receive and send data. NFC devices can operate in three different modes:

- **Reader/Writer mode** - An NFC device can function as both a reader and a transmitter. This mode of operation refers to communication between an active NFC device and a passive NFC tag.
- **Peer-to-peer mode** - in this mode, the devices are connected wirelessly to exchange information in a controlled manner. In addition, the NFC device can be connected to an external resource via the Internet.

- **Emulation mode** - in this mode, a smartphone equipped with NFC technology functions as a contactless smart card. This mode of operation allows the mobile device to be used for identification, payment or access control.

To effectively and innovatively promote library services to users inside and outside the library, it is necessary to apply modern marketing trends. A smart poster stands out as a suitable solution for the realization of the mentioned activities. The smart poster represents a new generation of media for displaying promotional materials. Physically, it still has the visual appearance of a traditional poster, but due to the integrated technologies inside the poster, it has the possibility of interactivity that connects it to the virtual world. Multiple places can be marked on the poster and each one generates different content. Whenever an individual brings an NFC device near the smart poster, the NFC tag transmits data and/or launches an application on the device. In addition to NFC tags, QR codes can be placed on the poster so that users have more ways to access the content. The advantage of using NFC tags is that devices equipped with NFC technology do not require additional software, while a special application needs to be installed to read QR codes. Since not all phones are equipped with NFC technology, a combination of these technologies is recommended.

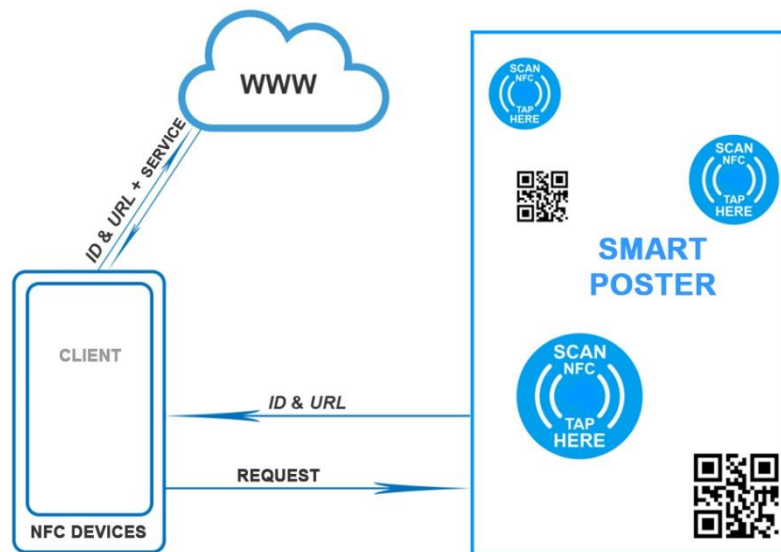


Figure 4: A simplified representation of the smart poster architecture

The smart poster is connected to software and tracks every user interaction with a QR code or NFC tag. Every time the user scans the code or brings the phone closer to the place where the NFC tag is located, the device receives feedback in the form of an identification number and a web address (Figure 4) and then redirects them to the specified web address, after which the web page is opened or service. In addition, the software identifies which poster the user has scanned each time. If the posters are in multiple locations, the library will have a clear insight into the locations and will receive precise data based on which it can measure the success of the campaign in each location and make the necessary corrections.

Mobile technologies



In order to achieve the highest possible quality of library operations, it is necessary to provide systems that will provide users of library services with the requested information and other available resources at any time. By introducing mobile applications into the operations of libraries, they can significantly improve their services and show users, especially younger groups, that they are ready to follow modern trends. Libraries that plan to offer and adapt services for mobile devices must develop applications designed specifically for mobile platforms [31]. First of all, this results from the fact that mobile platforms offer a positive user experience and access to information through fast mobile networks and wireless internet. The marketing value brought by mobile applications for institutions that decide to offer their services through mobile platforms is also not negligible. Libraries should, in cooperation with institutions dealing with the development of mobile applications, investigate their potential application in the library business. Mobile devices can serve as an interface or intermediary in the provision of library services to people who take advantage of them, and this number is not insignificant [32]. Users who want to access library resources and other services from a remote location can be of particular benefit.

Mobile applications can be used to display basic information, such as opening hours, address, phone number, new headlines, news, and most read publications for example. To provide more complex services, say: access to the user account, searching the electronic catalogue and downloading digital content, the integration of mobile technologies with the integrated library system must be carried out. The mobile concept enables communication between the library and clients, from any location and different mobile devices and platforms [33]. Interaction with users via mobile technologies is achieved by using adaptive design when creating the library's web presentation so that the content is displayed correctly on users' mobile devices. Mobile applications developed for different platforms (Android, iOS, Windows, etc.) allow libraries to connect with users who are not physically located in the library. By explaining different practical examples of how to transfer business philosophy into a library King gave an example of the sales policy of a bookstore [35]. Management encouraged employees to take customers to the appropriate section of the bookstore and physically place the book in their hands, thus demonstrating high-quality service. Almost thirty years later, the same philosophy can still be applied, but instead of putting a book in the customer's hands, we could put the book or information in their smart device, since most library patrons use it nowadays.

Conclusion

To provide long-term support, libraries should continuously create and provide services that meet the expectations and realistic needs of users of library services. Instead of measuring the number of visits or the number of publications issued, public libraries should focus on measuring user satisfaction, examining the quality of the services they provide and the impact these services have on the community. These activities can only be achieved through the effective implementation of advanced technologies in the daily operations of the library. By automating certain or most daily library activities, librarians would have more time to devote to the needs of users, and users would in return receive complete information and better quality service. In order to achieve this, libraries should apply new business models, which are mostly based on the use of modern business strategies and information technologies.



Trends indicate that the new generation of integrated library systems, based on SaaS (Software as a service) technologies, will initiate a new migration of ILS systems and experts call them "platforms for library services". In essence, the predictions are that in the future, libraries will lease integrated library systems over the Internet or on an as-needed basis, in which case they will not need expensive infrastructure or technical staff. In the future, smart technologies will be an indispensable part of public libraries day to day operations.

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References

- [1] Seal, R. A. (2015). Library spaces in the 21st century Meeting the challenges of user needs for information, technology, and expertise. *Library Management*, Vol. 36 No. 8/9, pp. 558-569.
- [2] Scherer, M., & Sidhom, S. (2011). Progress of concepts and processes in library information system: towards Library 2.0. *Information Systems and Economic Intelligence* (SIIE'2011): 4th edition, 2011, pp. 123-130.
- [3] Moorefield-Lang, H. M. (2014). Makers in the library: case studies of 3D printers and maker spaces in library settings, *Library Hi Tech*, Vol. 32 No. 4, pp. 583-593.
- [4] Herson, P., Altman, E., & Dugan, R. E. (2015). *Assessing Service Quality: Satisfying the Expectations of Library Customers*, ALA. Chicago, IL)
- [5] Nitecki, A. D., Wiggins, J., & Turner, N. B. (2015). Assessment is not enough for libraries to be valued. *Performance Measurement and Metrics*, Vol. 16 No. 3, pp. 197-210.
- [6] Yuvaraj, M. (2016). Library automation with cloud-based ILMS Librarika: a case study of Central University of South Bihar. *Library Hi Tech News*, Vol. 33 No. 7, pp.13-17.
- [7] Bahri, S., & Ibrahim, A. (2013). RFID in libraries: a case study on implementation. *Library Hi Tech News*, Vol. 30 No. 5, pp. 21-26.
- [8] Kinner, L., & Rigda, C. (2009). The Integrated Library System: From Daring to Dinosaur? *Journal of Library Administration*, Vol. 49 No. 4, pp. 401-417.
- [9] McDonald, J. D., & Levine-Clark M. (2017). *Encyclopedia of Library and Information Sciences*, 4th Edition, CRC Press.
- [10] Feather, J., & Sturges, P. (2003). *International Encyclopedia of Information and Library Science*. 2nd Ed, Routledge, London, New York.
- [11] Simović, A. (2018), "A Big Data Smart Library Recommender System for an Educational Institution", *Library Hi Tech*, Vol. 36 No. 3, pp. 498-523. <https://doi.org/10.1108/LHT-06-2017-0131>.
- [12] Wójcik, M. (2016). Internet of Things – potential for libraries. *Library Hi Tech*, Vol. 34 No. 2, pp. 404-420.
- [13] Buckman, A. H., Mayfield, M., & Beck, S. B. M. (2014). What is a Smart Building? *Smart and Sustainable Built Environment*, Vol. 3 Issue: 2, pp.92-109.



- [14] Rosenthal L., & Stanford V. (2009). NIST Smart Space: Pervasive Computing Initiative, *National Institute of Standards and Technology Information Technology Laboratory*.
- [15] Min, B. W. (2012). Improvement of an Integrated Management System for Smart Libraries Based on SaaS. *International Journal of Software Engineering and Its Applications*, Vol. 6 No. 4, pp. 223-246.
- [16] Hong, Q. (2009). The Analysis of RFID Technology Applying in Libraries. *Journal of Modern Information*, Vol. 6, pp. 130-132.
- [17] Coyle, K. (2005). Management of RFID in libraries. *The Journal of Academic Librarianship*, Vol. 31, pp. 486-489.
- [18] Bradley, J., Henshaw, N., McVoy, L., French, A., Gilbertson, K., Becksford, L., & Givens, E. (2016). Creation of a Library Tour Application for Mobile Equipment using iBeacon Technology. *Code4Lib Journal*, Vol. 32.
- [19] Ong, I., Goh, C., Chua, L., & Pak, P. (2014). Empowering the Library Patron: The Public Libraries of Singapore's experience with transactional services delivered through a mobile application. *Confluence for Knowledge in Session 210 - Information Technology*. IFLA WLIC 2014, Lyon, France.
- [20] Boss, R. W. (2003). RFID technology for libraries. *Library Technology Reports*. November-December 2003.
- [21] Wu, S. I., & Hung, J. M. (2008). A performance evaluation model of CRM on non-profit organizations. *Total Quality Management & Business Excellence*, Vol. 19 No. 4, pp.
- [22] Khor, J. H., Ismail, W., Rashid, M. N., Ismail, A. A. W., Omar, M. Q., & Zanal, F. H. M. (2015). UHF RFID proof of concept (POC) with open-source ILS at University Sains Malaysia (USM). *Libraries. Program*, Vol. 49 No. 2. pp. 135-150.
- [23] Alwadi, A., Kilby, J., & Gawanmeh, A. (2017). Tracking and automating a library system using Radio Frequency Identification Technology. *International Journal on Smart Sensing and Intelligent Systems*, Vol. 10, No. 2, pp. 425-450.
- [24] Edwards, S., & Fortune, M. (2008). A Guide to RFID in Libraries. *Book Industry Communication*, 2008.
- [25] Younis, M. I. (2012). SLMS: a smart library management system based on an RFID technology. *International Journal of Reasoning-based Intelligent Systems*, Vol. 4 No. 4, pp.186-191.
- [26] Butters, A. (2008). New RFID Technologies & Standards – What Does it Mean for Your Library? Paper Presented in VALA Conference 2008.
- [27] Howard, L., & Anderson, M. (2007). RFID technology in the library environment. *Georgia Library Quarterly Spring*, pp: 17-20.
- [28] Mallon, M. (2011). Info on the Go: Using QR Codes to Enhance the Research Experience. Brick and Click Library Symposium (2011).
- [29] Schultz, M. K. (2013). A case study on the appropriateness of using quick response (QR) codes in libraries and museums. *Library and Information Science Research*, Vol. 35, No. 3, pp. 207-215.
- [30] Liao, P. K., & Shieh, J. C. (2015). The Development of a Library Mobile Book-Finding System Based on NFC. IIAI 4th International Congress on Advanced Applied Informatics, Okayama, pp. 148-153.
- [31] Canuel, P., & Crichton, C. (2015). Leveraging apps for research and learning: a survey of Canadian academic libraries. *Library Hi Tech*, Vol. 33 Ho. 1, pp. 2-14.



- [32] Breeding, M. (2014). Library technology forecast for 2015 and beyond. *Computers in Libraries*, Vol. 34 No. 10, pp. 22-24.
- [33] Kerr, A., & Rasmussen Pennington, D. (2018). Public library mobile apps in Scotland: views from the local authorities and the public. *Library Hi Tech*, Vol. 36 No. 2.
- [34] King, D. (1996). Transferring corporate service philosophy to a library setting. *LIBRES: Library and Information Science Research Electronic Journal*, ISSN 1058-6768, Vol. 6 No. 1/2.