

IMPLEMENTATION OF RFID TECHNOLOGY IN LIBRARY SYSTEMS

Case Study: Turku City Library

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Case Study: Turku City Library

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ABSTRACT

Library management plays a key role in patron satisfaction. RFID technology can effectively improve the selfservice and the collection management, which correspondingly leads to improving the patrons' satisfaction with using the library.

This thesis focuses on introducing RFID technology and the benefits gained from using the technology by looking into each work process in the case library. Though a new technology can offer new features and benefits, it's not always clear to see if these benefits are substantial enough so that investing money in it can be judged wise. Thus the needs of actually investing in this technology are also discussed.

A case study is conducted in a library to gain better understanding of how RFID based library management works and a SWOT analysis is used for gaining a better picture of the current situation in the library. Then the survey is conducted to find out whether RFID technology offers any actual value for the library patrons.

Lastly, the conclusions are drawn based on SWOT analysis and the survey result, and the thesis will end with expectations for further development of RFID technology in the case library.

Keywords: RFID, library management, Turku City Library, Helsinki City Library

ABBREVIATIONS

AFI	Application Family Identifier
EAS	Electronic Article Surveillance
EEPROM	Electrically Erasable Programmable Read-Only Memory
EM	Electromagnetic
HCL	Helsinki City Library
HF	High Frequency
LF	Low Frequency
LMS	Library Management System
PIN	Personal Identification Number
RFID	Radio Frequency Identification
R&D	Research and Development
SWOT	Strengths, Weaknesses, Opportunities and Threats
TCL	Turku City Library
UHF	Ultra High Frequency
UID	Unique Identifier/Identification

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1 INTRODUCTION

1.1 Objectives

Library management includes areas such as borrowing and returning of books, classification of materials, cataloguing and barcoding. Many of these areas, including the aforementioned, have direct effects on customer satisfaction. As an example, even in small libraries, where the collection size is small, items can often be misplaced which can cause discontent in patrons.

RFID technology had its first commercial applications introduced in the late 1980's. Since then technologies in different fields have advanced causing the cost of RFID tags and readers to go down, thus making it available to a broader market. For example, libraries have slowly started to adopt this technology as RFID tags have become cheaper.

The goal of this thesis is to find out whether RFID technology offers any significant benefits for library management and how do these benefits reflect to customer satisfaction. Also, in order for a library to get the best possible benefit from using RFID they need to take into account certain factors well before making any investment decisions. These factors will also be discussed about.

1.2 Structure of Thesis

The thesis starts by looking into the theoretical background introduction of RFID technology such as the components and work principles; features compared with barcode; standards and the privacy issues.

Then, the current traditional barcode based library is overviewed, as barcode based libraries especially in bigger sized ones, the traditional way of managing the collection cannot meet the increasing patrons satisfaction, thus it comes up with a need to implement new technology to improve the library management and services. The needs of actual using RFID technology in the library are discussed to see whether these benefits are substantial enough so that investing money in it can be judged wise.

Next, report on a case study concerning the application of RFID technology in library systems in Turku City Library. The paper leads you to see through the whole work process by the use of RFID in the case library. And then SWOT method is applied to formulate the current situation of case library.

Following by, a small sampling survey questionnaire is conducted and aim of comparing from two libraries, Helsinki City Library with barcode based and Turku City library with RFID based to find out if the RFID change the patron's satisfaction of using library. And then the statistical result is analyzed through cross-case analysis method.

In the final chapter, the conclusion from SWOT analysis and the survey result are drawn and the chapter ends with the expectations for further developing RFID technology in the case library.

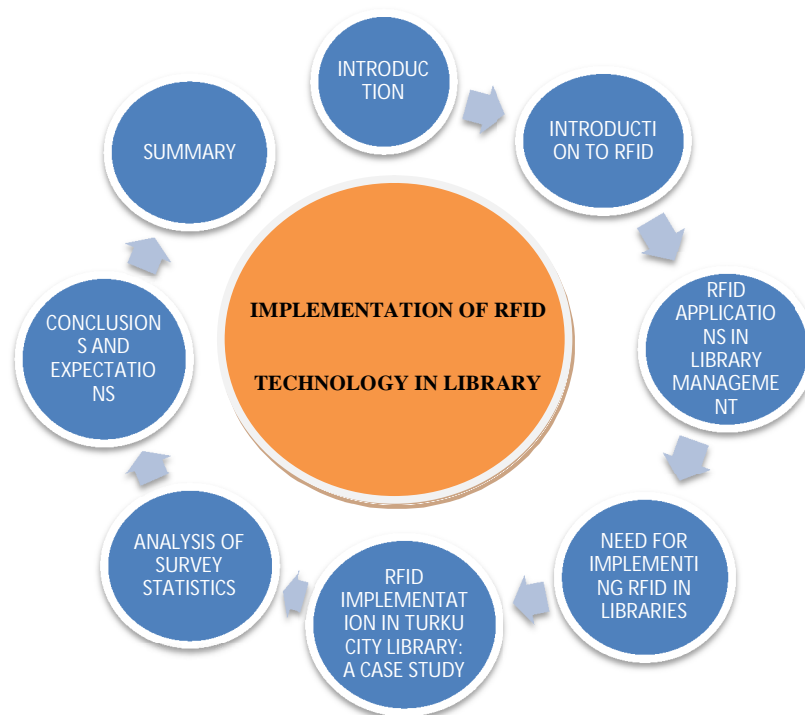


Figure 1: Structure of Thesis

1.3 Research Methods

Qualitative research method and quantitative research method are both used in this paper.

Qualitative research method is used to collect information for the case study, and the information collected mostly based on the interview to an information specialist in Turku City Library. By looking into the whole library work process and services in the

case library, the new features and the benefits of RFID bring to the library are represented.

In addition, as to the quantitative research method, 60 library patrons are selected in total with convenient sampling method to the survey questionnaire in two libraries. The purpose of the survey is to compare from two libraries, Helsinki City Library with barcode based and Turku City library with RFID based to find out if the RFID change the patron's satisfaction of using library. And the statistical result will then analyzed through cross-case analysis.

The topic of this study is 'Implementation of RFID Technology in Library Systems', And the primary research question is to find out if the RFID change the patron's satisfaction of using library compared to barcode based library system.

This thesis starts by first introducing RFID technology on a theoretical level after which it goes into analyzing the problems associated with barcode based libraries while also pointing out the need to use RFID technology. In this part, information was gathered based on the literatures and theories.

In the case section of this thesis, work process of using RFID technology indicate the obvious profits RFID brings to the case library, and the information collected in this part is based on the interview to a library information specialist. And then the SWOT method is applied to formulate the current situation of the case library.

Finally, a quantitative survey questionnaire is conducted to two libraries to find out if the RFID change the patron's satisfaction of using library. And then the statistical result is analyzed through cross-case analysis method. And after that, the conclusion from SWOT analysis and the survey result are drawn and the final chapter ends with expectations for further developing RFID technology in the case library.

2 INTRODUCTION TO RFID TECHNOLOGY

RFID technology is a new technology to the business today and still in its developing stage. This technology is used to describe a system that transmits the identity of an object using radio waves. And compare to barcode, each RFID label has one and only one UID code globally. (RFID Journal LLC, 2005)

This chapter is based on the literature review, starts with the background introduction of RFID technology by viewing its history. Then, the components of the technology are introduced and how RFID works is described. Next, the differences between RFID technology and the traditional barcode are compared through representing their features. Finally, the Issues of security, privacy of using RFID and its standards are discussed.

2.1 RFID history

Although RFID technology in recent years is getting more and more attention, it is not a new invention. The history of RFID can be traced back to World War II (1940s). It was used to distinguish enemy aircraft from our aircraft. People rarely speak of Radio Frequency Identification in the 40 years since World War II. Until 1991, Texas Instruments Incorporated applied RFID technology to animal husbandry. In 1999, Massachusetts Institute of Technology began to study how to benefit wholesalers from technology. Since then, the range of RFID applications has become an increasingly widespread. (Mark Roberti, 2002-2011) Radio frequency identification has been around for decades and its development can be divided into 10-year periods as follows:

Table 1 - the decades of RFID (Landt, J. 2005)

The Decades of RFID	
Decade	Event
1940–1950	Radar refined and used, major World War II development effort. RFID invented in 1948.
1950–1960	Early explorations of RFID technology, laboratory experiments.
1960–1970	Development of the theory of RFID. Start of applications field trials.
1970–1980	Explosion of RFID development. Tests of RFID accelerate. Very early adopter implementations of RFID.
1980–1990	Commercial applications of RFID enter mainstream.
1990–2000	Emergence of standards. RFID widely deployed. RFID becomes a part of everyday life.
2000-	RFID explosion continues

2.2 RFID components and the principle of operation

A basic RFID system consists of three modules: Tags, Readers and Antennas. An RFID Tag is made up of a coupling element and a chip; each tag has a unique electronic code, attached to the object used to identify the target. RFID readers are devices that are used to retrieve and write the information on RFID tags. There are handheld readers and fixed readers. Handheld readers designed that act like handheld bar code scanners and fixed readers are mounted to read tags automatically as items pass nearby them. The antenna emits radio signals to activate the tag and to read and write data to it. (Wang Guang Hui, 2008, 6)

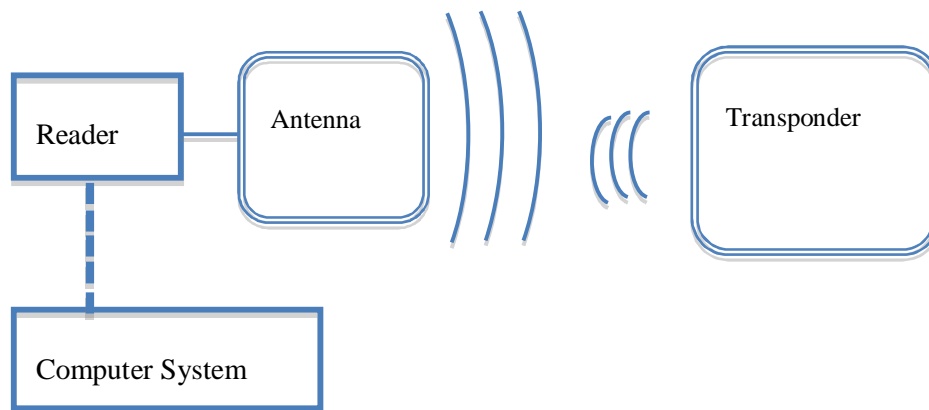


Figure 2 RFID connectivity (R. Moroz Ltd, 2004)

As it can be seen from figure 1, a reader transfers energy to the transponder by emitting electromagnetic waves through air. A transponder uses RF energy to charge up and as well as receives data signal and responds accordingly. The reader receives transponder response and sends to a host computer or or external devices through its control lines. (R. Moroz Ltd. 2004)

In practical applications of using RFID technology, a tag is attached to an object used to identify the target, when the target object pass through the area that the reader can read, the tag and the reader builds up the radio signal connections, the tag sends its information to the reader, such as unique code and other data stored on, the reader receives those information and decodes them, and then sends to a host computer so as to complete the whole information processing.

2.3 RFID and Barcode

The Barcode Recognition Technology is not new to the library. But RFID technology may still be unfamiliar to most people in this field though its application in certain areas is widely used.

The biggest difference between Barcode and RFID is that bar coding scans a printed label with optical laser to identify the object whereas RFID interrogates a tag using radio frequency signals. (ZEBRA technologies)

Applying RFID technology in a library, a micro-chip will be embedded into the items. Micro-chip will automatically send data such as serial number to the scanner, which will not require as much manual scanning as in the bar code technology. In contrast, RFID can reduce the production costs and improve retail efficiency, hence more and more people think that RFID technology will be a replacement for bar code technology. More comparison of the features of RFID and Barcode can be seen in the following table: (Wang Guang Hui, 2008, 7)

Table 2- RFID vs. Barcodes

	RFID vs. Barcodes	
	RFID	Barcodes
Data Stored	EEPROM	Paper
Line of sight requirement	Not Required	Required
Tag's Capabilities	Read/Write Capable	Read Only
Number of items that can be scanned	Multiple	One
Reusable	Yes	No
Durability	High	Low
Harsh Environment	Yes	No
Event Triggering	Capable	Not capable
Security	High	Low
ISO Standard	Incomplete	Yes
Cost of Tag	Expensive	Inexpensive

2.4 The Issues of Security and Privacy

RFID data security means protecting the data on the tag and the data transmitted between the tag and the reader to ensure it is accurate and safe from unauthorized access. RFID tag can be read from a long distance and its contents can be read by anyone with an appropriately equipped scanner, because RFID tags cannot tell the differences between one reader to another. (Mr Tan Jin Soon, Dr Li Tieyan, 2008)

Assume that a third party intercepted a message between tag T72 and the reader E8, and assume also that the third party can determine that the message was "788A54B68" but can't know what this message means. It would be considered as a breach of security. Furthermore, if the tag T72 was affixed to an article purchased by Lisa with its contents "Item: Prescription Drug; Brand: PharCo; Drug: Cancergone; ProdDate:

1/1/200”, then the intercepting party would know that Lisa just purchased a drug to treat cancer. It would be considered as a breach of privacy. (Banks, J., Pachano, M., Thompson, L. & Hanny, D. 2007)

2.5 Regulation and Standardization

At present, RFID has not formed the unified globalized standard, the market has coexistence of multiple standards, and three representative standards include: Europe’s and America’s EPC Global, Japan’s Ubiquitous ID Center and ISO/IEC18000. Different standards made significant differences in wireless frequencies bands and data formats etc, and resulted in incompatibility of products from various manufacturers. This has brought difficulties to the widespread application of RFID and created the enormous hindrance for RFID products to be intercommunicated and developed in the use of the library. (Wikipedia, 2010)

Every country can set its own standards for the frequencies used for RFID (Wikipedia, 2010). There are typically 4 RFID frequencies bands used today as you can see from table 3

Table 3: RFID 4 key frequencies (Finnish Libraries' RFID Working Group, 2005, 39)

RFID Frequencies		
Type	Allowable Frequency	Description
Low Frequency (LF)	125-134 KHz	Is mostly considered for specific applications although its deployment is global
High Frequency (HF)	13.56MHz	Is widely deployed and very suitable for library application since they have longer read ranges, about 3 to 5 feet
Ultra High Frequency (UHF)	860-960MHz	Cannot be used globally as there is no single global standard
Micro Wave Frequency	2.45GHz	Is more globally available than UHF

In brief, different frequencies are used and different powers are applied causes the different ways of processing the signal.

3 NEED FOR IMPLEMENTING RFID TECHNOLOGY IN LIBRARY MANAGEMENT SYSTEM

3.1 Overview of barcode based library systems

Use of barcodes in library management is still very common. Each item in a library is labeled with a barcode which is used for circulation management. This type of management system always requires a line-of-sight, meaning that when items are borrowed and returned, each item needs to be processed separately. As barcodes are nothing more than 2d-images other means are needed for security measures. This is where electro magnetic (EM) tags come into play. These tags work by creating an electromagnetic field to which the security gate system will react to when an active tag comes close enough to the gate. This is why when an item is borrowed the tag is de-sensitized and when returned the tag is activated again. Barcodes do not offer any benefits for collection management. Even though check-in units can be barcode based the returned items still need to be sorted by hand before returning them back to their shelves. It can be said that the defining characteristic of barcode based library management is the lack of efficiency. (Wikipedia, 2011)

3.2 Values of Using RFID technology in libraries

In libraries there are tasks, such as check-in and check-out, that can be further automated by use of this technology. This will enable better allocation of workforce and funds when library staff can concentrate better e.g in customer service instead of spending their time on mundane tasks. By keeping this in mind, it is clear that the main values of RFID based systems lie in better efficiency, which in turn leads to

reduced costs. Then, in what ways does RFID help to increase efficiency? (Pandian, 2010, 50)

Though selfservice check-in units can also be based on barcodes, RFID offers better functionality. RFID readers can recognize several books at once where as with barcodes each book needs to be read separately. By installing a separate sorting machine, which will read the tag information from the returned items and sort them into corresponding carts, it is possible to make the check-in unit even smarter. This will save time as the library staff can straight deliver the books back to their shelves without first spending time on sorting the items. With RFID it is also possible to make it so that the library patrons return their items straight back to the shelves by themselves instead of using the selfservice check-in unit. Of course this method works best if a patron only has a few items to return. (Pandian, 2010, 50-51)

Missplaced and missing items are very common problem in libraries. This is also an issues where RFID can be used to make things easier. By using handheld readers a librarian can easily check if a shelf has missing or missplaced items, thus making controlling the inventory much quicker. This could also be made so that the shelves themself contain a RFID reader which will automatically update the information to the staff. This way it becomes possible to quickly check the state of each shelf from the computer without having the need to separately check every shelf. (Pandian, 2010, 51)

With barcode based systems, when a new book arrives to a library it needs to be labeled with a barcode and also with an electromagnetic tag that is used for anti-theft purposes. On the other hand, a single RFID tag can be utilized for both circulation management and for anti-theft purposes. This makes processing new books and

making them ready for circulation much faster. Thus, RFID also makes security more efficient. (Pandian, 2010, 50)

3.3 RFID applied situations in the world library

RFID system applied in a library has more than 10 years of history. The first application of radio frequency identification technology was fully deployed in Bukit Batok Community Library in Singapore in 1998, afterward e.g. the United States, Australia, the Netherlands, Malaysia (in this order), started using this technology to construct the automated library system. According to the Checkpoint statistics, over 440 libraries worldwide used of RFID technology as of 2005, and this figure rose to 2,000 in 2007 and 3,000 by the end of 2009. Moreover, the speed of growth for those worldwide large libraries using RFID technology is at 30% of annual rate. (Zhou Wenhao, 2008, 2)

3.4 RFID Standards in Library

Finnish Data Model sets the national standard and regulations for Finland. HF band are now widely adopted for library applications in Finland. The benefits of HF for the library application are:

- Excellent immunity to environmental noise and electrical interference
- Reliability of bulk tag reading, of tags in various orientations
- Unaffected by human body shielding, making it the most suitable for EAS security functionality
- Small tag size

- Appropriate Reading range
- Low cost tags and readers
- Easier for Global applications due to harmonized regulatory environment
- Ideal for item-level tracking
- Supported by many suppliers of RFID tags and readers

(Finnish Libraries' RFID Working Group, 2005)

3.5 Challenges of using RFID in libraries

It's become clear that RFID offers many benefits in library use but every technology has its problems. From patrons point of view the most troubling one is the privacy issue. Though a RFID tag doesn't contain any personal information the tag itself makes "tracking" and "hot listing" possible. Tracking, as the name implies, means tracking the movements of a RFID embedded item by using tag readers. This coupled with "hot listing", a way to create a database of items and their corresponding tag identification numbers, creates a rather serious privacy issue. (Pandian, 2010, p.70)

When viewed from the financial point the greatest obstacle is the cost. Though costs are coming down, the cost of an RFID based library management system is still more than a system based on barcodes and electromagnetic tags. As the amount of money needed to update to RFID is high there is uncertainty whether the return on investment is high enough to cover the costs. (Pandian, 2010 p.70)

Though RFID makes implementing security measures easier when compared to electromagnetic tags there are issues that undermine this benefit. Depending on the strength of a RFID reader it is possible to either greatly hinder or completely block the

tag signal by wrapping an item, embedded with a RFID tag, with several layers of aluminum or tin foil. This, combined with the not always so well performing gate sensors, makes risk of items getting stolen quite high. Also if the RFID tags are not embedded inside the book covers it is easy to just remove them.remove the tag.

(Pandian, 2010, p.70)

4 RFID IMPLEMENTATION IN TURKU CITY LIBRARY: A CASE STUDY

The case study is conducted in Turku City Library and the information is collected from the interview.

The purpose of the case study is to gain better understanding of how RFID based library management works and a SWOT analysis is then used for gaining a better picture of the current situation in the library.

4.1 Library Background Introduction

Turku Main Library includes the new library building built in 2007 and the old library building built in 1903, and as well as the former governor's office from 1818, which now houses the library's conference rooms and café. (Turku City Library, 2010) It has 150-170 employees with 14 branches libraries and 2 mobile libraries. By 2007, there are approximately 1 million collections, 2 million visits and 3 million loans. (Turku City Library, 2011, 2-3)

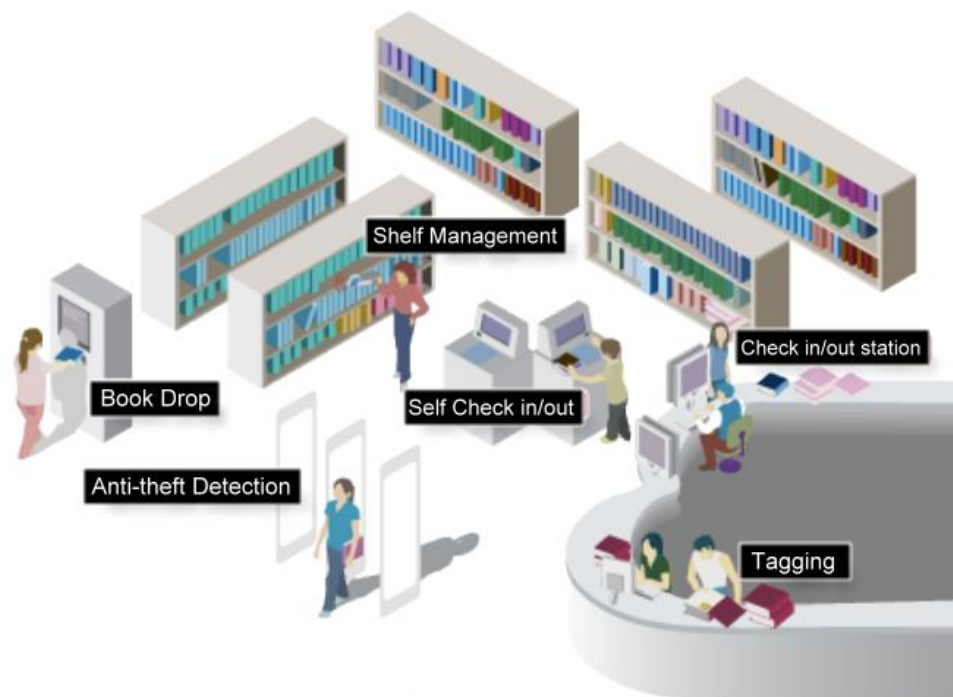


Figure 3 Library RFID Management Systems (LibBest, 2007-2010)

As it can be seen from Figure 3, RFID technology is involved in various modules in libraries. Such as Tagging station to tag the RFID label to each library material; patrons self check-out station to borrow the books using the self service; book drop station is used to return the books; and anti-theft security gates ensure the items are checked-out before leaving the library by detecting if the RFID label that are attached in the item is activated; and finally as to the self management, for example patrons can track the searching items that were mis-shelved by the use of RFID handheld reader.

The main library adopts RFID technology aim of improving the selfservice. Patrons can borrow and return the items using automatic lending machines, which require a library card and a PIN. Selfservice becomes much easier with this new technology as it does not require line of sight and max. 3 items can be borrowed at a time. So far, the frequency of selfservice is nearly 100% (Valikainen, 2010).

Besides, sorting the returned books greatly reduces the library staffs manual work. As RFID label has anti-theft function, there is no need for an extra alarm strip to be attached to the item, which makes the borrowing and tagging tasks a lot easier accordingly.

4.2 Introduction to Hardware Products

In this section, the hardware products based on RFID technology used in the library will be introduced.

1) RFID Tags

RFID tags allow materials to be accurately identified and tracked. Specific object information is stored in the memory of tags and is accessed via the radio signal of RFID readers.

All materials in Turku City Library are attached with 3MTM RFID tags provided by Top Tunniste Oy, Finland. Tag model D7 is used for books, periodicals and videos, and tags model CD8 are applied to CDs and DVDs.



Figure 4 RFID TAGS

2) Table Readers

Table readers in libraries are mainly used for check-in/checkout units to achieve the fast and efficient reading functions. RFID table readers can read library cards through barcode or RFID chip, and it is possible to read max. 3 items at the same time within a range of 54.5cm length and 30cm width on the table reader. Top Tunniste Oy provides the system with High Frequency 13.56 MHZ domain and Ab AXIELL Kirjastot Oy provides its interface.



Figure 5 Table Reader

3) Staff Station Readers

Staff station readers check if the item has already RFID tag attached or not before connecting it to the system. RFID staff station readers are mainly used for cataloging module.



Figure 6 Staff Station Reader

4) Handheld Readers

25 handheld readers are applied with High Frequency 13.56 MHz domain, which is provided by Top Tunniste Oy, Finland. The handheld device is light and its reading speed is fast and there is no angle restriction while reading. However, the reading distances are small, only one item can be read per time. Besides, misreading or disable reading can't be 100% avoided. Handheld readers are mainly used for shelving in libraries.



Figure 7 Handheld Reader

5) RFID Security Gates

RFID Security gates are used to detect RFID tags to ensure that all items leaving the library are checked out. Each library item is embedded in a RFID tag and the AFI (Application Family Identifier) status in the tag is activated until the item is checked out. The RFID tag triggers the alarm system if the AFI status is not deactivated. However, RFID readers may not be able to detect items if there are metals surrounded or tags embedded in items are been squeezing when passing by the security gate.

Mikroväylä is the provider of the security gate units, which can detect the RFID tags within one-meter range without interference of magnetic items.



Figure 8 Security Gate

4.3 Introduction to RFID Modules

In this section, the application of RFID in the case library will be introduced in each module.

1) RFID Tagging Station

A tagging station consists of a network PC, reader and antenna. All library materials must be tagged and programmed and the tagging station is used to affix the tags to the materials and program them.

As the system is now still barcode based in Turku City Library, thus RFID tagged items must connect to the system through barcode. To build the connections, first the staff station reader checks if the item that are on it has already

RFID tag attached or not, and if it doesn't, attach it first, then the system will formulate the connection by using handheld reader to scan the item's barcode. After that, information can be added into RFID label using the system. And one RFID label can be used for only one item, so if the barcode destroyed, RFID label needs to be changed too.

However, the library is planning to change the system from the barcode based to RFID based, which will achieve the inventory and localization functions in the near future.

2) Patron Self-Check-out Stations

The Self-check-out unit greatly improves customer service and increases operational efficiency while providing a strategic competitive advantage (ECR Software, 2010). The patron Self Check-out unit benefits both patrons and the librarian. To patrons, it reduces their time for waiting lines and provides them privacy. To librarian, they can be relieved from heavy work of daily routine so as to better service patrons.

The Patron Self Check-out Station consists of a PC with a touch screen monitor, a built-in RFID reader, and completes with a receipt printer. The systems interface is provided by Ab AXIELL Kirjastot Oy, Finland.

RFID Self Check-out unit has its own features as listed following:

- Dual Function as identifying both RFID and Barcode library card. RFID library card can be read in any orientation and any side up as long as it is in the reading area (54.5cm length, 30cm width) where as Barcode based library card can be only recognized by directing a beam of light across the bar code.
- Intellectualized recognition: items can be read in the reading area. Max. 3 items can be read at the same time and in any orientation.
- Ease of Use: the interface of self-checkout systems is simple, visualized and easy to use. It guides the patron step-by-step to borrow the item individually and speedy.
- Reusable labels: labels are embedded in the items can be re-written for over 100,000 times, which improves the work efficiency and saves costs for the library. After the patrons complete the borrowing processes, a receipt will be printed, the receipt information includes item name, borrowing date, returning date and so on.

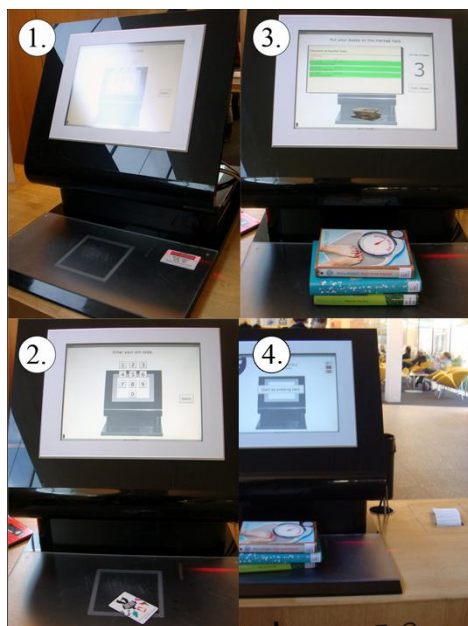


Figure 9 Patron self-checkout Processes

The Self-check-out unit is easy to use as shown in Figure 9. Firstly, the patron chooses one service language from the touch screen monitor, and then the patron will be identified with a library card and its PIN code. After identified, the patron can place items to be borrowed on the reading table, and then the monitor shows the items status, borrowed or not. Once items are successfully borrowed, the receipt will be printed.

However, the patron can always asks help from the librarian if they need guidance to get started of using the checkout unit or if some items cannot be read for some reason.

Data flow diagram, as shown following in Figure 10, presents the whole self-checkout processes:

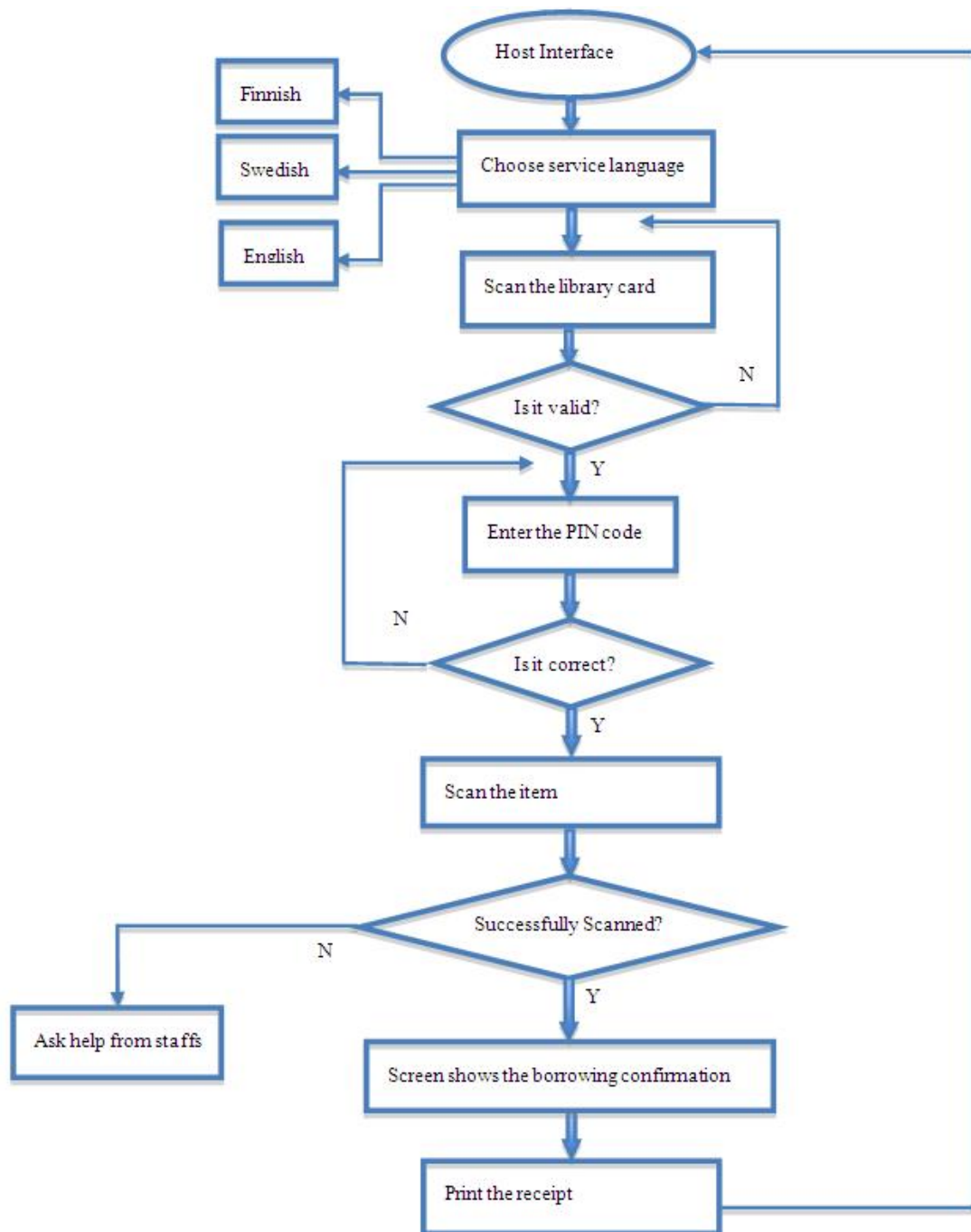


Figure 10 Self-checkout dataflow diagrams

2.1) Children's Check-out Units

Mikroväylä Company provides a special design for children's checkout unit.

Visualized interfaces with sound are the features to attract children to checkout items by themselves.

Children's Checkout unit works basically the same way as the Patron Self-Check-out Unit as discussed earlier. However, it is a lot easier to use, as the user is not required to enter the PIN code when identifying the library card.

However, all library cardholders are allowed to use those children's checkout units without requiring the PIN code. Thus, in the future, it changes so that age only under 18 years old patrons can checkout without password.



Figure 11 Children's Self-Checkout Unit

3) Self Service Check-in Station

ATP Automation Ltd Oy is the supplier of the check-in systems. Check-in station consists of a PC with a touch screen monitor, a built-in RFID reader, and completes with sorters.



Figure 12 Check-in Station

The self-service check-in process basically works same as the self-service checkout process, but a lot simpler as identifying the library card step is not required. Items are reactivated security when returned and the returned information is showned in computer screen and receipt can be then optional printed.

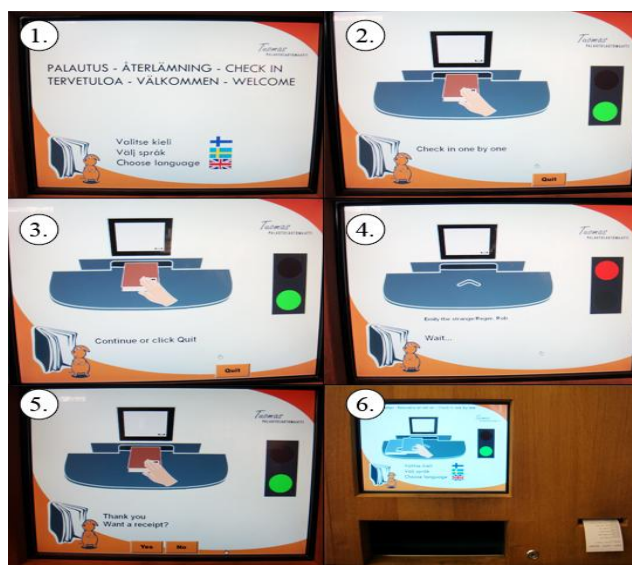


Figure 13 Interface of Check-in Unit

However, if the returned item is improper, the check in station will reject it and return it back to the patron.

Once items are returned, a digital sort conveyor belt can place them in appropriate bins from where staff can place them in their correct shelves (RFID4u, 2005, 6). There are 16 units for sorting the material and different classified material goes to different book bin. Book bins are classified as fiction, non-fiction, children, magazines, items that are reserved etc.

The book bins are smart in a way that there is an alarm system, which informs the staff when a bin is 80% and 100% full. The bins are linked to a system where the computer monitors the check-in information and displays the information in a list. When for example bin #1 is almost full the computer will inform the staff about it and they can press the blue button (figure 14) to stop the processing while they replace the full bin with an empty one. After the bin is changed the staff will press the green button and the processing will continue.

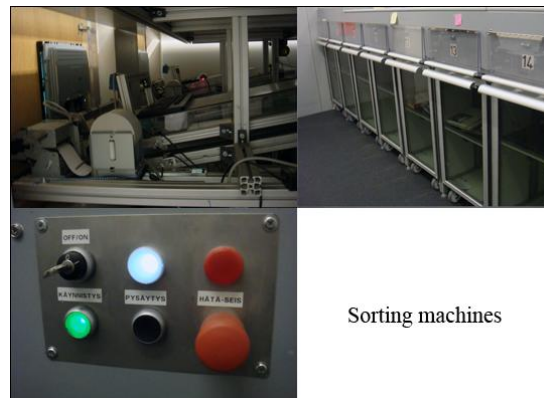


Figure 14 Sorters

As Turku City Library has two buildings - old and new, patrons can return the items to either building. The transportation system allows the items to be transported between two buildings, and the visible areas on the floor presents the transportation process to patrons as you can see from the figure 15.

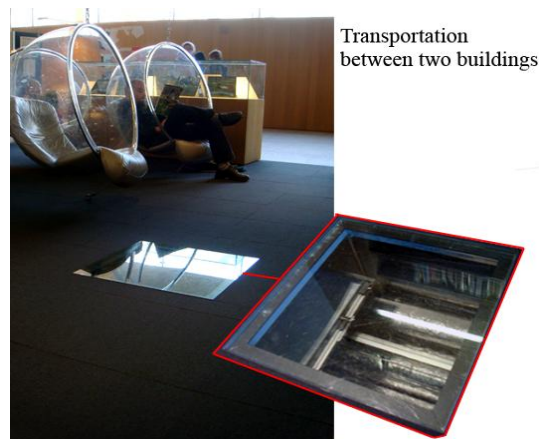


Figure 15 Transportation between two buildings

4.4 Costs

The cost is one of the major issue influencing acceptances of RFID. For the middle size or large size libraries, that is over 100,000 items, it will be huge expensive to

implement RFID completely. Turku Main Library holds 1 million collections with 10 million euros annual budget. Turku Main Library started implementing the RFID technology in 2006, and the costs are presented in table 4:

Table 4 Costs

Costs			
Products	Units	Costs	YearPurchased
RFID Library Card	80,000	80,000€	2006
RFID tags	390,000	172,000€	2006-2008
Check-in Unit + Sorters + Transportation System	2+16+1	700,000€	2006
Check-Out Unit	6	110,000€	2006
Security Gates	7	50,000€	2006
Total		1,112,000€	

Moreover, when introducing new processes and technology, it always increases the costs to train the personnel. Furthermore, there will be always the ongoing costs, such as around 50,000 tags need to be purchased per year for new acquisitions and as well as the equipment maintenance costs.

4.5 SWOT Analysis



Figure16 SWOT Analysis of RFID applying in Turku City Library

In this chapter, SWOT method is used to evaluate and analyze the Strengths, Weaknesses, Opportunities, and Threats based on the use of RFID technology in Turku City Library. In addition, SO strategies (use of the advantages – catch the opportunity), ST strategies (use of the advantages – avoid the threat), WO strategies (improve the disadvantages – seize the opportunity), WT strategies (reduce the disadvantages – avoid the threat) are adapted.

Strengths

RFID technology has been applied in libraries just over a decade, though the technology is not yet mature but its rapid development allows more and more functions to be achieved. RFID is still in its developing stage in libraries, the technology originally can only simply achieve the self check-in and check-out function, but till now, the effectively inventory, logistics and sorting the returned books are all able to be achieved.

Compared to the traditional barcode and magnetic strip, RFID has its obvious superiority.

First of all, the speed of self-checkout/in is faster. With barcode when identifying the object, its speed is limited in a large extent because it requires the line of sight and the physical contact recognition. However, RFID doesn't have those requirements and multiple items can be read at a time, which improves the self-checkin/out efficiency and saves the patron's time.

Next, the efficiency of the management of collections is improved. Periodically inventory or locating the mis-shelved books can be a very time consuming and challenging task based on barcode technology. However, the problem can be easily solved by the use of RFID technology. Time spent on inventory can be greatly reduced due to the technology's unique feature that allows multiple books to be read at a time without physical contact. In addition, RFID technology can precisely locate the book within a short time, which can solve the problem of finding the mis-shelved books and improving the searching efficiency.

In the third place, staff daily routine work and the labour intensity are reduced because

more and more patrons prefer to self-checkin/out the books, as selfservice is much easier with RFID. And staff's workload can be focused on a new way.

Following that, RFID is used in library theft detection systems. The barcode does not have theft detection function. It requires a separate EM (Electromagnetic) alarm strip to be attached to the item to achieve the anti-theft function. Unlike barcode, RFID tags embedded in every library item, and the AFI status in the tag remains activated until the item is checked out. It triggers the alarm system if the AFI status in the tag is not deactivated. And the alarm accuracy is almost 100%.

Further, library opening hours can be extended according to the library's automation management -100% self-service availability. The self-service is nearly 100% except renewal and reservation services.

Finally, RFID tags have large information storage capacity and long life expectancy. Unlike barcode, RFID tags can store a large amount of information and the information stored can be modified as well. Besides, RFID tags have long life expectancy and adapt to harsh environment whereas barcode labels wear out easily and then the reader cannot read them.

Weaknesses

As RFID is not yet a mature technology and has not been applied in libraries for long, some problems still exist and need to be solved and these problems are also the main reasons impeding the adoption of this technology in libraries.

To begin with, there is no single global standard for this technology and every country can set its own rules. As a result, the library in one country may not share its resources in another due to its incompatibility. If world regulatory bodies are not able to agree on a more uniform set of RFID regulations, interoperability between systems around the world will remain low, that would inhibit the adoption of RFID (Hunt V. Daniel et al. 2007, 105).

In the second place, it is expensive to buy RFID products. Though the price of RFID tags decrease every year, the system equipment, tags price in general and the maintenance costs are still relatively high for most libraries.

Finally, metal and water can interrupt the frequency of the chips because the RFID technology is not mature enough.

Opportunities

With rapid development of RFID, its technology is continuously improving and its application is involved in more and more fields. With the larger amount of RFID tags producing at a time, the cost will be accordingly reduced as well. All those will make RFID's future in the business more apparent and positive and bring more opportunities also to the small investment.

The first opportunity is that many RFID standards are still being developed and constantly being updated. Standards for uniformity ensure that products interoperate between different entities and broaden markets and thereby encourage competition. This should result in lower prices for users of RFID products that adhere to standards.

The second opportunity is the prospect for development. RFID technology is developing rapidly, and its application is adopted in various fields due to its unique features. If this technology could be adopted in the books publishing industry in the near future, it will bring the revolutionary change for the whole industry chain such as shipping, retail and library collection management etc. Moreover, R&D unit of RFID technology is closely cooperating with library field and more functions are continuously introduced to library modules such as intelligent book stacks, intelligent reading table and smart bookshelf and so on (Du Ye Li et al. 2010, 4).

Threats

In the first place, people believe that their privacy has been violated, which is one of the biggest problems that restrict the technology's development. Next, staff may lose jobs due to the better technology applied and less human resources required. What is more, small business that could not afford to use the chip technology could go out of business.

Lastly, compared to barcode, RFID is a new and immature technology though it has lots of advantages. As the principle of operation between barcode and RFID is different, only one of them will be eventually survived in this field. Rfid technology is facing the challenge.

Strengths and Opportunities (SO Strategy)

The strengths of RFID technology are good reasons of why to implement it in library management. Both the library's management efficiency and also the patron satisfaction can be improved by adopting this new technology. RFID is one of the fastest growing and most beneficial technologies being adopted by business today, though it is still quite new to libraries. However, more and more new RFID applications in various fields are coming out and the technology is continuously improving while the costs of it are reducing. In the future, it is expected that this technology will be adopted also in the book publishing industry, meaning that books are going to be tagged with RFID labels already before shipping them to libraries. This will make RFID's future in library management more apparent and positive.

Strengths and Threats (ST Strategy)

Although RFID offers advantages in library use, it is still in the development stages and the way the market develops is still unclear. Therefore, different libraries need to consider different factors e.g the amount of books in the library, funding, the number of patrons, type of the library, the location of the library etc. All these factors should be considered before selecting which RFID technology (e.g UHF- of high frequency tags) to invest in.

Weaknesses and Opportunities (WO Strategy)

RFID technology still has issues such as functionality and lack of standardization that need to be further refined and improved but due to the rapid growth of the industry these issues shouldn't be difficult to solve. Also, new possible RFID applications are continuously discovered which in turn makes prices go down. Once a standard for the technology has been established it will also reduce the current security issues that are associated with RFID.

Weaknesses and Threats (WT Strategy)

There seems to be two important issues in RFID technology. Firstly, the imperfections and limitations of the technology. Secondly, the strong competition that RFID needs to face. These challenges can also be seen as opportunities to further develop and reduce the weaknesses of RFID technology. Because of these issues, in order for a library to gain real benefits from using RFID it needs to consider various factors before investing in it.

5 ANALYSIS OF SURVEY STATISTICS

The survey questionnaire is guided by the research questions and is the data collection tool to gather the statistical data. The survey focuses on the library service and patrons satisfaction. And the research question is: Does the use of RFID change the patron's satisfaction of using the library services compared to a barcode based library system? Helsinki City Library uses the barcode technology, which is selected to compare with Turku City library as it is the biggest library in Finland and the larger size library has, the more obviously benefits RFID brings to.

A small quantitative survey questionnaire has been conducted with 60 respondents in Finland during the time 15th February to 18th February in 2011. The survey uses the convenience sampling method to gather the quantitative data from 30 library users who use RFID library card from Turku City Library and 30 random library users who use Barcode library card from Helsinki City Library.

Moreover, designing good questionnaire questions is really important because it often has an effect on the the quality of data gathered. To design good questions in questionnaire in order to gather the information, first of all, the question objectives should be defined and the kind of answers need to meet the objectives of the question. Then, the key terms of the question should be understood as same as that intended by the person writting the question. Next, it is important to ensure that the respondents know the answer and are able to answer it and are willing to answer accurately. Thus, the answers can be aggregated to produce statistical data. (Floyd J. Fowler, Jr. 1995, 9)

This chapter first give the background introduction to two case libraries, and then present the collected data and finally the data is compared and analyzed by a cross-case analysis.

Case one: Turku City Library

Turku Main Library comprises the new section completed in 2007, the old library building built in 1903, and the former governor's office from 1818, which now houses the library's conference rooms and café. (Turku City Library, 2010) It has 150-170 employees with 14 branches libraries and 2 mobile libraries. By 2007, there are approximately 1 million collections, 2 million visits and 3 million loans. (Turku City Library, 2011, 2-3)

The main library adopts RFID technology aim of improving the selfservice. Patrons can borrow and return the items using automatic lending machines, which require a library card and a PIN. Selfservice becomes much easier with this new technology as it does not require line of sight and max. 3 items can be borrowed at a time. So far, the selfservice is nearly 100% (Valikainen, 2010).

Moreover, the library staffs can be also benefit from RFID as their working efficiency can be greatly improved and they can be relieved from the daily routine work. For example, the inventory tasks take less time and labor and locating the materials can be accurate and much quicker. Furthermore, time saved from the employees will certainly benefit the library from the economic point of view.

Case two: Helsinki City Library

Helsinki City Library was founded in 1860 by the initiative of Helsingfors Fruntimmersföreningen. As the largest public library in Finland, it has approximately 500 employees with 36 branches, two mobile libraries and 11 institutional libraries. (Helsinki City Library, 2011) By 2007, there are almost 2 million collections (Helsinki City Library, 2008, 34), 6.4 million visits and 9.6 million loans (Helsinki City Library, 2008, 7).

Helsinki City Library uses the traditional barcode to manage the collections, which requires a lot of manual work for both staffs and patrons. For staffs, mis-shelved items can not be quickly and accurately tracked, inventory is time consuming and manually, borrowing and returning the items for patrons are daily routine work; For patrons, self-lending the materials is not very efficient as the barcode on the library card and materials requires line of sight scanning. However, the cost of barcode technology is much cheaper than RFID technology.

5.1 Cross-case analysis (Turku City Library vs Helsinki City Library)

In this section, the collected data is presented in the table and then interpreted, which is used in the comparative study in both libraries.

Six questions were designed in the questionnaire (see appendices). And the questionnaire has been developed based on the patrons satisfaction of service quality.

Respondents General Information

Table 5 the respondents' gender

	Gender	
	Female	Male
Turku City Library	11	19
Helsinki City Library	16	14

The Table 5 represents the number of female and male who take part in the survey in TCL and HCL. In Turku City Library, about one third of the respondents are female while male respondents account for two thirds of the total. As male respondents form the main customer group in TCL library, taking their wishes into consideration is particularly important. However, in Helsinki City Library, about half female and half male respondents are participated in the survey.

Table 6 The respondents' age in years

Age	Turku City Library	Helsinki City Library
Under 20	3	8
20-29	7	10
30-39	11	7
40-49	5	2
50-59	3	1
60+	1	2

Table 6 represents the respondents' age group in years in both TCL and HCL, and the age group is divided so all ages are included e.g. teenager, adult and senior.

Measuring Frequency

Respondents are asked how frequently visiting the corresponding library. The response categories are in this scale: daily, weekly, monthly and yearly, which are made according to library customer survey in Lahti City Library.

Table 7 Frequency of visiting the library

	Daily	Weekly	Monthly	Yearly
Turku City Library	8	16	6	0
Helsinki City Library	4	16	2	8

Table 7 shows the frequency of library visits by presenting the number of female and male in TCL and HCL. And from the collected data, it can be seen that more than half of respondents visit the library weekly.

Table 8 Frequency of using automatic lending machine

	<i>Every time</i>		<i>Often</i>		<i>Seldom</i>		<i>Never</i>	
	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>
Use self-check-out station	47%	40%	20%	30%	23%	23%	10%	7%
Use self-check-in station	50%	40%	17%	28%	27%	29%	6%	3%
Use staff check-out station	0%	3%	6%	3%	57%	74%	37%	20%
Use staff check-in station	0%	3%	3%	3%	60%	67%	37%	27%

Measuring the frequency of using the automatic lending machine uses another approach as a proportion of time to get four response scales: Every time, Often, Seldom and Never. The scales of frequency are clearly defined and commonly understood instead of defining the middle or intermediate categories such as 'Usually' or 'Always'.

In addition, the percentage of total in each scale of frequency is calculated and presented in the table. For example, 14 respondents use self-check-out station every time in TCL, which account for the total of 30 respondents, so the percentage of total is $14/30 * 100 = 47\%$. What's more, TCL stands for Turku City Library and HCL stands for Helsinki City Library as it told in abbreviations.

As the figures can be seen from above table, most respondents use self check-in and checkout services. In TCL, there are 50% and 47% of respondents use self check-in and check-out services while the corresponding respondents in HCL are 40% and 40%. However, the differences in these two figures are not very big as three fourths of the respondents use the self-service with high frequency in both libraries.

Measuring Patrons Preference

As using the automatic lending machine in Turku City Library is highly recommended and required for every patron, and the self service can be with or without librarian assistance, so it is important to know if the result of measuring self check-in/check-out frequency is as their willings.

Table 9 Patrons Preference of borrowing and returning the books

	Use self service	Service from staffs
Turku City Library	70%	30%
Helsinki City Library	77%	23%

About three fourths of the respondents prefer to use self-service to borrow and return the books while asking services from staffs account for a fourth of the total. Thus, the result of measuring self check-in/check-out frequency is as their willings.

Measuring Satisfaction

Measuring patrons' satisfaction of using the library is the core of this survey paper, and the measuring result would be the answer to the research question.

In the following table, there are 5 response scales as shown in numbers in the first row: 5 means very satisfied, 4 means somewhat satisfied, 3 means neutral, 2 means somewhat dissatisfied and 1 means very dissatisfied. Besides, the number of questions is listed here in the first column of the table, instead of the question itself due to the space limits. The questions are 'How satisfied are you with:

Question 1: Services provided by the library

Question 2: Ease of use of self-checkout station

Question 3: Speed of self-checkout items

Question 4: Ease of use of self-check-in station

Question 5: Speed of self-check-in items

Question 6: Self-check service in general

To get the value of average, such as in Question 6 in TCL in table 10, the formula is:

$$(5 * 17 + 4 * 11 + 3 * 2 + 2 * 0 + 1 * 0) / 30 = 4.5$$

Table 10 Measuring Satisfaction

	5		4		3		2		1		Average	
	TCL	HCL	TCL	HCL	TCL	HCL	TCL	HCL	TCL	HCL	TCL	HCL
Question 1	13	12	15	16	1	1	1	1	0	0	4.4	4.3
Question 2	14	16	12	7	3	5	1	2	0	0	4.3	4.2
Question 3	17	14	11	9	2	6	0	1	0	0	4.5	4.2
Question 4	13	15	12	10	4	4	1	0	0	1	4.2	4.3
Question 5	12	14	12	12	6	3	0	0	0	1	4.2	4.3
Question 6	17	17	11	10	2	3	0	0	0	0	4.5	4.5

The following barchart is generated so as to give the reader a more visualized view from the comparison.

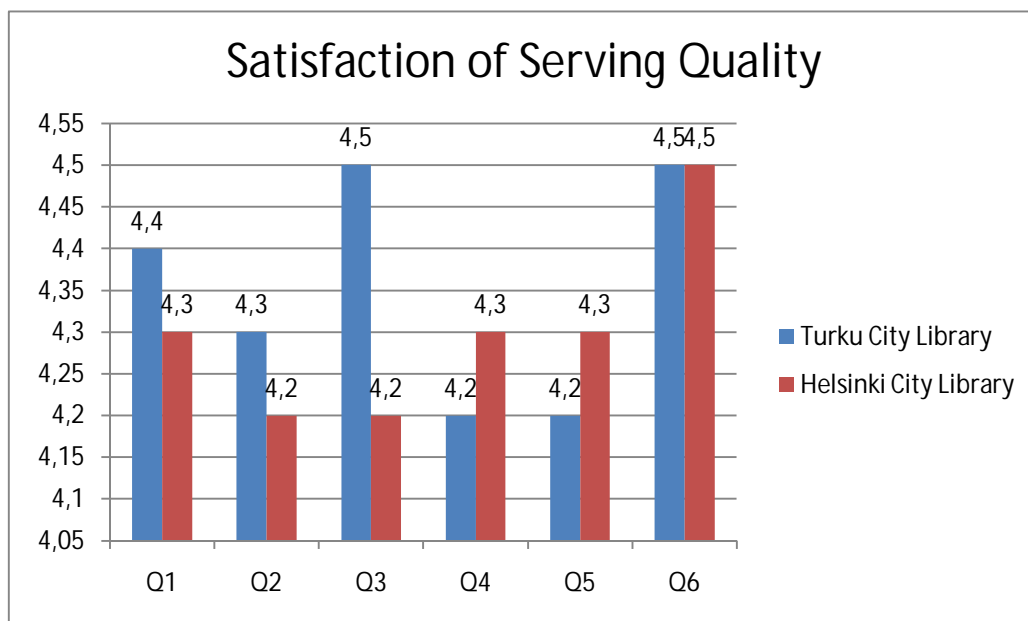


Figure 17 Satisfaction for library serving quality and self-service

As it can be seen from the above figure, the self-check service in general (Q6) in two libraries got the same score. Moreover, the comparison of other criterias remain about the same satisfaction score except for the comparison of the speed of checkout (Q3), which the satisfactions score in TCL is 0.3 higher than in HCL.

In conclusion, the result does not have much difference. Besides, the sampling size is so small, which cause the big margin of errors. From the comparison of this study, there is no difference between two libraries on patrons' satisfaction of using library.

However, there are more than half respondents visit library weekly (out of 16), so I would like to compare and find out whether the result for the satisfaction of those frequency library visitors differs.

Table 12 the satisfaction of patrons who visit library weekly

	<i>Very Satisfied</i>		<i>Somewhat satisfied</i>		<i>Neutral</i>		<i>Somewhat dissatisfied</i>		<i>Very dissatisfied</i>		<i>Average</i>	
	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>	<i>TCL</i>	<i>HCL</i>
Question 1	10	2	5	12	1	1	0	1	0	0	4.6	3.9
Question 2	11	6	5	4	0	5	0	1	0	0	4.7	3.9
Question 3	10	4	6	6	0	5	0	1	0	0	4.6	3.8
Question 4	9	5	7	8	0	2	0	0	0	1	4.6	4.0
Question 5	9	5	6	9	1	1	0	0	0	1	4.5	4.1
Question 6	10	6	6	8	0	2	0	0	0	0	4.6	4.3

The following barchart is generated based on the above table.

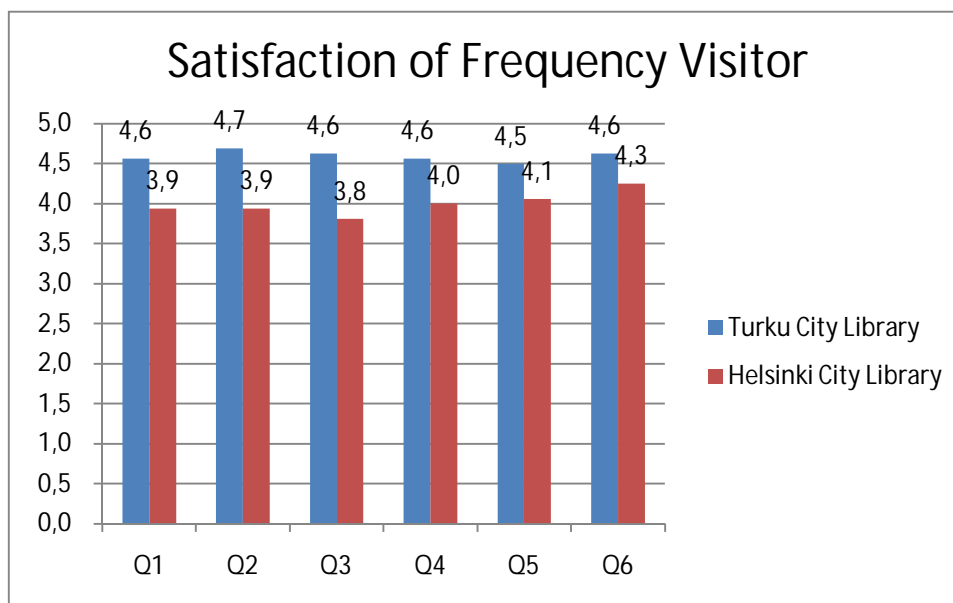


Figure 18 the satisfaction of patrons who visit library weekly

As it can be seen from the comparison above, the result of weekly visitors had a significant difference than the result of all group visitors. The satisfaction level of patrons in Turku City Library is a lot higher than in Helsinki City Library in each variable especially for approving the ease of use and the high speed of RFID technology.

From the comparison of two libraries, the satisfaction score of services provided by the library (Q1) in TCL is 0.7 higher than in HCL, and for the easy of use in check-out station (Q2) and the speed of checkout station (Q3) in TCL are both 0.8 higher than in HCL. And for the easy of use in check-in station (Q4) in TCL is 0.6 and 0.4 for its speed (Q5). As to the satisfaction of general selfservice (Q6), 4.6 score is given in TCL while 4.3 score is given in HCL.

In conclusion, there might be difference on patrons satisfaction in two libraries from the survey statistic, but I can not be sure before making the further studies.

6 CONCLUSIONS AND EXPECTATIONS

The conclusions are drawn based on the SWOT analysis and the survey result, and the chapter ends with expectations and perceptions for further developing the use of RFID technology in Turku City Library.

RFID offers considerable advantages in library management as compared to conventional bar codes and magnetic stripes. It provides more intelligent library management which in turn means better service quality for the customers. Though the technology still needs improvements, the rapid development and increasing markets will lead to a bright future and RFID will surely play an important role in library management in the future.

As mentioned, there are many factors that need to be considered before investing in RFID technology. Thus the decision should be based on real needs instead of mandatory instructions. In this way RFID will benefit both the library as well as the patrons.

A small quantitative survey was conducted and the objectives of the survey is to find out if RFID increase patron's satisfaction of using library by comparing with two libraries. According to the survey result, the satisfaction level in two libraries remain the same. Then, the group of weekly visitors' satisfaction are compared and in this group the number of respondents take up more than half. The result in this group shows the big difference of the satisfaction level in two libraries, and it is clear that the weekly visitors in Turku City Library have higher satisfaction than in Helsinki City Library.

However, the final conclusion can not be drawn before I should make the further studies because the satisfaction level of all respondents in two libraries shows no difference, and though the level of weekly visitors' group (16 respondents) in Turku City Library is a lot higher than in Helsinki City Library, the 16 sampling size is too small and the margin of errors is too large to make the conclusion.

RFID technology can be applied best in middle or larger size libraries. The bigger collection a library has, the more obvious benefits can be achieved by using RFID. For example in National Singapore Library, as one of earliest users of RFID technology in the world, the changes that the new technology brought to the library were significant by greatly improving the patrons selfservice efficiency and effectively reducing staffs working time.

However, as to the case study, RFID technology in Turku City Library is not fully adopted yet in each work process so far such as intelligent inventory or tracking the books can not be achieved yet due to the system currently is still based on barcode. But the old system will be replaced (information is from the interview, 2010)

In the future, it is expected that this technology will be adopted also in the book publishing industry, meaning that books are going to be tagged with RFID labels already before shipping them to libraries. This will make RFID's future in library management more apparent and positive.

SUMMARY

To sum up briefly, RFID is one of the fastest growing and most beneficial technologies being adopted by business today, and the benefits it brings to the library are obvious. By adopting RFID in middle or bigger sized libraries, the patrons selfservice efficiency can be greatly improved and the staff's work time can be effectively reduced.

The selfservice improvement by the use of RFID is mainly manifested in the following areas: firstly, the automatic lending machine is more efficient to use for library patrons because the reading speed is faster as max. 3 items can be read at a time without requiring the line of sight. Secondly, as barcode does not have anti-theft function and there is always a need for separate alarm strips to be attached, when borrowing such items attached with an extra strip, the patron will always have to ask the library staff to take it off before the item can be borrowed whereas the RFID label itself has anti-theft function, which reduces the borrowing steps.

Meanwhile, the reduced staff working time by applying RFID was mainly manifested in the following aspects: first of all, librarians can be relieved from the daily routine circulation tasks as the level of selfservice increases, so their job responsibility can be enlarged or enriched then. Next, RFID technology can decrease the librarians' intensity of labor to a great extent as sorting the returned items and inventory is more efficient and tracking the mis-shelved items by the system can be achieved. Thus, the efficiency of managing the collections is improved accordingly.

This paper mainly focuses on patrons self service improvement through the case library study and as well as the survey research. By comparing the survey result from

Turku City Library – RFID based library management system and Helsinki City Library – traditional barcode based, it can be seen that the RFID technology does benefit the library by improving the patrons satisfaction of using the library.

As to the expectations for RFID technology future development in the library sector, it is expected that this technology will be adopted also in the book publishing industry, so that books will be tagged with RFID labels already before shipping them to libraries.

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APPENDICES

Survey for check-in/out services

Please answer the following questions and return your response to me. Your responses will be used in evaluation and planning for check in/out services for the library. Thank you!

1. *General Information*

Library name _____

Gender

<input type="checkbox"/>	Female
<input type="checkbox"/>	Male

Age _____ Years

2. *How often do you visit this library?*

<input type="checkbox"/>	Daily
<input type="checkbox"/>	Weekly
<input type="checkbox"/>	Monthly
<input type="checkbox"/>	A few times a year

3. *Measuring frequency*

<i>How often do you:</i>	<i>Every time</i>	<i>Often</i>	<i>Seldom</i>	<i>Never</i>
Use self-check-out station				
Use self-check-in station				
Use staff check-out station				
Use staff check-in station				

4. Do you prefer to?

- Use self-check-in/checkout station
- Ask service from staff check-in/checkout station

5. Measuring Satisfaction

How satisfied are you with:

	Very satisfied	Somewhat satisfied	Neutral	Somewhat dissatisfied	Very dissatisfied
Services provided by the library					
Ease of use of self-checkout station					
Speed of self-checkout items					
Ease of use of self-check-in station					
Speed of self-check-in items					
Self-check service in general					

6. What would make the check in/out service more satisfactory?

Thanks for completing the library survey!