Dynamic Categorization: What We Can Learn from the Emergent Arrangement of Physical Artifacts in Libraries

by

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A thesis submitted in conformity with the requirements for the degree of Master of Information Studies
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Abstract

Radio frequency identification (RFID) is a technology used in many applications for the identification of objects. This thesis presents a concept of how libraries could use RFID technology to locate physical items within the library.

The ability to locate items within the library changes the way users interact with physical material, creates new ways of user collaboration, and influences the ability to browse the shelves for physical items.

Several implementation scenarios are presented in detail and implications on collaboration and browsing are analyzed.
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1 Introduction

Much has been said about Web 2.0 and how this “new” social Internet fosters the collaboration between users over large distance and through time (Ibrahim, 2006). Lev Grossmann (2006) calls Web 2.0 “a massive social experiment” (para. 10) that is “about community and collaboration on a scale never seen before” (para. 2). This “new” Internet is about “collective intellectual productivity” (Han, 2010, p. 201), a collaboration that was not achieved before. Tim O’Reilly (2005) coined the term Web 2.0 and explains how the concept can be understood. According to O’Reilly the main trait of Web 2.0 is its flexibility and the possibility of user participation. Users are no longer mere consumers of news and information but become collaborative contributors to the web (Maness, 2006). Users can write reviews and comments, create news on their blogs, connect with friends in social networks like Facebook, share videos and pictures, add tags to categorize a resource, or collaborate with each other to create new information (e.g. Wikipedia).

Clay Shirky (2008) describes collaborative production as one level of user participation in the Internet and explains how users are able to create the online encyclopedia Wikipedia through collaborative production. Collaborative production means “no one person can take credit for what gets created, and the project could not come into being without the participation of many” (Shirky, 2008, p. 50). Wikipedia is a good example for the power of Web 2.0, where anybody is able to participate in the creation, revision, and deletion of information. For Wikipedia it is not important which user contributes what and how much. A user could add text and pictures, edit the writing of another user, or just correct some minor spelling or formatting errors. In the end it is the contribution by many mediated through an Internet application that leads to the creation of new information.

There exists active research and practice (Han, 2010; Ibrahim, 2006; O’Reilly, 2005; Petersen, 2008) to facilitate social interaction and collaboration on the Web. Yasmin Ibrahim (2006) describes the Internet as a place for “disembodied presence” (para. 6), a “virtual sphere” (para. 6), where people interact without being limited by time and space. David Weinberger (2007) describes what he terms “the order of things” and points out that the digital realm offers new possibilities since the digital world is not restrained by space limitations. According to Weinberger the first order of things is about how “we organize [physical] things themselves” (p. 17-8). The second order organizes items of the first order. For example, a card catalog “points to
the physical place where the first-order photo is stored” (p. 18). This means that the first two orders “arrange atoms” (p. 19) and therefore these methods organize the physical world. The third order is about the digital world and Weinberger points out how in the digital world space and place do not matter anymore. Users do not have to worry where data is stored; more important is to find the data, for example through a search engine like Google.

Weinberger offers an interesting way to think about how we organize information. However, Weinberger does not talk about the combination of the first and third order. When the physical objects of the first order are combined with digital data from the third order new ways of user interaction with physical material might become possible. This does not only mean that users could search for physical objects through a digital search engine and the technology would direct the user to the location of physical items. Current online catalogues are doing exactly this; users search for items online and the system allows them to find the physical item on the shelves by providing a number to the user that identifies the book. This approach, however, is limited since it is unidirectional. Digital information is searched to find physical material. The interaction of users with the physical material is not captured and does not influence the digital realm.

The goal of this thesis is to outline one possible way that might allow users of a library to collaborate through the interaction with physical materials. Current library systems do not allow users to collaboratively rearrange the physical items in the library. The current systems are not flexible enough to allow such a rearrangement of items. In order to allow social interaction and collaboration through the interaction with physical items a system is needed that links the physical with the digital world.

To be more precise I suggest using Radio Frequency Identification (RFID) technology to determine the location of physical items within a library. Every item in the library will be equipped with a RFID chip, the so called ‘tag’, which will be able to uniquely identify an item to a RFID reader by sending an identification number upon request. However, the RFID technology is not only used to identify objects; RFID will also be used to determine the location of any physical item within the library. The user will be guided by the technology towards the items. Since the system always “knows” where an item is located, items will not get lost and cannot be misplaced. As a consequence users are free to move items in the library around without having to worry that the replacing of items makes it impossible or harder to find it again. Using RFID
technology is a means to allow users new ways to interact with physical items in the library. This thesis will argue that users ought to be freed from restrictive organizational systems imposed by librarians and instead be able to create their own categorization and grouping of physical items in collaboration. Users should be able to create groups of items by rearranging physical items within the library. The RFID technology would allow recording all item movements in the digital space. Being able to track how physical items are grouped and regrouped can as a result be used to create new categories for items.

Using RFID technology to locate items in a library raises many questions. The following research questions will be addressed in this thesis:

1. Would the introduction of RFID technology enhance collaboration in libraries?
2. What would user interaction with items do to users’ ability to browse physical items?
3. Would it be possible to use the principles of Web 2.0 to organize physical material?

The contribution of this thesis is a new understanding of how RFID technology can be used to merge the digital and physical world together. This merge challenges Weinberger’s division of the physical and digital world into separate orders. Instead, this thesis will show how actions in the physical world can affect the digital and vice versa. This thesis will add to the understanding of how the interaction between physical and digital fosters the collaboration of library users in new ways.

1.1 Outline of the thesis

In chapter 2 the reader will learn what RFID technology is and how RFID technology works. Further, some examples of current usage of RFID technology will be given.

How RFID technology is currently used in libraries, and how this technology can be used to determine the location of a physical library item will be explored in chapter 3. The user will get an understanding of how RFID technology links the digital and physical worlds with each other.
Changing the way in which items in the library are located and allowing the user to interact with the physical materials in new ways might have an influence on the way physical items are browsed. Chapter 4 will introduce the concept of physical browsing in the library and describe how this activity might be affected by the RFID technology introduced in chapter 2 and 3.

Chapter 5 will explore user participation in libraries through categorization. A description of levels of user participation and enabling factors for participation will be given. Furthermore, participation through categorization will be introduced and explained.

In chapter 6 scenarios will be outlined and used to describe how RFID technology can be used to link the physical and digital world. Examples of user collaboration through the interaction with physical material will be given.

Chapter 7 will provide a conclusion to this thesis and highlight further research directions.
2 Radio Frequency Identification (RFID)

2.1 What is RFID?

RFID is the abbreviation for Radio Frequency Identifier and describes a technology that uses radio frequencies to establish a communication between a transmitter (reader or interrogator) and a transponder (tag). Examples of these two components are shown in Figure 2-1. The main components of a tag are an antenna and a circuit. The circuit on a tag facilitates the communication between the tag and the reader and holds a unique identifier among other functions (Curran & Porter, 2007). Hereby the tag is usually designed to respond to the communication that is initiated by the reader.

![RFID reader and tag](http://www.flickr.com/photos/undermyskin/3607391769/)

**Figure 2-1 RFID reader and tag**

There is no agreement on the roots and early history of the technology. In the mid 20th century the allies used a transponder and transmitter technology during World War 2 to differentiate between their own and enemy aircraft. However, there is agreement that the patent received by

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Currently, RFID does not refer to a uniform technology; rather, it is a class of technologies. The differences are modes of operation, frequencies used, data storage, and implemented standards. Before these differences are explained in more detail it is important to get an overview of radio frequency, the underlying physical phenomena used by the RFID technology for communication.

### 2.2 Radio Frequency

Since RFID uses radio frequency (RF) to communicate it is important to understand what RF is and which frequencies are used by the RFID technology.

All electromagnetic radiation is represented in the electromagnetic spectrum. Components of electromagnetic spectrum are visible light, ultra violet light, infrared light, X- and gamma-rays, and radio waves (“Electromagnetic spectrum,” 2009).

Radio waves are a distinct part of the electromagnetic spectrum with frequencies ranging from almost 0 Hertz (Hz) to 30,000 GHz (GHz means Giga Hz, giga refers to 1 billion, and 1 GHz is one billion Hz). Electromagnetic radiation with a frequency above 30,000 GHz is considered infrared light and therefore is not part of the radio wave spectrum anymore. Radio waves with a frequency above 300 MHz are often referred to as microwaves; however, they are still part of the radio wave spectrum (“Electromagnetic spectrum,” 2009; “Radio wave,” 2009). To get a good overview over the electromagnetic spectrum and to understand how the whole spectrum is further subdivided see Figure 2-2.

Radio waves are not exclusively used by RFID technology but by a variety of technologies to communicate through the air. Examples of technologies using radio waves for communication are: TV, radio, wireless local area network (WLAN), Bluetooth, and mobile phones.
Frequency and wavelength table of the electromagnetic spectrum.

Figure 2-2 Electromagnetic Spectrum

Electromagnetic radiation distributes in sine waves and Hertz (Hz) is a measurement unit to describe how often per second these sine waves are repeated. Wavelength is the distance over

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which a sine wave repeats (see also Figure 2-3). If the frequency of a wave is rising, as a result, the wavelength is decreasing. Wavelength is therefore inversely proportional to the frequency (“Frequency,” 2009; “Wavelength,” 2009).

A plot of a sine wave and points between which wavelength is measured (lambda) (marked by the arrows).  

Figure 2-3 Sine wave and wave length

RFID technology is operating on a variety of frequencies, but most commonly in the Low Frequency (LF) band (30-300 kHz), the High Frequency (HF) band (3-30 MHz), and the Ultra High Frequency (UHF) band (300-3000 MHz) (“Radio spectrum,” 2009). Palmer (2009) makes a distinction between tags in the UHF band and tags in the microwave spectrum. This might be confusing since the microwave frequency outlined by Palmer (2.45 GHz) belongs to the UHF spectrum. However, Palmer mentions frequencies of 433 MHz and above for UHF tags and 2.45 GHz for tag in the microwave spectrum. While Palmer’s distinction might be not completely correct, his categorization makes it easier to talk about, and distinguish between, RFID technologies that utilize different radio frequencies.

2.3 Standards for RFID

The ISO/IEC 18000 standard regulates the ways in which RFID operates on different frequencies. This standard has various subsections and five of these subsections describe the communication over the air-interface for various frequencies. Part 2 of the ISO standard refers to LF communication (135 kHz) and part 3 refers to HF communication (13.56 MHz). Communication in the UHF range is covered by part four (2.45 GHz), six (860-960 MHz), and seven (433 MHz) of the ISO standard (“Radio wave,” 2009; “Radio-frequency identification,” 2009; Palmer, 2009).

While the ISO/IEC 18000 standards regulate the way reader and tag communicate, it does not give any guidance on how data itself is encoded during transmission nor does the standard describe the way data is stored on the tag. This issue makes the interoperability of different RFID systems from competing vendors difficult and unpredictable. For a library itself the interoperability is only an issue if the library participates in inter-library loans. If not, this might not be an issue at all.

For some time the ISO/IEC 15693 standard described the communication protocol of RFID tags and smartcards. Currently, the standard ISO/IEC 15693 governs RFID chips in smartcards rather than tags used to mark objects like books. The standard might be important for libraries when RFID equipped smartcards are used as library cards. These 'smart' library cards could be used to identify the library patron at a self-checkout terminal (Palmer, 2009).

The problem of RFID is that many standards are issued by different standard bodies (Palmer, 2009, p. 42) and standards can be of international or only of national importance. Despite international standards there might be conflicting national standards, which describe the operation of RFID on different frequencies. Even worse than various standards, which might be overlapping or conflicting, are RFID implementations which do not follow a standard at all and have a proprietary way of handling the communication between tag and reader. Not following RFID standards might create systems that are not able to interoperate with other RFID systems. This might be an issue for libraries if they want to share items with other libraries and be able to use RFID tags from other libraries. The best solution would be recommendations for RFID technology and standards through library associations like the American Library Association (ALA).
2.3.1 Regulations of the electromagnetic spectrum

While RFID systems can be implemented without following standards there are some limitations. The usage of radio frequencies outside of RFID standards is limited since the government regulates most electromagnetic frequencies. Many radio frequencies can only be used with permission after a license fee is paid. Good examples of this are frequencies that are used for mobile telephony services. As a result, a RFID manufacturer might not follow any standard on how to handle the communication between RFID tag and reader. However, the radio frequency spectrum will most likely be regulated and only certain parts of the spectrum will be available to be used by RFID technology.

The Industrial, Scientific and Medical (ISM) radio bands are an exception in the frequency regulations of many countries, since ISM bands are open to unlicensed usage. Unlicensed usage means that everyone can use the specific bands for any purpose. This usage is possible without the need to pay license fees. Technologies like wireless local area network (WLAN or Wi-Fi), Bluetooth, and microwave ovens use frequencies on ISM bands in the microwave range (“ISM band,” 2009; Palmer, 2009). Although the ISM band allows the frequencies to be used without licensing, this does not mean that the frequencies are free of regulations. Most countries define the spectrum that represents the ISM band according to the Radio Regulations of the International Telecommunication Union (ITU) (“ISM band,” 2009).

2.4 RFID operation modes

One important aspect of RFID tags, as previously described, is the frequency they operate on. Another important aspect is the operation mode of the tag. A RFID tag can be in passive, active, or semi-passive operation mode. The operation mode has an influence on the durability, reach, and size of a tag.

Passive tags consist of an antenna and a circuit. These tags do not have their own power source; rather, the tags receive the power through the electromagnetic field generated by the reader. As a result, the antenna is needed for the communication between the tag and reader as well as for
providing the power of the electromagnetic field to the circuit in the tag. Once powered up by the energy from the electromagnetic field, the circuit on the tag performs the communication with the reader. The circuit contains the logic of the communication protocol as well as the data stored on the tag. The power to operate a passive tag has to be provided by the RFID reader. As a result, passive tags need a relative near proximity to the reader in order to gain enough energy to work. A major advantage of passive tags is that they last a very long time since they have no power source that has to be replaced or recharged. “Most RFID vendors claim a minimum of 100,000 transactions before a tag may need to be replaced” (Boss, 2003).

Active tags are similar to passive tags with the difference that active tags contain a separate power source. The separate power source allows the tags to communicate over a larger distance since they are not depending on the strength of the electromagnetic field provided by the reader. Another advantage is that these tags can start a communication with a RFID reader or build up a peer-to-peer communication between various active tags in the area (Curran & Porter, 2007). A passive tag only answers after being activated and “called” by a reader. An active tag, on the other hand, could be connected to sensors and transmit sensor readings on a regular basis to a RFID reader or another RFID tag within its proximity.

A semi-passive tag has a power source much like an active tag. The difference is that the source is used to power the circuit and external sensors. The communication is still initiated by the reader. However, the power source can be used to increase the communication distance since the tag is not solely relying on the strength of the electromagnetic field (Palmer, 2009; “Radio-frequency identification,” 2009).

### 2.5 Data handling

Previous sections described differences in RFID technology that have to do with the radio frequencies they operate on (see 2.2), how the tag is powered, and how communication is initiated (see 2.4). Other differences in RFID technology are the ways data on the chip are manipulated and stored. Further, RFID tags vary in the size of their memory, and memory size determines the amount of data that each RFID tag can hold.
2.5.1 Data manipulation

The circuits on a RFID tag not only enable the communication with the reader. Moreover, the circuits are used to store and retrieve data. Once a reader begins to communicate with a tag, the RFID tag will transmit the data stored on the circuits to the RFID reader upon request. A distinguishing feature of RFID tags is the data manipulation they allow and enable. Some RFID tags are read only, some can be changed once and then become read only, while other RFID tag can be changed multiple times.

2.5.1.1 Read-only RFID tags

Read-only tags are preprogrammed by the manufacturer and cannot be altered later on. Tags of this kind do not allow for a lot of flexibility and most likely these tags will just reply with a single, unique number. Despite the limitation of a read-only chip, these tags can easily serve as a replacement for a barcode on an item like a book. A barcode represents a number and to be useful this number has to be associated with an object or a class of object in a computer system. Once a barcode is scanned it is matched against a database to retrieve the corresponding data record.

A similar behavior can be achieved by using a read-only RFID tag. The tag is placed on an item that has to be identified. In a library this could be a book, magazine, journal, CD or any other artifact. Once the tag is placed on the item, the information on the tag becomes the identifier to retrieve the data record of the item. For this to happen, the identification information on the RFID tag has to be read and stored with the dataset of the item.

After this initial merging of data, the tag provides the same functionality as a barcode. One benefit of RFID tags over barcode labels is the fact that RFID tags do not need a line of sight to be read. Tags can be placed anywhere on the item and do not require to be on the outside or another easy to reach position.
2.5.1.2 Write once read many (WORM) RFID tags

Write once read many (WORM) tags allow the user to store any information at the beginning of the life cycle of a tag. This gives users the freedom to use their own identification scheme on a tag instead of adapting to the information that is pre-stored on a read-only tag.

As a result a library is able to store a unique item identification number, which they are already using in their system, on the WORM tag. This is as opposed to read-only tags, where libraries would have to extract the unique identification number that was preset on each tag and associate it with an existing record, which might introduce the need for a new data field to hold the RFID tag identifier.

2.5.1.3 Read-write RFID tags

Read-write tags give the users a maximum of flexibility. Instead of only using the tags as barcode replacements these tags can be used to store additional information that can change over time. An active read-write tag with an attached temperature sensor, for example, could record the temperature in an interval and store the last three temperature results. Once a RFID reader builds up a communication with such a tag, the three stored data points are available for transmission. The ability to store date could allow a reader to collect data from multiple tags without the need to contact each tag before a new recording cycle starts.

Read-write tags can easily be reused since they can be reprogrammed with any data for another item. Moreover, the tags could be used to store additional information about the corresponding item. In the library this could be bibliographic information like the title, author, publisher, and date of publication. Furthermore, a RFID tag could store ratings or comments about library items. The only limitation is the available storage space on each RFID tag. Limited space might require storing additional data like comments and ratings with the item record on the computer system.

Depending on the usage a WORM tag might be preferred by libraries over a read-write tag since users cannot alter the information on a WORM tag after the data was initially written on the tag. However, which type of RFID tag is used in a library depends on the price differences between
different tag categories and various requirements of each individual library. Some libraries might have concerns about data alteration and prefer WORM or read-only tags. Other libraries might want to use their own item identification instead of adapting the identification number that comes with a read-only tag. Some libraries might want to store as much information about the item as possible on the RFID tag to allow RFID readers that have no connection to the library database access to this information.

In the end the RFID tags used have to fit into the overall strategy of the library and the way in which data is handled. An additional parameter is the data capacity and size of the tags, which will be discussed in the following subsection (2.5.2).

2.5.2 Data capacity and tag size

RFID tags are available in different sizes, which are influenced by the operation mode and other factors. An active tag with a power source and extra sensors will be a lot bigger than a passive tag that is used to identify a library item. The tags used in libraries are about 50 mm by 50 mm and are normally as thin as barcode labels (“Radio-frequency identification,” 2009).

There are smaller RFID tags available that can be as small as 0.05 mm by 0.05 mm, however a small size will affect the distance negatively (“Radio-frequency identification,” 2009).

Size is not a major issue tagging items in libraries, while read distance could be an issue. The earlier a item can be read at the security gate the more items can be read while the patron walks through. Moreover, to enable detection and tracking of items in a library a great read distance would be crucial. To track an item everywhere in the library and determine the location the RFID tag of the item has to be detected by several RFID readers at the same time. This synchronous reading of a single RFID tag is needed to determine the position in space through trilateration (see also 3.1.3.2).
2.6 Usage of RFID technology

RFID technology is used in various industries and for different purposes. The intention behind the usage of RFID is to identify and track objects, animals, and humans.

In the logistic business RFID is used to replace the identification of goods and pallets via barcode. Since no line of sight is required, items on a pallet or in a box are individually identifiable. With barcodes only the pallet or box could be identified and the content would not be readable. An example for object tagging is the inclusion of RFID tag in clothes to enable better stock management (see Figure 2-4).

![RFID tag in clothes](image)

**Figure 2-4 RFID tag in clothes**

In the production sector RFID allows the identification of parts and components in an environment where barcodes and other labels might not last. Throughout the lifecycle of a manufactured good a RFID tag could document where, when, and by whom the item was produced. This documentation might be important for guarantee issues and liability claims (Bishop, 2004).

RFID is used to identify humans and animals alike. So-called *smartcards*, credit card sized cards with an embedded RFID tag, are used to identify humans and grant them access to services and
places. A smart card can be used as a door key or for the identification of a library patron at a self check-out terminal.

RFID tags for animal identification are usually implanted under the skin. Having a tag under the skin allows the automatic identification of an individual animal. This identification can be used to monitor and control the food and water supply for any animal on a farm automatically.

These are just a few ways in which RFID technology is currently used. RFID technology is already implemented in some libraries. The following chapter (see chapter 3) will describe which kind of RFID technology is currently used in some libraries and for what purpose. Furthermore, novel ways of using RFID technology to locate items will be introduced.
3 RFID in the library

Libraries started using RFID technology in the mid 1990s and today about 300 libraries around the world are using RFID. Between 2001 and 2005 there was a substantial growth of libraries using RFID from around 50 to 300 libraries. Reasons for this are falling costs for tags and equipment as well as a growing number of suppliers and an increasing standardization of the technology (Palmer, 2009; Ching & Tai, 2009).

This section looks at what kind of RFID technology is used today in libraries, what the possible problems are, and for what reasons the technology is implemented. The purpose is not to be exhaustive; instead the reader should get an idea of why RFID technology is currently used in libraries. Understanding the current usage of RFID in libraries will help to put the later proposed usage of the technology into perspective.

3.1.1 Type of RFID technology used in libraries

Today, most libraries are using RFID tags and readers that communicate in the HF band at a frequency of 13.56 MHz. One of the reasons for high-frequency RFID technology to become a de facto standard in the library context was the fact that it was the only available RFID technology in the late 1990s when libraries started to implement RFID. Another reason is the availability of the 13.56 MHz frequency band for RFID technology in most countries of the world (Ching & Tai, 2009, p. 348).

Despite the wide usage within libraries it is problematic to use HF frequency tags on CDs and DVDs since the metal in the discs interferes with the communication between the reader and the tag (Palmer, 2009). Depending on the size of the CD and DVD collection of a library this might be a big issue and stop a library from implementing RFID technology. While the technology might get better in handling this interference, another solution might be to use RFID tags and readers that operate on another frequency.

Today, two kinds of RFID technologies are widely used by libraries. One is the already mentioned High Frequency (HF) system at 13.56 MHz. The other RFID technology is Ultra High
Frequency (UHF) with frequencies between 860 and 960 MHz. While HF technology is already well established in libraries, UHF is fairly new in the library context. However, both HF and UHF tags can and are used in the library context (Ching & Tai, 2009; Palmer, 2009).

Using UHF technology promises to offer better performance, higher accuracy, longer reading range, excellent reading of multiple tags at once, and less interference through metal (Ching & Tai, 2009). These features make UHF a good choice within the library setting. Ching and Tai (2009) describe a comparison between a HF and UHF RFID implementation at the Library of the City University of Hong Kong. The library equipped a new branch with UHF tags to collect performance data. This data was compared with performance parameters from branches that use HF RFID technology. Ching and Tai conclude that UHF technology can provide the same functionality for the library setting as the HF technology while easily outperforming HF technology.

While UHF tags perform well around metal they suffer from interferences through water. Since humans consist mainly of water, users moving in the library might have a negative influence on the performance of the UHF technology. The results of the study undertaken by Ching and Tai (2009) suggest that the possible interference created by humans can be neglected. As a result UHF tags would be better suited to tag items like CDs and DVDs since the metal does not interfere with the technology like it does with HF RFID technology.

3.1.2 Applications of RFID technology in libraries

In libraries RFID technology can be used to provide a multitude of functions. While all functions have the potential to improve the service in a library and streamline repetitive tasks, not every library implements every application. The following text will describe the ways RFID technology is implemented and used within libraries.

3.1.2.1 Barcode replacement

As earlier mentioned, RFID can be used as a replacement for barcodes. The same information that is on a barcode, a unique item identification number, can be stored on the RFID chip. Instead
of scanning the barcode with a laser scanner a RFID reader scans the RFID tag. Once the item identification number is retrieved from the RFID tag, this item identification is used to access the bibliographic record on the Library Management System (LMS). The identification information on the RFID tag is therefore an identifier for the data set in a LMS. Since both technologies, RFID tags and barcodes, offer the same functionality it is important to understand the benefits of each technology.

Barcode is a well established technology and offers some benefits. Barcode readers are relatively cheap, easy to set up, and easy to use. Furthermore, the way in which barcodes are encoded is standardized and barcodes are very cheap to buy. Furthermore, the library could print customized barcodes at a very small cost.

In comparison, RFID technology is more complex and comparatively expensive. Even if we assume that a RFID reader and barcode reader cost the same, the RFID tags are more expensive than a barcode that can be self-printed. In 2004 RFID tags cost around 50 cents (USD) and with increasing demand the costs are expected to drop as low as 20 cents (Bishop, 2004). Compared with barcodes, however, RFID tags are still more expensive.

The benefits of RFID tags over barcodes are the ability to read items without line of sight and to read multiple items almost simultaneously (Palmer, 2009; RFID in libraries, 2004). The speed and ease of usage of items with RFID tags helps to reduce the item handling time during check-in and check-out. Furthermore, RFID enables and improves self-service applications in the library, which will be described later in more detail (3.1.2.3). Another benefit of RFID tags is that they last longer than a barcode since they are not exposed to contact with anything (Boss, 2003). Depending on how many times a barcode has to be replaced within the average lifespan of a RFID tag, the costs for a RFID tag might be justified.

### 3.1.2.2 Security gates

Today many libraries use security gates to prevent the removal of items that are not checked out. In order to detect unchecked items with a security gate, each item needs to be equipped with a security strip. A security strip is a magnetized metal strip that usually is hidden in the spine of a book or in the casing of a CD/DVD. The security strip allows the detection of items that pass the
security gate. During item check-out the magnetic security strip is demagnetized to allow the patron to go through the security gate without triggering the alarm.

This demagnetization is an extra step in the check-out process of an item. Furthermore, it is not possible to use this security technology with cassettes. Cassettes store information on a magnetized band and the demagnetization process could destroy information on the cassette (RFID in libraries, 2004).

RFID technology offers a protection against the removal of non checked-out items from the library. This is also achieved through the usage of security gates. Instead of reacting to magnetized security strips these security gates scan for RFID tags. Once a tag is discovered the information on the tag is read to determine if the item is checked out or not (and sound the alarm accordingly).

There are basically two ways to implement the security gate. The first way to implement the security gate is by using a security bit on the RFID tag. During the check-out the bit is toggled to allow the user to proceed through the gate without sounding the alarm. The benefit is that this bit can be read very quickly and the security gate does not have to communicate with the LMS in order to determine if the item is checked out or not. The drawback is the fact that there is no standard on how and where information is stored on the RFID tag. This non-standardization creates potential incompatibilities between security gates, tags, and readers that are produced by different vendors (Palmer, 2009). Furthermore, using a security bit requires RFID tags that allow read and write operations.

The second way to implement a security gate is by reading the item identification number from the RFID tag. Once the identification number stored on the RFID tag is retrieved the RFID reader in the security gate is able to contact the LMS. The LMS uses the item record to determine if the item is checked out or not. The result is sent back to the security gate and an alarm is sounded if necessary. The benefit of this approach is that the gate does not need to know where the security bit can be found. Only the location of the item identification needs to be accessible. However, this process is more complex to implement and takes more processing time. Implementing the communication between the gate and the LMS adds another layer of complexity. Furthermore, the process to determine if a book can pass without ringing the alarm
needs more time and depends on a working LMS (Palmer, 2009). The benefit is that read-only and WORM tags can be used, which are more resistant against tampering than read-write tags.

### 3.1.2.3 Self check-out terminals

Self check-out terminals in libraries are nothing new to RFID technology and can also be realized with barcodes and barcode-readers. This is done at Robarts library at the University of Toronto. To check out books the user scans the barcode on the library card and then the barcodes of the items to check out. During this process the book has to be placed in a certain way to ensure that the barcodes can be read and the theft prevention is disabled (by demagnetizing the security strip). For this system to work the barcode and magnetic theft prevention have to be in the same place and be placed correctly by the users. This process is rather slow since all books have to be scanned one after the other.

Self check-out can be streamlined through the usage of RFID technology. First, it is not important where the RFID tag is placed on the item. The tag can be inside a book or directly on a CD/DVD by placing the RFID tag around the hole in the middle (see Figure 3-1). This allows to hide the tag and to secure the item (disc) itself instead of the package around it. For discs this means that no extra security case is needed to secure the item (RFID in libraries, 2004).

![Figure 3-1 RFID tags on a CD/DVD](image)

Second, all items that are near the check-out terminal can be read instantaneously without the need for a line of sight. This speeds up the process and simplifies the handling since not every book has to be placed at a certain position on the reader.
Third, while reading the RFID tag of an item and checking this item out in the LMS, the reader can simultaneously deactivate the security function for each tag. This deactivation of the security function is either done by changing the security bit on the RFID chip itself or by changing the LMS record to checked out (which is done in any case to record check out items in the LMS) (Palmer, 2009).

Issuing RFID-enhanced library cards to patrons enables the library to offer the patron a maximum of convenience and speed during the usage of a RFID self check-out terminal. To check out an item the user authenticates himself or herself by placing the library card close to a specified area of the reader. After this the items placed on the reader are scanned, checked out in the LMS, and security features are deactivated (Palmer, 2009; RFID in libraries, 2004). At the self check-out terminals at Robarts library the user can choose to receive a printed receipt of the transaction, an email summarizing the transaction, or no receipt at all. On a RFID enhanced card the user could store the preference for receipts and will not be asked later on.

The value of the self check-out cannot be emphasized strongly enough. Palmer (2009) calls self check-out a “killer application” (p. 12) of RFID technology for libraries. Self check-out allows libraries to automate a repetitive and recurring activity that normally binds a lot of library staff to this activity. Automating the check out allows the library staff to concentrate on other work. The time gained can be used to answer reference questions, guide patrons in the library, and work on research projects and outreach programs (Hadro, 2009).

3.1.2.4 Check-in and automatic handling

Not only does RFID technology allow a fast and convenient check-out process for patrons in a library; in addition, RFID technology can be utilized to streamline the check-in process and to enable automatic item handling.

Placing an RFID reader inside of book drops would enable the automatic recognition of returned items. This could be achieved by using the RFID reader to scan for items that are placed in a book drop. Once an item is detected the information on the RFID tag is read by the reader and transmitted to the LMS system. After receiving the item data from the RFID reader the LMS will automatically check-in the returned item. To ensure the detection of all returned items the system
could use multiple RFID readers. One reader could be near the slot where items are returned and another reader could be placed near the area where the items are collected. This way the second RFID reader can continuously scan for items not checked-in, yet. The librarians only have to pick the items up and place them at their designated locations.

Taking the automatic check-in process one step further is by having a conveyor belt behind the book drop. Once an item is returned it is transported away on the conveyor. By passing an RFID reader the item can be identified, checked-in, and a decision can be made where to transport the item to. This way it would be possible to transport items to different locations within the library. The system could sort items by medium or even by categories (Bishop, 2004).

3.1.2.5 Stock management

Items that are reported missing might still be within the library and simply be marked as missing due to misplacement. If an item is re-shelved by a patron or librarian at the wrong position the item cannot be accessed anymore. The only way to recover misplaced items is during an inventory of the whole collection, which is very time consuming.

RFID technology can help with the problem of finding missing items and perform a full inventory of the collection in a fraction of the time needed for a traditional inventory, which is done by manually looking up all items. This can be done with a magic wand, a PDA equipped with a RFID reader and RFID software (Palmer, 2009; RFID in libraries, 2004). Equipped with the magic wand a librarian can walk through the stacks and scan items on the shelf. The program on the PDA can signal the user that a missing item is near in order to retrieve missing items. To perform an inventory the librarian walks through the stacks with the magic wand and the PDA records all items on the shelves. This allows performing an inventory in hours and therefore on a regular basis (Palmer, 2009).

3.1.3 Possible future usage of RFID in libraries

Currently libraries use RFID technology successfully to provide faster material handling, better security, and more efficient stock management (Palmer, 2009). The technology, however, has the
potential to further improve and change how items are located and handled within the library. I suggest using the technology for the automated and continuous tracking of items within the library. The idea is that various RFID readers periodically read the tags of all items within the library, allowing the library management system (LMS) to keep a record of items that are within the library and where they can be found.

Tracking library items in real-time means that the system performs the tracking within a given time frame ("Real-time computing," 2009). For the RFID systems this means that within a defined time period (e.g. 2 seconds) the system performs a complete read cycle. During such a read cycle all RFID scanners do a scan and report their results to the central LMS. The LMS is then able to keep a constantly updated record of all items and their position within the library.

Two possible ways to implement an RFID system that locates items within a library are proposed in this thesis. The goal is to give the reader an understanding how each approach works and what the benefits and drawbacks of each solution are.

### 3.1.3.1 Locating items on the shelves

One possibility to constantly track items in libraries is through the usage of *smart shelves*. A smart shelf divides a library shelf into sections and is equipped with several RFID readers. When items with RFID tags are placed on a smart shelf the RFID readers will immediately detect the tags and determine the locations. The accuracy of the location determination is around 30cm (Intellident Inc., 2008), since this is the usual width of a section on the shelf. The accuracy might vary and is determined by the width a library chooses for a section on the shelf. The smart shelf can detect in which section an item is located; however, it is not able to determine the exact position of a single item within a section. The sketch in Figure 3-2 helps to understand the layout of a smart shelf.

A smart shelf will constantly read all RFID tags of all items on the shelves and transfer this data to the LMS. Through this the LMS knows which items are on the shelves and in which section they are. Smart shelves are already in usage and if smart shelves are used for all items in the library they allow for a system that always knows which items can be found where (Ching & Tai, 2009).
Storing and constantly updating the location data of all items on the shelves allows the LMS at any time to provide the user with accurate location information. This information can be used by the user to find the shelves, or the LMS can guide the user towards the location of items the user wants to retrieve. A detailed description of the processes can be found in chapter 6 (see section 6.3.1).

Figure 3-2 Smart Shelf
3.1.3.2 Locating items anywhere in the library

The second possibility, which is more complicated to implement, is to create a *smart library*. A smart library automatically keeps track of the items in stock and their location, but does not rely on a smart shelf. Instead items could be tracked anywhere within the library. To enable automatic item tracking anywhere within a library, all rooms would have to be equipped with RFID readers in order to be able to access the RFID tags of any item anywhere within the library.

Locating an RFID tag in a room can be done through trilateration, a mechanism based on triangle geometry. Trilateration is a method also used by the Global Positioning System (GPS). To calculate the position of an object using trilateration, the distance between the object and at least three reference points must be known. The distance information and the known location of the reference points are then used to calculate the current position of the object. In GPS systems, satellites are the reference points, whereas in the smart library, RFID readers would be the reference points. An object could be a person with a GPS receiver in the former case and in the smart library case, the object would be an item with a RFID tag.

In a GPS system the GPS receiver has to assess the distance to at least three GPS satellites to determine its position on the earth surface. Once the GPS receiver has contact with three or more satellites the receiver is able to calculate its own position. In the smart library the LMS has to calculate the position of a RFID tag that is attached to a library item. In order to calculate the position of an item the LMS needs the distance information between the RFID tag of this item and at least three RFID readers. An individual RFID reader will detect the RFID tag, determine the distance to the item, and transmit the information to the LMS. Once the LMS has three distance information sets or more a position can be calculated.

It can be assumed that the position of RFID readers stays the same once the system is working well since the readers are installed permanently within the library. Once a reader is installed the position of the reader within a room has to be determined and stored in the system. If an RFID reader is moved to another location the new position of the reader needs to be updated in the system.
Within a library a grid of RFID readers is installed and the position of each reader is known to the LMS. The grid of RFID readers has to be dense enough to allow at least three readers to detect the RFID tag of an item at the same time regardless of where that item is placed within the library. As Zhou and Shi (2009) pointed out the usage of active RFID tags will raise the distance over which a reader can still communicate with a tag. Using active tags, however, is not possible and desirable in a library setting. For one most libraries already implement a lot of passive RFID technology, which is too expensive to replace. Further, active tags are too big to be placed in most library items and the batteries in active tags need to be replaced frequently. The space issue and the costs connected with continuous battery maintenance do not allow the usage of active tags.

To allow the localization of library items using passive RFID tags, the library probably needs shorter distances between the RFID readers. This makes the grid of readers denser but at the same time drives the costs up. Further research within the library is necessary to determine how many RFID readers more are needed in a passive RFID scenario in comparison with an active RFID set up. Active RFID tags are expensive compared with passive RFID tags and depending on the difference in the number of RFID readers the cost difference could be marginal. Without data from research this will however be speculation.

In the following part I will explain how RFID readers are able to determine the distance between the reader and a detected RFID tag.

3.1.3.3 Determining the distance

Zhou and Shi (2009) explain that each RFID reader receives a “radio signal strength indicator” (RSSI) from a RFID tag. This means that once an RFID reader builds up a communication with a detected RFID tag, the RFID tag will submit a unique identifier, additional user data (depends on the system setup), and the number to indicate the signal strength (RSSI). This RSSI information can be used to calculate the distance between the RFID tag and reader.

If three or more RFID readers are able to communicate with an RFID tag at the same time, the position of the RFID tag can be calculated. In their paper Zhou and Shi explore various algorithms for the localization. The authors describe the accuracy of different algorithms and
how the number of RFID readers influences the result. Although the results are based on experiments in a real environment and not on simulation, each library has a unique room setting. The results of Zhou and Shi can be used as a starting point. However, each installation needs to undergo thorough testing to determine the ideal number of RFID readers.

Picking and recommending an algorithm and making assumptions about the number of RFID readers needed for a system to perform well in an indoor environment is outside of the scope of this thesis.

3.1.3.4 Impact on privacy and security

When a technology is able to track every movement of an item within the library, this technology might pose a threat to the privacy of the patron. Identifying, locating, and tracking the user along with the items in the library, which might be possible through a RFID enabled library card, will enable user profiling. The library could store every item a user potentially looked at, every item the user moved, how long the user was near an item, and where the user went in the library. These are serious concerns and the library must ensure that no user information is stored without the knowledge and consent of the user. Users must be able to revoke their consent for data collection later on and be able to request the deletion of all data that was already collected.

The best strategy for libraries is to address any privacy issues up front and inform patrons thoroughly about the new technology introduced (Bishop, 2004). The best protection against unauthorized access of the data on RFID tags is to store as little information as possible and store information that does not make sense on its own. If the library uses only an identifier on the RFID tag, which could be pre-stored or set by the library, an attacker would gain little information by reading the RFID tag. The identifier stored on the tag only makes sense with access to the LMS and a library could change the identifier each time an item is checked in by the patron. This way no pattern of numbers can be created since numbers are assigned arbitrarily to items.
3.1.3.5 How the usage of the library might change

Introducing RFID technology in the library to locate and track items will have an impact on the way libraries are used, how users interact with physical material, and how physical interactions influence the digital representation.

Existing library categorization systems allow, among other things, the physical organization of items. This organization of items helps to give an item a certain place. Being able to sort items with a library system is important for the location and retrieval of items. Since the RFID technology is able to locate and track the movement of every item, this technology can be used to enhance the existing library categorization system. The RFID technology enables item retrieval without the need for a fixed position, which in return allows users to re-organize items within the library. Users are able to interact with the physical materials by placing them anywhere in the library without having to worry that the item cannot be located afterwards.

Users would be able to group physical items together and place such a grouping anywhere in the library. The LMS could capture and store all movements and groupings of items. This would allow users to later access the groupings they created in the physical world by digital means. Groupings created through physical interaction with library material could be named in the LMS and users could also publish a statement to inform other users about the purpose of the grouping. This would allow other users to comment on the group in the LMS, use user-generated categories (folksonomies) to add meaning to a group, and interact with the group in the physical space. Once other users understand the purpose of a new grouping they could alter the grouping by removing physical items from and adding physical items to any group. This represents a new form of user collaboration, which is enabled by the combination of RFID technology and existing LMS.

3.2 Conclusion

This chapter gave an overview of RFID technology in general and how this technology is used in libraries in particular. Furthermore, it explained how RFID technology could be used in libraries to allow the automated location and tracking of material.
Hopefully the reader got an idea of how RFID technology would connect the digital and physical world and allow the interaction between both realms. Users could generate groupings of items through physical interaction with those items. These groupings could be the foundation for further user engagement and collaboration both in the digital and physical world.

Allowing users to reorganize and replace items in the library has an impact on the way in which items are organized and sorted in libraries. As a result browsing the physical shelves might be affected. The following chapter will examine shelf browsing and how it may possibly be affected by the introduction of RFID technology.
4 Browsing

Introducing RFID technology into libraries, which allows user to interact with the physical material in new ways, might result in changes in the way in which libraries are used and material arranged (see 3.1.3). Changing the arrangement of items in the library might have an impact on the ability to browse shelves for material of interest. This chapter will give a definition of browsing, describe browsing in libraries, and identify different types of browsing. The goal of this chapter is to explore the impact RFID technology might have on shelf browsing.

4.1 Defining browsing

To understand browsing, it is helpful to take a look at the origin of the word browse. Apted (1971) states that the noun browse describes “a young shoot or twig” (p. 228). The word browsing, in its original meaning, refers to an animal eating twigs or grazing for food (Apted, 1971; Shoham, 2000).

The *Dictionary for Library and Information Science* gives a definition that is more meaningful in the library context:

To look through a library collection, catalog, bibliography, index, bibliographic database, or other finding tool in a casual search for items of interest, without clearly defined intentions. To facilitate browsing, libraries assign similar call numbers to items on the same subject, which groups them together on the shelf.

In information retrieval, a search directed by the user in a dynamic but casual way. A clearly formulated query may determine the initial point of entry into an index or database, but searches that begin systematically often give way to an exploratory approach as new terminology is revealed in the results retrieved. (Reitz, 2004)

Browsing could be understood as a ‘grazing’ for new information sources. This is reflected by LeBlanc (1995), who remarked that shelf browsing resembles the original meaning of the word browsing “in the sense that one draws nourishment from knowledge” (p. 294). Hyman (1972)
also analyses the etymological roots of the word browsing and points out that the word itself represents “the idea of unhurried casualness or of an informal search pattern” (p. 19).

To take the word browsing into the library context, browsing is a way for patrons to find material of interest, which then can be borrowed, by grazing the shelves for nourishing items (Apted, 1971; Shoham, 2000).

Not only is the word browsing referring to very different activities in general, grazing animals vs. patrons searching library shelves. The word browsing is also used to refer to the search for items to buy in a store, reading and following links on the Internet, and information retrieval practices in libraries (Shoham, 2000). Furthermore, the word browsing refers to different activities within the library context. Browsing can occur in a catalogue or in the shelves. In the context of this thesis, browsing refers to a search for physical items on the shelves of the library. During browsing a patron is able to access, review, and retrieve physical library material found during the search.

### 4.2 Browsing in the library

In order to browse a library collection and be able to casually look at library items, the material must be accessible for the user. In the context of browsing, accessibility describes the ability of the user to go to the shelves and be able to touch and retrieve material without mediation of a librarian. The ability of patrons to enter the stacks is also known as the open-shelf concept, which became a popular form of access in British and American public libraries during the end of the nineteenth century. Granting patrons direct access to the shelves became the main form of item retrieval in American academic libraries during the beginning of the twentieth century (Shoham, 2000).

During the process of shelf browsing the patron walks through the stacks of the library looking for books, magazines, journals, and other material that are of relevance. The user is able to look for authors s/he knows or titles that promise to contain relevant information among the available material. One of the main benefits of shelf browsing is that the user has direct access to the item,
which allows the scanning of the table of content or the skimming of a chapter. Hosmer describes browsing this way:

As you pass along the shelves, it is enough, in the case of most books, merely to touch the title page with the antennae; with others, a paragraph may here and there be tasted; as to few, content does not come until a chapter has been devoured; while, for two or three, the conscience will not be appeased until they have been chewed and digested from cover to cover. Who can tell what books he wants without preliminary tasting? (Hosmer, 1890, p. 34)

Hosmer describes browsing as a selection process that allows users to pick books, while walking through the shelves, and decide if the content might be of interest to them. In contrast to Hosmer’s description of the browsing process, Morse (1970) analyses browsing by applying search theory. Search theory was developed during World War II to discover enemy submarines using scouting aircrafts. The theory suggests that there is a relationship between the chance to discover something of interest (aircrafts or books) and the effort spent for the search activity (p. 391). Morse compares the search for submarines and the browsing activity by stating “the action of browsing, of looking along a section of library shelves in the hope of finding a book of interest, is a similar activity [as looking for submarines] with a similar law of diminishing returns” (p. 391). Morse (1970) understands browsing as a search and he analyses this search in the light of efficiency. He is concerned with the maximum number of titles in a subject section that still allows an assessment of this section in “a quarter- to a half-hour” (p. 400).

Hildreth (1982a) agrees with Morse, that browsing is a form of search, by describing browsing as a subject search. For both authors browsing requires the classification of items on the shelf by subjects. Such a classification is achieved by using a library classification system, like the Dewey Decimal System or the Library of Congress Classification, to arrange the books on the shelves. For Hildreth browsing is part of the subject search process and the main reason for browsing is “to find items relevant to a topic or area of interest” (Hildreth, 1982a, p. 127).

Although Hildreth uses the term search while describing browsing he does not understand browsing as a strictly structured process. This becomes obvious when Hildreth states "persons browse, among other reasons, because their criteria of interest are not precisely defined, or are open-ended and subject to redefinition" (Hildreth, 1982b, p. 185).
The descriptions of Morse and Hildreth describe browsing as a search activity used to find items of interest. This interest might be fixed or change during the browsing since the user might skim material, which might refine or change the interest.

LeBlanc (1995) describes browsing as being not the central activity for information retrieval; however, he sees browsing as an activity that brings new insights and inspiration to the library user. This becomes obvious when LeBlanc states, “the value of browsing in a library context can be seen as a supplementary, but also vital, one” (p.295). LeBlanc understands browsing as a way for users to refine vague interests and to discover unforeseen information.

Markey (1984) uses the term “bookshelf-browsing” (p. 91) for shelf browsing. Markey suggests that browsing allows patrons to link their search subject with at least one location on the physical shelf. The shelf locations a user selects are defined by the classification scheme used in a particular library. Users match their own search subject against the classification scheme by using “the catalog to find class number areas for browsing” (p. 91). Querying the catalog will provide the users with locations, which are then used to browse the shelves for other related material. This description of using the catalog as an entry point for a search on the shelf overlaps with the description of browsing in the Dictionary for Library and Information Science (Reitz, 2004). Hancock (1987) describes browsing in a similar fashion, where the user either uses a bibliographic tool to locate an item of interest on the shelves or goes to a know shelf directly.

Browsing can be understood as a direct search of the library shelves for items that correspond with the needs of the searcher. Some sources describe the search as a directed activity to search certain shelves, which were identified by the searcher to suit his or her needs. Other sources understand browsing more as an exploratory activity that reveals new information, which leads to a change in the search. Instead of looking for sources that fit the needs the user creates new needs during the browsing.

The following section explores how browsing is divided into different browsing types.
4.3 Types of browsing

Various conceptualizations of browsing are described in the literature and these descriptions often imply that there are different types of browsing, depending on the purpose and goal of the user. Herner (1970) describes two types of browsing, which he calls directed browsing and undirected browsing. Directed browsing intends to achieve a specified goal and to satisfy an information need, while the path to the goal is unknown. The user knows what he is looking for, but does not know in detail how to get the information. Undirected browsing, in contrast, is done without a specific goal or need in mind. The user is looking or skimming through books, journals, or magazines without having a defined goal of what to find or learn. Most likely the users want to be surprised by the findings (Herner, 1970).

In a similar fashion to Herner’s conceptualization of browsing, Apted (1971) suggests dividing browsing into general browsing, general purposive browsing, and specific browsing. Apted’s general browsing is explained as an activity without purpose, which is most likely performed for pleasure (Apted, 1971). As a result, Apted’s general browsing and Herner’s undirected browsing represent the same idea; browsing is done without a specific goal in mind. General purposive browsing is undertaken for work or study purposes and sources might be accessed either planned or unplanned. Furthermore, the users have a goal in mind and hope to discover new information that suits the goal of the search. Users are often unable to specify exactly what information is needed until it is discovered. In contrast, specific browsing is described as a very directed search performed by researchers to find needed information. The user has an intended search direction and the search is not performed casually (Apted, 1971).

In contrast, Buckland (1988) does not divide browsing, as done by Herner and Apted, but rather describes it as one activity. Browsing is characterized as a casual and informal activity “which is low on document specificity but might at any level be of information specificity” (p. 56). This means that the browser does not intend to find information in a specific item (low document specificity); however, the user might have a more or less defined need to find certain information (information specificity). This is also reflected in Table 4-1.
Table 4-1 Document and information specificity of browsing

<table>
<thead>
<tr>
<th>Information specificity</th>
<th>Document specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>low</td>
<td>X</td>
</tr>
</tbody>
</table>

Buckland’s description of browsing can be interpreted as being the same as Herner’s undirected browsing or Apted’s general browsing. An indicator is that Buckland describes browsing as being casual and informal. Further, low document specificity can be understood as an undirected and casual search where the user did not spend much time to ensure that the document categories match his information need. That browsing “might at any level be of information specificity” (p. 56) emphasizes the casual nature of the activity. The user evaluates sources during the browsing and decides then if the information fits his needs.

Baker (1986) makes a similar point to Buckland’s by stating that “browsers use informal, but not necessarily unsystematic, search strategies” (p. 316). In Baker’s example, a library patron has a clear idea of what information to look for. The patron looks through several hundred titles to find material that fits to the information desired. However, this looking through, or browsing, is influenced by external factors, like book covers, titles, and author’s names (Baker, 1986). This is probably what Baker means with informal search, since not all material is treated in the same way and the external factors might draw more attention to certain items. Baker’s description, however, matches Herner’s directed browsing in the fact that the user has a clear understanding of the information s/he is looking for.

Goodall (1989) divides browsing into three levels “ranging from a haphazard and heuristic approach to one relying on chance and commonsense or even one that utilizes a systematic search” (p. 7). This means that Goodall understands browsing as an activity that ranges from being unplanned, almost chaotic, to a very structured search activity. Describing different levels of browsing is in line with Herner’s and Apted’s descriptions. Describing browsing as a systematic search reflects the ideas of Apted's purposive and Herner's directed browsing.
Browsing that relies on chance could be seen a form of general or undirected browsing. The heuristic and haphazard form or browsing introduces a new concept. A user might not look for anything particular and come across an item of interest by coincidence. Such a discovery is also known as serendipity.

Beheshti (1992) acknowledges the division of browsing according to purpose. However, the author summarizes these divisions into two browsing categories and calls them random browsing and systematic browsing. Random browsing is described as being done in public libraries mainly for leisure reading. Systematic browsing is part of a systematic search strategy to find information that the user needs at this moment (Beheshti, 1992). Beheshti’s systematic search matches Apted's purposive and Herner's directed browsing. Random browsing seems to be the same as Goodall’s heuristic and haphazard browsing. Users looking for leisure reading might not look for a specific item and might not have defined information needs. The discovery of interesting items is random and serendipitous.

4.3.1 Serendipitous browsing vs. aware browsing

Many have written about browsing and distinguished different types of browsing. While the degree of organization differs for the described ways to browse, most share that the fact that users are aware of their information needs. Regardless of the fact that users search the stacks in a very organized way or not, most users search to find information about certain topics. I call this aware browsing, because the user is aware of the information that s/he wants to discover.

Serendipitous browsing, in contrast, is a type of browsing where information is discovered randomly and without intent. This does not mean that the information might not fit to the information needs of the person browsing. However, it means that browsers are not aware of their needs while browsing.

Buckland (1988) describes serendipity as the result of a vague, unsystematic search for anything of interest. Information of interest is discovered by accident during browsing and not as the result of a directed search. It is important to note that Buckland understands serendipity as finding material that the user has a need for, but is discovered accidentally during browsing. The user was not looking for this material during browsing. Apted (1971) describes serendipity as a
accidental discovery during browsing and this backs Buckland’s definition. Hyman (1972) describes serendipity as an activity during which the searcher discovers unexpected, yet valuable, things by accident. However, Hyman opposes the usage of the term serendipity to be used in conjunction with browsing since it is “not relatable to any intellectual goal or activity” (p. 133). For Hyman, browsing is a search activity that is only possible through a collection that is arranged by library classification systems. Such an arrangement allows users to discover material for the information needs they are aware of. Serendipitous browsing uncovers material by accident and there is no need for system to sort material to allow a random discovery.

Aware browsing is an activity to find material that satisfied an information need that the browser is aware of. In contrast, during serendipitous browsing users will find material that suits an information need that they were at this moment not aware of. A user is not looking for specific information and finds information by chance.

### 4.3.2 Berrypicking

Marcia Bates (1989) describes an approach to information retrieval that differs from the traditional model where a user has a fixed information need for which s/he defines a search query. The goal of the search is to find a resource that fits to the query and as a result satisfies the information need. In contrast Bates describes a much more fluid model of information retrieval, which she calls berrypicking (p. 410). During the search process a user will retrieve and access various sources in order to determine how useful the content is. With each resource that a users reads the user will gain “new ideas and directions” (Bates, 1989, p. 410) and the user will be create “a new conception of the query” (p. 410). As a result the user will go from source to source and with every resource s/he accesses the initial information need and search query will be adapted.

Not only are the information need and the query changing, but also the way in which the information is discovered. Bates mentions six widely used strategies for resources discovery: footnote chasing; citation searching; journal run; area scanning; subject search; and author searching (Bates, 1989, p. 412). All of these strategies, with the exception of area scanning, are meant to identify a resource first and then retrieve the resource for access. Area scanning or
physical browsing gives access to resources and the user accesses them without having identified a specific resource beforehand. According to Bates (1989) browsing exposes a searcher to material that “may be related in unexpected ways” and create “serendipitous discoveries” (p. 417).

While allowing users to organize the physical items in the library might have an negative impact on browsing it seems that serendipitous browsing and discovery is fostered by unexpected relations and their discovery. If more or less of these unexpected discoveries happen after the RFID technology is introduced has to be seen. Chances are that material that is arranged by a user will create serendipitous moments for other users.

Information Foraging Theory might help to predict how browsing is affected by the RFID technology and the resulting re-organization of items by the users. Information Foraging Theory leans from optimal foraging theory which is used in biology to describe how organisms decide where and what to forage and when it is beneficial to move to another source (Pirolli, 2007). According to Pirolli (2007) humans evolved to be informavores and we store and gather information to adapt to our environment (p. 13). We are driven by information cues or scents that allow us to determine if it is beneficial for us to search for information in a resource we are currently accessing or if it is better to move on and look for another resource.

While Pirolli’s work is focused on how we forage for information on the web it might be a helpful framework to make better predictions about shelf browsing. Marcia Bates understand information retrieval as a fluid process in which we access information, change our search query, and move on to new resources. The decision when to move on to another resource might be explained with Pirolli’s information foraging theory. The question is which cues or scents help users during physical browsing to decide which source to access and when to move on to another resource. Future research might build on both approaches to understand what influences browsing and makes it successful or not.
4.4 Conclusion

This chapter introduced the concept of physical shelf browsing in libraries. The word browsing itself contains different meanings, as does the concept of browsing within the context of libraries. Some scholars describe browsing as an unordered activity, not meant to achieve a certain goal or follow an explicit purpose (Apted, 1971; Beheshti, 1992). In contrast, others describe browsing as part of access to bibliographic records, which complements catalogue searches as well as other forms of access (Markey, 1984; Hancock, 1987). Browsing is understood as a systematic search following the goal to satisfy a certain information need of the searcher.

For Apted (1971) it is necessary to sort items on the shelves of a library to enable browsing. Only if the material is arranged through a classification system will users be able to find material that satisfies the information needs they are aware of. This is of relevance to this thesis. Introduction of RFID technology into the library and using it to locate any items in the library allows new forms of user interaction. The ability for users to place items anywhere within the library, since the system is able to locate items at any time, will affect browsing that is based on a classification system. Once users start to shuffle items around in the library they will presumably dissolve the way in which items where organized by traditional library categorization systems.

To understand the concrete effects of the RFID technology on aware browsing empirical research is necessary. Research in a library where users are able to reorganize items might help examine the effects on browsing. The distribution of items might be so random that aware browsing becomes unfeasible. However, there is also the possibility that users group and arrange items according to new user-generated categories that also allow aware browsing. A final and satisfying answer will only be available once libraries are using RFID technology as suggested in this thesis and research is conducted to understand the effects on browsing.

The unordered, serendipitous, and almost accidental concept of browsing applies to any kind of library and material. The success of the browsing activity does not rely on a certain way of organizing the material. In contrast, many argue that the classification of material is necessary to use browsing as a research method; however, only if the material on a shelf is covering a certain topic will browsing help the searcher to discover material related to his or her information need. There are some problems with this argument, ranging from whether one classification scheme
will sort the material in a useful order for all users, to technical problems like borrowed or misplaced material. Either way, browsing seems to be a controversial concept.

During serendipitous browsing users find material they are not actively looking for. They are looking over various items and randomly discover material that triggers their interest. There is no description that serendipitous browsing depends on the sorting of items with a classification system. On the contrary, Apted (1971) describes serendipity as being the opposite of “browsability” (p. 133) since it depends on accidental discovery and not on a structured collection. Discovering items during shelf browsing by accident in a random manner seems not to depend on how and if the items are organized and sorted. As a result, it seems safe to assume that serendipitous browsing will not be affected by the introduction of the RFID technology outlined in this thesis. However, research would allow comparison of the effects of different material organization strategies on serendipitous browsing.
5 User participation in libraries

5.1 Introduction

Libraries need to change to get ready for the future. Change, however, is nothing new for libraries; libraries opened their stacks in America and Britain during the beginning of the 20th century (Shoham, 2000) and changed from using card catalogues to online public access catalog (OPAC). The next major change might be caused by a technological change that connects physical and digital interaction of users more closely. Using RFID technology to track the movement of library items allows users to browse for and interact with physical material in novel ways.

On the Internet users are increasingly able to participate, not only in the consumption, but also in the creation of media. This shift from a media that mainly pushes information to users to a media that blurs the line between consumption and creation is often labeled as Web 2.0, a term that was coined and explained by Tim O’Reilly (2005). Web 2.0 was already discussed in chapter 1 of this thesis.

The library world is starting to think about user participation and uses Library 2.0 as a term in analogy to Tim O’Reilly’s Web 2.0 (Casey & Savastinuk, 2006; Maness, 2006). In this chapter I explore user participation in the library and how participation is influenced by physical interaction with library items. A framework for levels of user participation will be described as well as a framework for enabling user participation. These frameworks will help demonstrate how user participation and new ways of interaction with physical material influence each other. In addition, the impact of user participation and physical interaction with items on browsing is discussed.

5.2 Library 2.0 and user participation

Tim O’Reilly (2005) describes flexibility and the capacity for user participation as the key elements of Web 2.0. In order to express similar developments in the library world, Michael Casey coined the term Library 2.0 (Maness, 2006). Casey and Savastinuk (2006) define “user-
centered change” (para. 3) as the main feature of Library 2.0. They define Library 2.0 as “a model for library service that encourages constant and purposeful change, inviting user participation in the creation of both the physical and the virtual services they want” (Casey & Savastinuk, 2006, para. 3).

Maness (2006), in contrast to Casey and Savastinuk, understands Library 2.0 as being limited to web-based technologies. Nevertheless, user driven interaction, collaboration, and innovation are at the core of Maness’s definition of Library 2.0. In the context of this thesis the definition of Casey & Savastinuk is more helpful since their definition describes Library 2.0 as being a term that governs user participation in physical and virtual services.

Library 2.0 is about change in the library, and like change in Web 2.0, this change is constant and user-centered (Casey & Savastinuk, 2006). The goal is to allow users to determine the services a library offers and how these services are used. According to Casey and Savastinuk this is achieved by allowing library users to contribute and share in order to use the collective intelligence of all users. Much like in Tim O’Reilly’s vision of Web 2.0, Library 2.0 allows the user to participate in the production and consumption of content (Maness, 2006).

In the following sections I will explore Library 2.0 by looking at user-generated categorization, also known as folksonomies (see 5.3). Further, I introduce a framework to describe different levels of user participation (see 5.4), and a framework of enabling factors for user participation (see 5.5). This will help to understand how user participation can be enabled in the library context. Further, the connection between user participation and browsing will be discussed.

5.3 Folksonomies

The word folksonomy is a neologism that combines the word folk and taxonomy into one word. The term folksonomy was coined by Thomas Vander Wal in 2004 (Vander Wal, 2007) and expresses the idea of a user generated (folk) categorization (taxonomy) in one word.

A common way to allow users to create folksonomies is by allowing users to tag resources. Tagging means that a user is allowed to assign free text labels to a resource. The user is able to assign as many tags to one resource as seems appropriate to the user. Through tagging the users
categorizes the resources and creates multiple ways to later find this resource again (Smith, 2008). As a result, tags represent users’ categorization of a resource. Once users start to share their tags with other users, a combined, user-generated categorization is created. LibraryThing\textsuperscript{4} is a website that allows users to manage their own book collections. Users are able to add book descriptions and tag each of the books in their own collection. In addition to their own tags users see the tags added by other users. If multiple users add the same tags to a book the tags gain more weight and show up larger when displayed in a tag cloud. A tag cloud shows tags added to a resource by various users. If many users add the same tag to a resource this tag gains more importance and appears bigger within the tag cloud. In a way a tag cloud visualizes how much different users agreed on the usage of various tags for a resource. More agreement makes a tag appear big in the tag cloud, whereas little or no agreement makes a tag appear small.

Delicious, a social bookmarking site, and Flickr, a photo sharing site, are often used as examples for the early usage of tagging and folksonomies (Dotsika, 2009; Smith, 2008; Vander Wal, 2007). This means that resources are often described as links or pictures; a resource, however, could be anything. Some examples for resources that can be tagged and services allowing the tagging of these resources are: bookmarks - Delicious; pictures - Flickr; Mails - Gmail; presentations - SlideShare; videos - YouTube; posts - Wordpress; and books - LibraryThing (Smith, 2008). This list is just an example to show that virtually any resource could be tagged on the Internet. Instead of restricting tagging to a picture on Flickr users might want to tag a set of pictures or parts of a picture. The more flexibility a system offers the better the system is.

In the context of the RFID system suggested in this thesis a resource could be the entry of an item in the library management system (LMS). Another possibility would be to capture groupings of material in the LMS. These groupings could be created by a user through the arrangement of physical items, which should be part of the group, together at the same location. Allowing users to add tags in the LMS to such a grouping would allow users to create a resource through physical interaction and use the resource in the digital world to create their own tags. Further, other users could also tag this group and collaborate with the user that initiated the group. Folksonomies allow users to add explicit meaning to a grouping of items that was created

\textsuperscript{4} http://www.librarything.com/
through interaction with physical items. As a result folksonomies are part of the collaboration between users of the library.

Folksonomies represent an important tie between physical interaction and digital representation. Groupings of items are generated through physical interaction and captured by the LMS through the RFID technology. These groupings can be named, through folksonomies, and are the basis of further user collaboration.

This subsection introduced folksonomies and briefly addressed how they could be used in conjunction with the RFID enhance library. The following section will introduce a framework for levels of user participation to analyze on which level of participation smart libraries are.

5.4 Levels of user participation

User participation, like user-generated categories, can be analyzed by evaluating the effort it takes for an individual to participate in the group effort. Shirky (2008) uses the analogy of a ladder to describe different stages or levels of group effort and their requirements. Going up the ladder means that more coordination between the group members is necessary to achieve a goal. In addition, going up the ladder means that the things created by the group increasingly represent a coordinated group effort instead of the sole accumulation of individual work.

The framework described by Shirky has four levels of user participation with growing involvement of individual users. These are the stages:

1. **Sharing**: This is the basic level of user participation with low demands on the users. A user is free to participate as much or little as s/he wants and there is not much group coordination needed. Uploading pictures to a photo sharing site like Flickr or bookmarks to a social bookmarking site like Delicious allow the user to share content (picture or bookmark) as well as tags automatically with other users. Users offering content and tags just need to allow their contribution to be visible for others. Users that want to access content can search for new pictures or bookmarks by searching the tag terms added to the content. Communication and coordination between the users is the next possible step to reach the next stage (Shirky, 2008, p. 49).
2. **Cooperation**: The main difference between cooperation and sharing is that users have to align their behavior with other users to cooperate. Users know each other, share some sort of group identity, and communicate with each other. “Conversation creates more of a sense of community than sharing does” (Shirky, 2008, p. 50). If a sharing site enables and encourages communication between members the result might be cooperation instead of mere sharing. The video portal Vimeo, like some other video portals, allows users to comment on videos. This creates a discussion about the video; Shirky similarly points out that YouTube has a function allowing users to respond to videos with a video and mark it as a response (p. 50). Cooperation and communication introduce the problem of inappropriate conversations that can range from spam to name-calling. As a result some policing and coordination is needed to counteract these problems.

3. **Collaborative production**: Shirky describes collaborative production as being part of cooperation but in “a more involved form” (Shirky, 2008, p. 50). However, it makes sense to see collaborative production as a separate step on the ladder since the group does now start to create things together in a coordinated effort instead of only having a discussion about each other’s work. The characteristic of collaborative production is that “no one person can take credit for what gets created, and the project could not come into being without the participation of many” (p. 50). The group has to make decisions and has to coordinate the efforts of individuals. Wikipedia is a good example of this stage. Although every user is able to add, delete, and edit content without talking to others, the technology allows community members to monitor changes to selected articles. If a user disagrees with changes made to an article by another user, the changes can be reverted and the users can join into a communication to coordinate their efforts and negotiate about future changes. Collaborative production requires much negotiation and policing to achieve an outcome that satisfies most members of the group.

4. **Collective action**: This is the last step on the ladder of user participation and the hardest to reach level. Not only do users align to create a group and coordinate their efforts to collaboratively produce something; moreover group decisions become binding for the individual users. In collective actions responsibilities are shared among group members “by tying the user’s identity to the identity of the group” (Shirky, 2008, p. 50). An example of collective action would be a union or political party where each member of the group
shares the group identity and is bound to group discussions. Shirky gives no example of an Internet service that reaches this level at the moment. This might be true because groups in the Internet are often only loosely knit around a goal that needs to be achieved. Such goals could be the creation of an encyclopedia article or the discussion of a current political issue. Once the goal is reached the group might dissolve and members might join different new groups. Collective action requires long-term commitment.

Folksonomies are at the sharing level of this user participation ladder. Each user adds tags to either existing resources or resources s/he added. There is no need for users to communicate, collaborate to produce, and most certainly users are not bound by group decisions. Enabling library users to add tags to resources, which could be a single item or a group of items, introduces sharing into libraries. However, more interaction between users is needed to foster collaboration and collective action.

Wikipedia embraces discourse between its individual contributors. A user is able to use the contributions of others to build on. This could be by editing a text, deleting a contribution, or by adding more to an article. In order to decide which articles are written, when they are written, and how they are done, users have to communicate with each other. The ability to challenge and question the contribution of other users is what fosters the communication within Wikipedia. Smart libraries can learn from the Wikipedia example to encourage collaboration. Collaboration could be achieved by encouraging users to challenge what other users do with the physical collection. For example, users should be allowed and encouraged to look at groupings created by other users and challenge those groupings. This could be done by adding a comment in the LMS about the grouping or the tags associated with the grouping. A user might also add his or her own tags to a grouping in order to challenge the tags added by other users. Further, a user can add or remove items from a grouping in order to alter the grouping. The digital world would allow a discussion about the changes throughout time.

Shirky does not give an example for collective action in the Internet and it is unclear how libraries can reach collective action. Users of a library might only have a temporary interest in participating within the library much like users of Internet platforms. In this regard libraries might have difficulties to reach collective action. However, libraries are institutions with employees, which helps to coordinate collective action. While users might come and go
librarians are able to provide continuity. The librarians can complement the collaboration between users by adding to discussions, contributing categorizations, and by challenging the contribution of users. However, librarians do not represent the user basis and the fact that librarians identify with the goals of the library has not implications on the users.

The RFID technology in smart libraries (see 3.1.3.2) makes it easy for users to challenge each other. All that is necessary to challenge and to change a grouping of materials is to rearrange some or all of the items of the grouping. All changes to the location of items are tracked and recorded by the LMS through the RFID technology. However, to collaborate users need to be able to engage in discussions in order to reach agreements about groupings of items and how these groupings are categorized. Such discussion is mediated through the digital space where users are able to leave comments on groupings and tags as well as they are able to respond to any discussion. Reaching collective action seems to be impossible for library users, since they are not bound to decisions and might not identify with the group at all.

Another dimension to analyze user participation is to look at what enables participation. The next section will introduce a framework for enabling factors of user participation.

5.5 Enabling user participation

To describe what enables user participation I will use a framework about participatory culture developed by Jenkins, Purushotma, Weigel, Clinton, and Robinson (2009). While the study is concerned with youth media literacy education, Jenkins et al. offer a framework to understand what enables participatory culture (2009, p. 5-6).

Participatory culture is defined by Jenkins et al. as follows:

- relatively low barriers to artistic expression and civic engagement,
- strong support for creating and sharing creations with others,
- some type of informal mentorship whereby what is known by the most experienced is passed along to novices,
- members who believe that their contributions matter, and
• members who feel some degree of social connection with one another (at the least, they care what other people think about what they have created).

(Jenkins et al., 2009, p. 5-6)

Using this framework will allow evaluating a RFID system that allows users physical interaction with library items in the light of user participation. While not every point might be offered by technology, the technology must allow these things to happen and can even support them. However, some of the points might also be achieved by a user community without explicit technological support.

The framework of Jenkins et al. (2009) can be better understood by discussing it with the example of users’ physical interaction with items in a smart library:

1. Creating groupings in a smart library is very easy. Users just have to place items that they want to group together at the same location. The LMS will use the RFID technology to locate items and record groupings without user intervention. User might later add one or more tag(s) and any word can be used as a tag.

2. User interaction with physical items is tracked automatically. Once a user adds a book to a certain location, other users can find the grouping and add tags to it. This is even possible if the user that created the grouping through physical interaction did not add tags to the grouping. Groupings represent the resources in a smart libraries user participation system. These resources are recorded and added automatically. Sharing happens instantaneously and automatically.

3. Mentorship in the Internet is often done through forums where users can help each other with problems. This is also true for systems that support folksonomies. LibraryThing calls the forum “Talk”, Delicious has a “community forum”, and Flickr a “help forum”. In each forum users are able ask questions about how to use the service and other users answer the questions. Forums are a form of mentorship to pass knowledge to novices. In a library users could have access to a forum. Furthermore, knowledge can be passed to users through direct interaction with other users or library staff.
4. Any user is able to create a grouping and is free to add a categorization in the form of
tags to such a group. Further, users are able to discuss the folksonomies used and items
included in a grouping. Any user can change items in a grouping or create a new one.
Giving users the feeling that their contribution matters is not easy to achieve. Their
groupings might be ignored and the items in this grouping might be removed and
distributed to other groupings. However, if a library is able to foster a culture where
groupings are rather challenged than removed users might feel that their contribution
matters. Even more so if the items stay where users put them. Furthermore, libraries can
encourage the tagging of groupings and items to foster user contribution.

5. The last point in the framework of Jenkins et al. refers to social connection. This point is
directly linked with Shirky’s levels of participation. Tagging in its known form is about
sharing and as a result offers little to no social connection between individual users. The
same is true for smart library systems. Groupings are added automatically and users never
have to communicate or collaborate with each other. However, users are able to challenge
a grouping of other users by adding or removing physical items from such a group. To
prevent users from merely negating each other’s changes these users will have to
communicate and agree on further steps. This requirement for communication and
collaboration creates a temporary social connection between users.

This framework can be used as a guidance to enable user participation within libraries. The goal
is to keep the barriers for participation for users low. Allowing and tracing physical interaction
with library items represents a very low barrier for participation. Libraries have to ensure that the
LMS makes sharing and collaborating easy for users. The most challenging parts will be to
ensure users that their contributions matter for themselves and for their other users in the library
community. These goals are hard to achieve solely by using technology and library staff has to
ensure that users feel connected with other users.

The following section will describe user participation in libraries and how it is connected with
physical interaction with items. Further, the influence on browsing will be addressed.
5.6 User participation in libraries

Most tagging only requires sharing and no coordination, communication, and collaboration between the users. Modifying folksonomies so they are more about collaboration than about mere sharing seems desirable in combination with RFID technology that allows users more interaction with the physical material. Users will be allowed to create the classification of material in a library and they will do this through interactions in the physical and digital space. Users can create groupings of material in the physical world and use these grouping in the digital world to collaborate with each other. Even if this classification does not replace systems like Dewey and exists alongside, libraries should ensure that the classification is created through user collaboration. The physical interaction with items will become more meaningful if users are able to share their groupings with other users and make it the basis of a collaborative process to create a folksonomy.

To achieve collaborative production in libraries it is important that the systems allows discussions and enables collaborations of users about which groups to categorize and which tags to apply. The key is the ability to challenge other user’s work. Although challenging of other users’ tags is not common in current systems that implement folksonomies it should be possible to integrate such a function. Voß (2007) suggests that feedback on tags is a characteristic of a tagging system that is not fixed and can be defined for each tagging system (p. 248). Integrating the ability to challenge tags is based on and encouraged by Voß’s suggestion.

Challenging the contribution of others is how Wikipedia ensures that content is created by collaborative production and not by mere sharing. Wikipedia gives its users a way to easily challenge edits from any user by reverting to a version before the edit. Users are then forced into negotiations about which parts of the edit should end up in the article and which not.

Since all users are able to move any item in the library, challenging the groupings of items is very easy for a user. Libraries have to make sure that users work together on the creation and improvement of groupings. The LMS can help to communicate the reason for and goal of various groupings to other users. Once a user understands what a grouping is about, s/he can add tags, challenge already existing tags, and change the items that are in a grouping.
One way to enforce more user agreement is by ignoring new tags. To make the tag visible a certain amount of users need to add the same tag in order to move the tag over a threshold, which makes the tag visible for others. Users could discuss new tags and promote them in order to secure enough support for a tag.

Libraries could also make it a custom for users to start a discussion about which items are to be included in or removed from a grouping before a user takes action.

Another way to ensure more user collaboration would be to do what Wikipedia does. Let everyone add content and at the same time allow everyone to easily challenge content. For tagging this would mean users are able to add tags to their heart’s content. If other users disagree with a tag the system should allow challenging this tag. Once a tag is challenged the tag is removed and the user that added the tag and the user that challenged the tag have to agree on the next steps. The users might decide to drop the tag, include the tag, or modify the tag before inclusion. Through this mechanism users have to communicate and collaborate to create the resulting folksonomy.

Requiring user discussion and agreement to change tags and alter groupings moves smart libraries up the ladder. They become more like Wikipedia, which is described by Shirky (2008) as enabling collaborative production. Integrating a challenging mechanism enables library users to create the classification in collaboration.

Using RFID technology to track item movement links actions in the digital and physical world. Integrating a challenging mechanism and fostering discussion moves users’ participation towards collaboration, maybe even collaborative production, on Shirky’s ladder. The barriers for participation are low, groupings are created and sharing automatically, and adding tags is very easy. Furthermore, digital forums and the librarians are able to support new users and pass on knowledge. All these features identify participatory cultures according to Jenkins’ framework. However, making users feel that their contribution matters and that they establish a social connection with other library users is not guaranteed. This is more a matter of user attitude and support by other users and library staff.

Unfortunately, connecting folksonomies with the physical interaction with items might have a negative impact on shelf browsing. Various types of browsing (see 4.3) depend on a know
organization of the items on the shelf in order to enable users to search through related items. This is not to say that groupings, created through the collaborative interaction of users, do not put items into an order that can be browsed. The problem is that there is no guarantee that each item is in some kind of relation to neighboring items. Users might put items together that are not related. A user might leave a book on a table after reading and another user might do the same. This might happen out of convenience and neither of the users intended to group the items. However, the items are now close to each other although they might not be connected in any way. This will make browsing at least difficult.

Another problem might be the fact that the order of items can change rapidly, depending on the contributions of users. This makes it hard for other users, which want to browse the shelves, to identify sections where they are able to browse since the order of items is in constant flux. Further empirical research might reveal the dynamics involved in grouping of items and the influence on browsing.

User driven categorization of library items might have a positive effect on serendipitous browsing and discover. Material that is grouped by users for users might allow more discoveries of material that is of interest to users. The items are not ordered by a uniform library system but by users that understand the needs of other users in the library community.

5.7 Conclusion

In this chapter two frameworks to understand user participation were introduced. Both frameworks were used to analyze libraries with RFID technology that allows users physical interaction with items. The analysis revealed the level of user participation and made suggestion on how to improve this level.

Libraries can foster a participatory culture through the right combination of technology and user encouragement. Not all requirements for a participatory culture can be met by implementing technology. Especially social connections between users and the feeling that each contribution is worthy are hard to influence with technology alone. The library community needs to embrace
contributions of new and old members alike. And library users must have the will to establish social connections with other users; no technology is able to provide this will.

The chapter concluded with a discussion of the impact of user participation on physical shelf browsing. Some assumptions can be made on the effects on browsing. However, only empirical research will be able to reveal the impact that the user participation, which is enabled by the RFID technology, has on shelf browsing.
6 Usage scenarios in a RFID enhanced library

6.1 Introduction

In chapter 3 I explored how RFID technology is currently used in libraries and how RFID could be used to allow the spatial tracking of library items. Being able to find each library item by using RFID technology could have an impact on how the items could be physically located, what system is used to categorize items, and who gets to categorize the items.

The idea is to use automatic localization of RFID tags to determine the position of physical items in the library. This allows localization and retrieval of items without having to rely on a library categorization system to organize items in space and opens up the opportunity for users to place material anywhere in the library. When I first started to think about this idea I proposed it to my peers; they often responded by arguing that allowing users of the library to arrange items in the library would destroy the ability to browse items on the shelves. In chapter 4 I looked at various concepts of browsing, which leaves the question: to which kind of browsing were my peers referring. Once users arrange items, it is no longer possible to browse for items in the same category if “the same category” refers to being in the same category according to an established library classification system. Since not many libraries allow their users to categorize the items there is little data on how browsing on user generated categories might work. However, serendipitous browsing (see also section 4.3.1) is still possible since this type of browsing is about discovery of unexpected material and less about systematic evaluation of what items of interest are contained within a certain library classification category.

Without doubt, using RFID to locate items will change the way items are accessed and browsing will be part of this change. Change does not mean that browsing will no longer be possible, change means that browsing will be different.

The biggest and most interesting change is that of allowing the possibility of new forms of user participation. Using technology to locate physical items within the library allows users to place items where they want. This freedom of placing items allows unknown interactions with the physical items in a library collection. Users of a faculty library could for example create a
grouping of books related to a course offered. Such a grouping could be initiated by the professor teaching the course, a librarian, or by some of the students. Regardless of who starts to group items for a certain purpose, every user of the library can contribute to such a group of items once the user community starts to agree on the goal of the grouping in question.

The following chapter will describe the possible design and implementation of an RFID system that can locate physical items in the library. The emphasis is on how items are tracked, how users are able to retrieve material from the library, and how users could participate in the creation of new categories for and relationships between items.

### 6.2 Finding physical items with RFID technology

Building a library system that guides users to the items they want to retrieve requires the ability to locate each item in the library collection. There are two different approaches to use RFID for the location of physical items. Since the two approaches could be combined there are three possible scenarios of implementing RFID technology in a library to locate physical items.

Scenario one, called “smart shelves”, uses smart shelves, which divide a shelf into sections and are equipped with RFID readers. These readers can detect items that are enhanced with an RFID tag and guide the user to the section of the shelf where an item is located. While this solution does not allow detecting items anywhere else but on the shelves, smart shelves are commercially offered solutions that have been proven to work.

Scenario two, called “smart library”, allows the localization of RFID tags in space to determine the location of an item that is equipped with an RFID tag. While this solution offers the ability to locate physical items anywhere in the library there is no ready solution available. There is, as of yet, no deployment of a system using RFID to locate items anywhere in a room in a library setting. However, there is experience with the localization of RFID tags through the application of various radio frequency based localization techniques, as shown by Zhou and Shi (2009). This solution is not readily available on the market right now. Nevertheless, this approach is based on research that suggests that such an approach should be feasible.
Scenario three is a combination of the other two approaches. The benefit is that this solution could combine the freedom of localization in space and the precision of smart shelves. Another positive aspect is that this scenario, “combination”, allows an implementation in stages. Smart shelves are available and could be installed within a short time frame to get the system started. The harder-to-implement second part to triangulate RFID tags anywhere in the library could be implemented later on. Problems occurring during stage two would not affect the RFID system since the smart shelves are already in place.

The following sections (see also 6.3, 6.4, 6.5) will explore the scenarios in more depth and provide a comparison of the benefits and problems of each scenario.

6.3 Scenario 1: Smart Shelf

Using RFID technology to determine the location of library items can be achieved by using smart shelves. The concept of smart shelves was introduced in section 3.1.3.1. A major benefit of smart shelves is their availability. A number of companies are marketing smart shelves for the usage within libraries. Using a technological solution that is proven to work and supported by a vendor helps libraries to lower the risks of failure during the implementation phase. A library introducing smart shelves is not attempting to implement a solution that might not be feasible. Furthermore, the manufacturer of a smart blade solution is able to offer support and expertise during the planning and implementation phase of a project, which intends to implement RFID technology to locate physical items in the library.

A smart shelf is able to track the inventory permanently. This means that the library management system (LMS) knows which items are on the shelf and in which section each item can be found. Continuous tracking of items on the shelves would give libraries access to data about usage of items that do not circulate and are only used within the library. If a user retrieves an item from a shelf and puts the item back at its original location, it is currently difficult for the library to record this usage.

5 http://www.intellident.co.uk/smartBlade/
Another benefit of smart shelves is that there is no need to do an inventory manually any more since the system is monitoring the inventory on the shelves permanently. This permanent awareness about which items are located where allows a very interesting change to the way libraries make their material available to the users.

Having a system that locates items provides an alternative access mechanism to existing library classification system. The smart shelf system will be able to guide users to the items they are looking for.

6.3.1 Guiding the user to the library item

To retrieve an item the user first has to find the item by searching the online catalogue of the library. The system is able to locate the item on the shelves at the same time and show the user in the search result if the item is on the shelf and where it can be found. To guide the user to the location of an item, shelves and sections need to be labeled. These labels should uniquely identify each shelf and each section on the shelf. The easiest way is to number the shelves starting at one and number each section on a shelf in the same manner. Combining the number of a shelf and section to guide a user could then look like this: 12-08. This would be the 12th shelf and on that shelf the 8th section. Such a numbering of shelves and sections would, however, not offer much of an improvement and the only benefit is that books can be moved around on the shelves while the systems keeps track of the shelf and section number.

An improvement in usability would be the introduction of interactive floor maps, which could make it easier for users to find and retrieve items from the shelves. A user would be able to search for an item in the online catalogue by the title, the author, the general topic, or any other way; much like a search is nowadays done in most libraries. The difference is the result of the search. Instead of having a call number, generated by a library classification system, the system would display the shelf and section number as well as a link to a map. Once the user follows the link to the map, the floor plan of the library will be displayed and the shelf that holds the requested item would be marked and emphasized by contrast and possibly color. Further, it would help if only the section that holds an item is marked and emphasized. Such a map should help the user to get a faster orientation of the stack and be able to retrieve items more quickly,
even if the user is unfamiliar with the library. An example of such a map can be seen in Figure 6-1.

Figure 6-1 Shelf-to-shelf routing

Viewing a map on a computer in the library allows users to get a better orientation of where to find items they want to access. However, it is cumbersome to memorize a map and becomes harder the bigger a library is. One possible solution to this dilemma involves handheld devices like smart-phone, PDAs, tables, and other easy to carry devices. Often the online catalogue is accessed through a web-browser and many modern handheld devices have a built-in web-browser. While many users already own a handheld device with a web-browser, the library will have to provide handheld devices, which can be borrowed by any library patron.

Users access the online catalogue on the handheld device and perform a search as they would do on a workstation. Once items are found the location of each item is displayed on the map within
the handheld device. Since the map is displayed on a handheld device users are able to carry the map around and use it as a reference to find the location of each item that they to access.

To offer further help and ease of use, the system should include a routing function. Routing could be done in a way similar to online mapping services\textsuperscript{6}. This means that the user is presented with a map in which the current location of the user is shown and a colored line indicates the route to the shelves where the user identified items for access. Furthermore, the system will provide step-by-step instructions giving the user directions on how to reach each intermediary point on the way to an item.

Enabling a routing from the current location of a user to a shelf requires that the system is aware of the user location. Since GPS does not work within a building, this technology and available products cannot be used. One solution is systems that use Wi-Fi based positioning. This is done by comparing the signal information of a Wi-Fi connection to a database that contains Wi-Fi connection information that was recorded beforehand at known points. By calculating the difference between the current signal and the signals in the database a position can be calculated. The “WiFi-based Indoor Position System” (WIPS) at the University of Toronto proved the feasibility of such an approach and also mentions other projects working on indoor positioning via Wi-Fi location\textsuperscript{7}.

The main problem is that current indoor positioning systems are not able to offer the same accuracy of GPS based systems. Missing accuracy and the fact that there are no defined routes, like roads, in an indoor environment make routing, which works like a car navigation system, hard if not impossible to build. However, the accuracy of indoor positioning should be high enough to offer a turn-by-turn navigation. Telling a user, for example, to go to the stairs can be done even if the positioning of the user is a few meters off the actual location. Once the user reaches the stairs s/he presses a button and receives the next instruction. To stay with the example, such an instruction could instruct the user then to go up two floors. Once there the user

\textsuperscript{6} http://maps.google.ca/

\textsuperscript{7} http://scyp.atrc.utoronto.ca/projects/wips
presses a button and gets the next direction. With each step an indicator on the map could change and show the new position on the map.

A benefit of a routing system, of any kind, is that the system is able to calculate the shortest route between multiple item locations and offer the shortest route to reach all locations on the map.

Combining labeled smart shelves with floor maps will give the user different ways to find physical items on the shelf. Another benefit is that the library is able to operate once the smart shelves are installed and labeled. The mapping function can be added later on to reduce the time it takes to implement the new system.

Being able to track items on the shelf allows for new ways of user interaction with the physical material in the library.

### 6.3.2 Interaction with physical items in the library

Not only do smart shelves allow the instant location of items and better user guiding towards an item, such a system also allows users to interact with the physical collection in new ways.

In current open shelf libraries the user is able to retrieve books from the shelf. However, re-shelving is done by the librarian and placing an item in the wrong location will result in future problems to find such an item again. With smart shelves the users are able to rearrange physical items on the shelves. Any user can put any item on any shelf. This opens the possibility for new interactions.

For example, assume a library user working on the restructuring of his garden at home. This user could locate books about gardening and put them on a shelf near the desk s/he is working at. Of course, anybody else could counteract this grouping of items, be it on purpose or by accident, building another group of items for a different purpose. However, it could also be that users find this collection useful and start adding more material to it. To do so users need to communicate that they have started to group certain items together as well as where they placed the items.

Creating a grouping that follows a clearly communicated goal allows other users to participate and foster collaboration amongst users. Collaborative production, as described by Shirky’s
framework, will be achieved if users coordinate goals and challenge contributions, be it either through physical changes to a grouping or digital changes to the associated folksonomies (see also section 5.4).

A way to announce the creation of a group could be the explicit naming of the group. A way to do this would be to tell the system which sections on the shelves are part of the group and give the group a name. The system is then able to determine which items are within the defined sections and therefore part of the group. Furthermore, groups can be viewed by all users and the system is able to show the location of a group on the map. Once other users understand the purpose of a grouping they can start to contribute by adding or removing items from the group of items.

The library staff will also benefit from the free arrangement of items on any of the stacks in the library. Any staff member could decide to put books on a shelf near the entrance to support a certain event. An example for such an event could be Black History Month, an event in “remembrance of important people and events in the history of the African diaspora” (“Black History Month,” 2010). This would only require gathering the items that should be displayed and putting them on the desired shelf. No booking or changes on the system are required since the shelves will recognize such item relocation automatically.

In an academic library shelves could be used to accumulate items for courses. A professor could start a grouping of items relevant to the course by placing recommended readings on a shelf, telling the system which sections on certain shelves are part of the group, naming the grouping, and adding a description about the purpose of the grouping. In order to announce the grouping the professor could link to the grouping in the LMS from a course website and from a learning management system (e. g. Blackboard). Further, the professor could tell the students to take a look at the grouping and give instructions of what s/he expects with the grouping to happen.

Students taking a course that has a grouping in the library could add items that they find useful for the course and at the same time could remove items that are not helpful. After the end of the course the professor could use the computer system to get a list of all items on the course related shelves. Such a list could be compared with the initial item selection and allows the assessment of which items were found to be useful by students and which were rejected. Such comparison
could be done during the semester or on a permanent basis. The system could record items that are added or removed and inform the professor continuously about changes.

6.3.3 Impact on browsing

Implementing smart shelves enables the library to track all items that are on the shelves. Furthermore, users are able to interact with these physical items to create groupings of items that are related with each other in a way that is meaningful to the users. In addition, users can use groupings created by physical interaction in the digital world as a basis for folksonomies. This means that users are able to tag the groupings, which are now the resources.

Allowing users to place items anywhere on the shelves has an impact on physical shelf browsing. If users intend to browse the shelves to search for items that suit their information needs, as described by Herner as directed browsing and by Apted as specific browsing (see section 4.3), they might not be successful. A user will browse a certain shelf because the items on that shelf are categorized according to a library classification system. The benefit of library classification is that the categories are well known and users might know what they can expect to find in a given category. Such a familiarity is lost if users are able to constantly rearrange and regroup items on the shelves.

A user could use the digitally available folksonomies to identify sections on the shelf that contain potentially interesting items. The difference between folksonomies and existing library categorization might be that they differ in their approach to what items get included in a grouping and how are groupings arranged in relation to each other. This means that groupings a user wants to browse are scattered all over the library. As a result Apted’s specific and Herner’s direct browsing might not work anymore.

However, browsing that is done to discover new, unknown material for an information need that the browser was currently not aware of is still possible. Serendipitous browsing is about discovery and less about a systematic search. It might turn out that the discovery of items is easier if other users arrange the items in the library. A browser can profit from the knowledge of other users about current trends and interesting items. Maybe some users dedicate some shelves solely for the discovery of such items.
This scenario describes how RFID technology could be used to locate items automatically on the shelves. In the next scenario RFID technology will be used to locate library items anywhere within the library.

6.4 Scenario 2: Smart library

Being able to automatically detect and locate items on the shelves of a library changes the way libraries are operated and used. Librarians can create an inventory of all items on the shelves instantaneously and everyone in the library is able to place any item on any shelf in the library. As described in the smart shelf scenario this allows some new ways of user interaction with physical library items. Users are able to create and manipulate groups of library items just by moving the physical item. No interaction with another system is required.

Although smart shelves might change how libraries are used and operated, they have a major limitation. Any item that leaves a shelf cannot be detected by the system anymore. As a result the system is not able to determine the location of items that are not on the shelves. The library patron will probably borrow most items s/he takes from a shelf; there is no need for the system being able to locate items that are borrowed. However, not all items are in circulation and non-circulating items have to remain in the library. If a non-circulating item is taken from the shelf, the system is not able to locate this item until it is put back on a shelf. The system cannot differentiate between such an item being used and lying unused somewhere in the library. Furthermore, a user might skim through books to determine if s/he wants to borrow any of these books. Books that are not interesting to the user might not be re-shelved by the user. Since there will be always books that are not on the shelves but still in the library it would be desirable to enhance the RFID system with the ability to locate items outside of a shelf. Of course, the library could equip tables at the end of the shelves with RFID readers. However, this would only cover a part of the area where users could leave books. Equipping every table with RFID readers could help the library to keep track of most books. Unfortunately, items could still end up in areas that contain no RFID reader.

The solution is to create a smart library instead of using smart shelves only. The concept of smart libraries was described in section 3.1.3.2.
6.4.1 Interaction enabled by the system

In the smart shelf scenario users can start a grouping of items and other users are able to contribute to such a grouping. A smart library is not only able to localize items anywhere in the library, but is able to track the movement of any item within the library. This data can be used to detect groupings of items that occur outside of the shelves.

Detecting and identifying groupings of items outside of the shelves allows new insight into the relationships between library items. Allowing users to create and manipulate groups by placing items on smart shelf allows for a new user interaction currently not possible. However, placing items on certain shelves requires an understanding of the purpose of the grouping and contributing to a group is an explicit process. In contrast, constant tracking of item movements within the library allows a deep insight into usage patterns of library patrons. A system that is able to constantly locate physical items offers the ability to track temporary grouping of items that is done during the usage of library material. Such groupings are built implicitly during usage since the user retrieves the books to accomplish a task. Creating a group of books is a byproduct of what the user is doing, the grouping is not the task itself.

Assume an academic library in which a user is doing research for a paper. The user will identify various physical items, retrieve these items from their location, and bring the items to a desk where s/he is currently working. Once the user has some items gathered s/he needs to assess how useful each item is and decide which item is worth a thorough reading and which item can be neglected.

An RFID tracking system is able to trace which item was at a certain location during a given time. In the case of our researching user the system can detect that various items are accumulated on the desk at which the user is currently working.

If the user is later able to access the tracking data, this user is able to get a list of all items on the table at a certain time. The user could take the grouping of items at a location during a certain time and describe the purpose for bringing the items together. In order to ensure that only relevant items appear in such a grouping the user only has to place items that do not fit into the group on another table or shelf.
Being able to retrace the movement of library items not only allows a user to pick a location and a time to create a grouping of items. Furthermore, these movements could be used by a library user to see how s/he discovered items. This could allow users to gain a better understanding of their research process. Such a trace of steps allows researchers to reflexively analyze their own access and selection behavior. Or imagine a user that remembers that s/he skimmed an interesting item during browsing. Being able to retrace the whole browsing and selection process would allow finding the item again in a much more efficient way. Furthermore, the tracking data of the research process could be attached to a publication and serve as research data the same way raw data from experiments is sometimes released with a publication.

Unfortunately, a system that is able to track and record the movement of physical library items creates also a threat for the privacy of library users. The data about search and retrieval patterns can be accessed by others and might be used against the user. This is a problem similar to the usage of a computer in a library. Any action performed on a computer could be recorded and this data could be used against a user. The difference is identification. To use a computer in a library a user usually needs to authenticate by providing a username and password. This allows to link actions with a user. While this allows the surveillance of a particular user, authentication at the same time enables a system to provide data about the usage of the computer only to the user that produced the data. In the example of tracing the movement of physical items there is no way to protect the data selectively. Either everyone has access to the data or only selected librarians.

A solution might be the usage of library cards with RFID tags. The tag in the library card could be detected and would allow to determine and record the location of the library users in the same way the system is able to record the movement of items. Combining the movement of items and users would allow connecting certain groupings of items to a user. What looks like more surveillance on the first sight could allow to protect the data from all other users, while at the same time allow the user to access the data about her/his own movement in the library.

The user needs to have enough trust in the libraries will and ability to keep the data about the movement of a user secure and private. RFID tags create many privacy issues that need further consideration. However, privacy and security issues are outside the scope of this thesis. Further research is needed to create a system that respects and protects the privacy of all library users.
6.4.2 Impact on browsing

As mentioned in section 6.3.3, browsing will be affected by the ability of users to interact with the physical material. While browsing in the smart shelf scenario changes, users are still able to browse to some degree. In the smart library scenario, browsing will be rendered impossible. Not only are items ordered by users without having to follow any schema but also items can be anywhere within the library. This means that the users are no longer able to search items through physical browsing in ways described in section 4.3.

Only empirical research might help to understand how users cope with such a situation. Browsing might be done more and more in the digital space. The benefit of digital browsing is that users will not miss items that are currently borrowed. Additionally, users are able to sort items according to different categorization systems, including folksonomies.

In smart libraries, users have the freedom to interact with physical material anywhere in the library while the RFID technology is still able to trace the movement of each item at any time. The following scenario will discuss the combination of the smart shelf and smart library approach.

6.5 Scenario 3: Combination

The two scenarios “smart shelf” and “smart library” offer different benefits and disadvantages. Smart shelves are an established technology that allows an automatic detection of any material placed on a shelf. Furthermore, the system is able to determine on which shelf and in which section an item is currently placed. The problem of smart shelves is that the system loses the ability to detect an item once such an item is removed from a shelf. This is where a smart library has obvious benefits. Any item can be detected anywhere within the library. However, such a localization technology is not readily available like the smart shelf technology. As a result, the implementation takes more time and bears more risks. More time is needed to calibrate the system and to find the right amount of RFID readers and the optimal place for the readers. The
risk is that the system does not work reliably or requires more RFID readers and work to optimize the system, which leads to higher costs.

Combining both approaches allows libraries to benefit from the advantages of both scenarios while avoiding or minimizing the disadvantages. A combination of smart shelves with the ability to localize items anywhere within the library gives libraries the ability to continuously trace any item within the library.

Smart shelves add a lot of precision to the determination of the location of an item while such an item is placed on a shelf. A system that uses trilateration will also be able to locate items on the shelves. However, the accuracy of the positioning might not be high enough to give the user enough information about where to find the book. The user might have to search through many items until s/he finds the desired item. Just imagine that the accuracy is off by 30 centimeters. For an item on the shelf this means that the system does not know on which side of a shelf the item is located. Smart shelves offer the ability to provide the user with the exact shelf and section on the shelf.

Since smart shelves are only able to detect items that are on a shelf they only cover a small part of a library and of the usage history of an item. This is where localization in space helps to bridge the gap. Once an item is removed from the shelf the system is still able to keep track of the item anywhere within the library and the item can be found regardless of being placed on a shelf or not.

A combination of smart shelves with a trilateration system, which is able to localize library items anywhere within the library, lowers the implementation risk for a library. A library implementing such a system could start by installing smart shelves and labeling all library items with RFID tags. Both things take time and can be done independently or in a combined effort. To install smart shelves old shelves have to be improved or removed. Either action requires removing all items from any shelf that is changed. Taking items from the shelves and placing them on the smart shelves later allows the library to equip these items with RFID tags and register each RFID tag with the associated library record.

Introducing RFID tags, smart shelves, and a computer system that locates RFID tags and links the tag identifier to the library catalogue records might require some time and money. However,
the library should be able to receive help to set up an operating smart shelf system since this technology is readily available. The benefit is that the library can build on top of the smart shelf installation once it is operational. Building the system in steps helps to achieve a working system and then extend the capabilities.

Using RFID technology to locate items anywhere in the library is a new idea and there is not much research and experience about how such a system can be built within a library using passive RFID tags. As a result, the implementation requires equipping at least parts of the library with RFID readers. Once some readers are operational it is important to start experiments and test to figure out how dense the grid of readers has to be to detect items anywhere. Further, tests have to reveal which algorithm to calculate the location works best for the library and how the number of RFID readers affects the accuracy. The goal is to reach good accuracy results, while using the least amount of RFID readers possible since each additional reader costs money to acquire and install.

After the experimentation phase a library will have estimates about how dense the grid of RFID readers has to be and which location methods suits their needs well. This knowledge allows building a test system. This could be in the whole library or if the library is big the system could be implemented on one floor or area. The purpose of a test system is to gain experience how well the system works under real use conditions. Especially interesting is how user traffic affects the detection of items and accuracy of the location of each item. During the test phase a library will acquire data and knowledge about the dynamics of the RFID system that allows an accurate calibration of the system to improve dependability and accuracy.

The implementation and test phase of the RFID system to locate items anywhere in the library will take a long time. However, having smart shelves, RFID tags, and the computer systems implemented allows a library to start using RFID technology before the system is fully finished. Users and librarians might need some time to adapt to the fact that items can be placed anywhere and that the RFID technology will be used by the computer system to locate items for the user. The only difference between the full implementation and the smart shelf stage is the area that can be used to place books.

The combination scenario give users the freedom to place items anywhere within the library while providing high accuracy in locating items on the shelf. Furthermore, the system can be
implemented in stages. After RFID tags and smart shelves are installed the users can start to use the system and get used to the fact that items are located for them and that they are able to interact with the physical items in new ways. A user can place an item on any shelf and create groups of related items on the shelves. After the smart shelf stage is reached a library has time to experiment with the detection of items with RFID tags anywhere in the library. Once a test area is equipped with RFID readers and the system is working, library users can be integrated in the test. All the library needs to do is to tell users that they can leave items anywhere within the defined test area.

6.6 Conclusion

This chapter showed different ways to use RFID technology for the detection and localization of library items. Three different scenarios were described and I explored how users would be able to interact with the physical collection. Furthermore, the impact on browsing was addressed.
7 Conclusion

This thesis explored how RFID technology can be used to enhance the collaboration between users in libraries; the effects of RFID enabled interaction with physical items has on browsing; and showed ways to apply the principles of Web 2.0 to organize physical material.

Currently, users’ abilities for collaboration in libraries are limited. Certainly users can use library items, facilities, and other resources to collaborate on projects. However, users are not able to collaborate to change the way in which items in the library are categorized and organized. Implementing RFID technology to localize physical items within the library enables users’ collaboration. Now users are able to place items anywhere within libraries to create groupings of items that are related with each other. These groupings can be captured by the library management system (LMS) and build the basis for users to organize their efforts. Once the purpose of groupings is communicated, through the usage of folksonomies and comments, to other patrons any user is able to change a grouping. All that is required to collaborate on the composition of a grouping is to physically add or remove items.

The ability to collaborate through the arrangement of physical items has impacts on physical shelf browsing. Currently, users are able to find items that were put in the same category in one location on the shelves. It is easy to find the beginning of a category and look over all books in this category. Allowing users to categorize items through the usage of folksonomies does not change this approach by itself. Assume that the most applied tag defines in which user generated category an item can be found. If the library would sort items on the shelves according to user-generated categories browsing would not change much. However, the scenarios in this thesis are built on the assumption that patrons are free to place items in any location they want. As a result no prediction about the order of items within the library can be made. All types of browsing that depend on a certain order of items will no longer be possible. Serendipitous browsing, which is about unplanned discovery, might profit from the organization of material in new ways since this organization better reflects users’ interests.

The main traits of Web 2.0 are flexibility and the ability of user participation. The application of RFID technology, as it was outlined in this thesis, allows the usage of Web 2.0 principles in the organization of physical material. Every user is able to group items by simply moving items
around in the library. Combining physical interaction with the digital representation fosters the collaboration on the physical arrangement of items. Users can use the digital realm to communicate the goals of certain groupings as well as they are able to coordinate their efforts. Users are able to participate in the organization of library items. RFID technology gives users the flexibility to arrange physical items in any way and at any time.

7.1 Physical and digital interaction

Using RFID technology to locate items within the library allows more interaction between the physical and digital realms. I described in this thesis how groupings of physical items are tracked in the digital world and how these groupings can be used as a basis for folksonomies. This changes what users can tag. Instead of only being able to add digital tags to physical items users are now able to add digital tags to groups of physical items, which they are able to create by placing the physical items close to each other. This means that users are able to determine the frame for digital tagging; users can tag 1 to n items with one tag. However, this solution only scales on an item level and users are not able to tag certain parts of an item.

A possible solution would be to allow users to mark a certain part of a book or journal by adding a physical bookmark that contains a RFID tag. Once the RFID tag is added the user will be able to link the physical tag with the digital item record and add digital tags as well as a description of the section tagged. To better understand the different frames for digital tagging see Figure 7-1.
Figure 7-1 Tagging frames

These examples show how the interaction with physical items influences the digital representation. The digital representation in return influences the physical world. The best example is the retrieval of physical items through routing. Patrons can search for items by title, author, tag, and other identifiers. Once an item is found through a search the LMS will be able to guide the user to the physical item (see also 6.3.1). The digital representation of the physical world enables the LMS to guide a user in the physical world to the desired item.

7.2 Impact on libraries and librarians

Introducing the RFID technology as proposed throughout this thesis will impact the way libraries are operated and change the role of librarians (see also 3.1.3.5). Library operation will become much more automated and users will gain more control over the physical items. This control includes the arrangement and placement of items within the library as well as the meaning making through the usage of folksonomies. Giving control and responsibility to users will challenge the authority of librarians since they will loose control over the meaning making and ordering of physical items. The interesting question in the future will be if libraries and librarians are willing to allow such an authority shift to happen.
Loosing authority and control might create resistance among librarians against the RFID technology presented in this thesis. However, librarians will not loose all of their authority and purpose. Librarians will most likely make the decision on which items are added to the collection since the resources of libraries are limited and each library has to justify the money spent for acquisition. And only if librarians decide how the money is spent they will be able to take responsibility of these expenses. Further, librarians will still play a crucial role in assisting users to find material that is relevant to the needs of the users, regardless of this material is digital or physical.

Introducing new technologies will also create new responsibilities for librarians and give them new authorities. Using folksonomies allows any patron of a library to add tags to resources. And while tags that are wrong, offensive, and meaningless do not matter in folksonomies on the Internet they will in a library. On the Internet it is the amount of people that participate that works as a correcting force. Many users will add the same tag to a resource. One offensive tag will not matter much and disappear in mass of non-offensive tags. Unfortunately, this works due to a large user base and might be a problem for libraries. A small library will not have many users to begin with and only a portion of the whole user base will contribute to the creation of a folksonomy. As a result an offensive tag will have much more weight and be more visible since there are not hundred of thousand tags to correct this. Removing offensive tags might become a responsibility for librarians and give them new powers. They will have the authority to remove tags from folksonomies. Of course, this new power comes the responsibility to not abuse the power to censor users or influence the unfolding folksonomy.

7.3 Future directions and research

This thesis presents a novel way to use RFID technology within libraries. While some issues where discussed it is not possible to cover all issues in this thesis. The main problem, however, is the lack of empirical experience and research. Currently, no library is using RFID technology to locate items and no library allows users to rearrange any item within the library.

Empirical research is necessary to explore the impact of the proposed usage of RFID technology on browsing. Some predictions about the effects on browsing where made. However, these
predictions are based on theoretical considerations and the only way to validate these theories is through field studies. Once libraries start to use RFID technology in ways that were outlined in this thesis, it is possible to experience and study the effects on browsing.

The ability to create groupings of items through physical interaction and use these groupings in the digital space as a basis for folksonomies is a novel approach. Future research should explore the influence of digital interactions on physical actions and vice versa.

This thesis explored a new way of using RFID technology. Understanding the problems and opportunities this brings to libraries requires the implementation and usage of the technology. The library of the Faculty of Information at the University of Toronto, called the Inforum, provides ideal prerequisites for the implementation of such a highly experimental technology. The physical collection and the space of the Inforum are rather small. This keeps the work necessary to implement the technology on an affordable level. More important than size issues is the self-image of the Inforum as an experimental space.
References


Copyright Acknowledgements

Figure 2-1 RFID reader and tag


Figure 2-2 Electromagnetic Spectrum


Figure 2-3 Sine wave and wave length