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An Analysis of the Radio Frequency Identification (RFID) Technology Implementation within an Independent Public Library System: A Case Study of the North Canton, Ohio Public Library

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An Analysis of the Radio Frequency Identification (RFID) Technology
Implementation within an Independent Public Library System:
A Case Study of the North Canton, Ohio Public Library

by

Keith Lyons

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

Graduate School of Computer and Information Sciences
Nova Southeastern University

2010

We hereby certify that this dissertation, submitted by Keith Lyons, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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An Abstract of a Dissertation Report Submitted to Nova Southeastern University
in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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June 2010

Public libraries require efficient control systems to maintain accurate inventories, statistics, and records of patron borrowing. Generally, public libraries use barcode technology to accomplish these tasks. Radio frequency identification (RFID) has gained the attention of public library personnel in recent years as a replacement for barcodes. RFID implementation contributes to improved staff productivity, increased operational efficiency, and improved item security as well. While potential benefits are significant, issues to consider prior to adoption include system costs, as well as privacy and security concerns.

As a consequence of increased patron use and limited budgets, the role of RFID in the public library is promoted as a solution to many of today's challenges. RFID in the public library can assist by improving inventory tracking, improving customer service, and decreasing theft. Using the case study methodology in conjunction with the System Development Life Cycle (SDLC), the author examined RFID use at the North Canton Public Library and its capabilities in improving inventory tracking, providing item security, and supporting customer service. Qualitative data were collected using focused interviews, documentation, direct observation, and participant observation.

Findings from this investigation revealed a significant decrease in time required to perform inventory tasks and an increase in time available for library staff to assist patrons. Additionally, evidence demonstrated an increase in the efficiency of patron records due to the automation of the checkout process. Patron privacy and data security were maintained by adherence to RFID implementation guidelines established by the American Library Association (ALA). The findings from this investigation provide public library administrators considering adoption of RFID with a thorough understanding of pre-implementation considerations and the benefits, drawbacks, logistical concerns, and privacy issues that must be addressed for successful results.

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Chapter 1

Introduction

Public libraries require efficient control systems to maintain accurate inventory statistics and records of patron borrowing. The majority of modern public libraries use barcode technology to accomplish these tasks (Ward, 2007). A technology that has gained the attention of public library personnel in recent years is radio frequency identification (RFID). This technology, which is a replacement for barcodes, offers the ability to improve staff productivity, increase operational efficiency, and maintain item security (Galhotra & Galhotra, 2009). The benefits of RFID implementation are significant, but other issues to consider prior to RFID adoption include system costs, security, and privacy concerns (Yu, 2007).

During World War II, allied forces first utilized a simple form of early RFID technology named Identify Friend or Foe to determine if an approaching aircraft was one of their own or that of the enemy (Garfinkel & Holtzman, 2006). This early version of RFID technology was simplistic in form and utilized one bit to indicate whether a tag was present or absent, whereas modern RFID technology provides additional information via multibit transmissions (Landt, 2001). RFID technology has improved significantly since World War II, and uses for this technology are increasing (Garfinkel & Rosenberg, 2006).

Modern-day RFID technology is used in various ways in many sectors, including healthcare, retail, government, transportation, and education (Garfinkel & Rosenberg, 2006). Wal-Mart, the world's largest retailer, uses RFID technology to improve inventory

tracking as items are processed through the supply chain (Vijayan & Brewin, 2003). Wal-Mart has been a major force behind the use of RFID in supply chain management since the 2003 announcement that its top 100 suppliers must utilize the technology for shipments to begin in January 2005 (Weinstein, 2005). Although unforeseen challenges slowed full-scale implementation by Wal-Mart suppliers, the retailing giant was the first major retailer to implement RFID throughout its supply chain and continues to move ahead with implementing this technology (Weinstein). Wal-Mart executives recently announced a change in their RFID implementation strategy. The company shifted focus from tagging pallets and cases shipped to Wal-Mart to concentrate on tagging shipments destined for its warehouse subsidiary, Sam's Club (Supply Chain Digest, 2009).

Sam's Club required suppliers to affix RFID tags to all pallets of goods sold to the retailer by the end of 2008 (Bacheldor, 2008a). On January 7, 2008, Sam's Club notified all suppliers that merchandise must be tagged at the sellable-unit level by 2010 (Bacheldor). Sam's Club executives recently announced new timelines for RFID implementation, including pallet-level tagging implemented chain-wide in 2010 and stated that the deadline for tagging at the individual item level is under review (Supply Chain Digest, 2009).

In the transportation sector, RFID technology supports access control functions (Shepard, 2005). For example, some FedEx drivers wear RFID-enabled wristbands to access secured trucks and to access secure FedEx facilities after regular business hours.

The healthcare sector is another area of RFID technology use, ranging from RFID tags embedded in patient wristbands to verify identity, to monitoring the location and movements of patients, staff, and resources (Karthikeyan & Nesterenko, 2005). For

example, emergency room equipment that is shared by multiple hospital departments is tagged at the MetroHealth Medical Center in Cleveland, Ohio, to track its location (Bacheldor, 2006).

U.S. prisons such as Calipatria State Prison of California, the J.W. Maxie Maximum Security Youth Institution of Michigan, and the Ross Correctional Facility in Ohio use RFID technology for inmate identification and access control (Swedberg, 2005). Inmates are fitted with RFID wristbands. Sensors placed throughout the prisons verify their locations at any time.

Present-day libraries offer patrons an assortment of items available for checkout, including books, magazines, videotapes, CDs, DVDs, video games, and newspapers (Brown, 2007). RFID technology is a solution to challenges faced by librarians in dealing with increased patron usage and limited budgets (Ayre, 2006a). RFID can improve inventory tracking, increase customer service capabilities by freeing library staff to answer patron questions instead of spending time checking out materials, and decrease theft of library materials (Ward, 2007).

An additional use for RFID in the public library environment is the experimentation in the use of RFID at the Helsinki University of Technology Library. The laboratory library at the university uses self-checkout, automated returns, and RFID security with video cameras to allow the library to remain open without a librarian on duty (Muhonen, 2007).

Librarians at Chicago State University library have implemented RFID technology in combination with the library's automatic storage and retrieval system (ASRS) to allow patrons easily to locate materials that have been archived and to allow

for automated return of the materials to storage (O'Connor, 2007). The Chicago State University library integrates RFID technology with an ASRS provided by vendor HK Systems and with the Voyager ILS (Engelter, 2008). Middleware by Integrated Technology Group provides the interface between RFID and the ASRS (Engelter). Patrons submit a request for archived materials to a circulation librarian. The request is forwarded to a staff member in the storage area who uses the ASRS to access RFID-tagged materials stored in the library archives. Requested materials are retrieved from the archive robotically and placed on a conveyor for delivery to the circulation desk (O'Connor).

Material handling in industries such as shipping and automotive manufacturing has used storage and retrieval systems for years; only during the last decade have libraries begun to implement these robotic systems to store and retrieve bins containing library materials (O'Connor, 2007). The library at Chicago State University was the first U.S. library where RFID instead of barcodes was integrated with the automatic storage and retrieval system, allowing materials to be retrieved from and returned to storage with minimal librarian intervention (O'Connor). Libraries utilizing barcode technology instead of RFID for storage and retrieval of archived material still require the library staff to scan the books individually and place them in the proper location.

In order to optimize the use of RFID technology in the public library environment, Golding and Tennant (2007) recommend increased research into the uses for the technology in the library setting in addition to the common present-day research practice of studying perceived and expected problems with the technology. Satpathy and Mathew (2006), who proposed an RFID assistance system to enable faster material

searches and checkout in a public library, performed one such study. Satpathy and Mathew recommended that patrons use specialized personal digital assistants (PDAs) to search the library database. The PDA provides a graphic layout of the library, the location of the searched item in the facility, and directions to the shelf where the item is located. The PDA also functions as an RFID reader and alerts the patron to the exact location of the item on the shelf when the reader is in range. Advantages of this system include reduced time spent by patrons locating materials, decreased patron checkout time, and increased time available for library staff to assist patrons with questions (Satpathy & Mathew, 2006).

Problem Statement

The problem investigated in this dissertation is how one public library system implemented RFID technology to improve operational processes such as asset tracking, maintenance of patron records, and improved customer service, while maintaining patron privacy and the security of data. Networked information technology (IT) systems are essential to the success of many organizations, and the public library system is no exception (Jiao & Onwuegbuzie, 2004; Turban, McLean, & Wetherbe, 2006). Librarians in the late 1970s and early 1980s began replacing physical card catalogs with computerized versions of the card catalog by utilizing automation systems (Rubin, 2004). These systems evolved into Integrated Library Systems (ILSs) that allow librarians to automate functions such as circulation, acquisitions, and cataloging (Rubin). The ILS is still in use at libraries today for enabling access to separate functions such as ordering, receiving, invoicing, cataloging, and circulation (Rubin). RFID in the public library

setting is implemented as a turnkey solution that interoperates with the in-place ILS, thereby adding increased functionality (Rubin).

Barcode technology is used in the majority of libraries to facilitate material loans, returns, and inventory tracking (Ward, 2007). Adapted for use within the library environment, RFID is a relatively new technology in comparison to barcodes (Boss, 2009). Boss estimates that approximately 1,500 libraries worldwide utilize RFID technology, up from 600 libraries in 2007. One of the differences between RFID technology and barcode technology is that barcodes transmit only product-identifying information, whereas RFID technology can identify a product and provide the option for additional information to be written to and read from the RFID tag, such as personal account information in the case of RFID-enabled credit cards (Boss). Barcodes also must use line-of-sight connections, and objects must be read one item at a time. RFID technology allows for the simultaneous reading of dozens of tagged objects in a group (Boss). Simultaneous reading increases the speed with which items are processed, thus providing a significant advantage over barcoding systems (Boss).

Key RFID components consist of RFID tags or transponders and readers or interrogators (Curran & Porter, 2007). An RFID tag with an attached antenna is affixed to the product and a reader is set up to act as a monitoring station for tagged items. The tags can be placed on or in a variety of items, including products, animals, or persons (Borriello, 2005).

The tag or transponder contains the unique identification number for the item as well as any additional information optionally programmed into the tag (Curran & Porter, 2007). The tag consists of a small silicon chip that contains the memory portion of the tag

and an antenna capable of sending and receiving radio waves (Myung & Lee, 2006). Tags can take many forms, depending on the intended use. Examples of distinct tag forms include flat tags affixed to an adhesive backing suitable for use in books and tags encased in glass used for implanting in animals or persons (Weinstein, 2005).

The two primary types of tags are classified as passive and active. A passive tag has no internal power source, whereas an active tag contains an internal battery. The power required to operate a passive tag is derived from the electrical field generated from the reader that powers the circuit and provides a response to the reader (Jose, Chand, & Rao, 2005). Typical read ranges for passive tags are between 4 inches and 10 feet. Benefits of passive tags include lower cost than active tags and a potential unlimited lifespan (Curran & Porter, 2007).

The internal battery on an active tag powers the chip and communicates with the reader (Curran & Porter, 2007). The batteries used by active tags allow for longer read ranges than passive tags but also add significant cost and bulk to the tags (Shepard, 2005). The onboard battery permits better noise immunity and improved readability than passive tags (Curran & Porter). Active tags have a limited life expectancy of approximately 10 years due to eventual battery failure (Ward & van Kranenburg, 2006).

A third type of RFID tag is a semipassive tag. A semipassive tag is a hybrid of an active tag and a passive tag (Curran & Porter, 2007). Similar to an active tag, a semipassive tag contains a battery. Unlike the active tag, the battery in a semipassive tag remains dormant until signals are received from a reader. A semipassive tag reflects radio frequency (RF) energy back to the reader similar to the way a passive tag operates, with the onboard battery used to run the chip circuitry. A benefit of semipassive tags is the

ability to extend the read range of standard passive tags to over 100 feet (Curran & Porter).

Examples of information that can be obtained via an RFID implementation include data on the movement of an item from one location to another, monitoring stock quantities remaining on a store shelf, and determining whether a shipment was placed on the correct truck for distribution (Garfinkel & Rosenberg, 2006). According to Weinstein (2005), narrowing a discussion of the applications for RFID is difficult because the technology is only now gaining widespread acceptance, and industries in sectors such as retail, education, transportation, healthcare, manufacturing, and government are experimenting with RFID adoption in an attempt to determine how best to utilize the technology. For example, government organizations such as the U.S. Navy use RFID technology to track damaged or broken parts and to determine the need for replacement (Weinstein). The Ford Motor Company announced plans to utilize RFID technology in F-150 trucks in 2009 to track assets in the vehicle such as tools and materials (Hazen, 2008). Nova Southeastern University in Florida issues identification cards to students, faculty, and staff embedded with an RFID tag to facilitate secure payments and access to systems and services (Williams, 2006).

An area of emerging RFID technology, wireless sensor networks allow for monitoring environmental conditions using active RFID technology (Philipose, Smith, Jiang, Mamishev, Roy, & Sundara-Rajan, 2005). Sensors to monitor conditions such as temperature and pressure existed in the past but were isolated from an organization's communication network (Clauberg, 2004). RFID tags with built-in sensor technology can respond to the demand by organizations for real-time status information about all

business processes via the organization's in-place network (Clauberg). Wireless sensor networks currently utilize active and semipassive tag technology, but next-generation sensors are expected to use passive tag technology, with the required power coming from alternative energy sources (Roundy & Frechette, 2005).

Goal of the Investigation

The goal of this investigation was to advance professional practice and knowledge in the area of public library applications of RFID technology and to contribute to future studies by examining in detail the RFID technology implementation at the North Canton Public Library (NCPL), in the state of Ohio, using system development life cycle (SDLC) analysis in combination with case study methodology. The case study methodology is appropriate for this type of investigation because it has a history of generating further knowledge in the IT field (Markus & Lee, 2000). Case study research method is time-intensive, but it also provides a great deal of detail and insight (Salkind, 2005).

RFID technology is generating significant interest among those in the public library system community (Ward, 2007). The interest in RFID among librarians is evident based on an examination of sources available from digital libraries such as the Association for Computing Machinery (ACM), the Institute of Electrical and Electronics Engineers (IEEE), the American Library Association (ALA), the ProQuest Dissertations and Theses database, as well as a review of journals such as the *Journal of the American Society for Information Science and Technology*, *Library Hi Tech*, *Information Technology and Libraries*, and *The Electronic Library*. At some public libraries where the technology was implemented, personnel have summarized implementation details but these documents are not in the form of traditional research reports (Schaper, 2005). As

industry implementation of RFID increases, academic researchers are interested in engaging in scholarly investigations of RFID capabilities (Curtin, Kauffman, & Riggins, 2004; Golding & Tennant, 2007).

Administrators at public libraries such as the Richland County Public Library in Columbia, South Carolina (B. Heimburger, personal communication, June 8, 2007) and the Algonquin College Library in Ontario, Canada (N. Therrien, personal communication, May 31, 2007) are considering RFID technology implementations. However, many issues must be considered prior to adopting RFID technology in a public library setting (Yu, 2007). Prior to adopting the technology, officials must address issues such as privacy, security, vendor selection, compatibility with current hardware and software systems, and the pros and cons of RFID in relation to other technology solutions such as patron self-checkout using the barcode system (Ward, 2007). Public libraries where RFID technology is adopted can provide valuable lessons for those considering its use (Haley, Jacobsen, & Robkin, 2007; Ward). Based on the literature review, a key problem for public library personnel considering adoption of RFID technology is that questions regarding implementation have not yet been addressed fully (Coyle, 2005; Ward). Findings from this investigation should serve as a helpful guide for public library personnel interested in implementing RFID technology within their public library systems.

The SDLC served as the framework for studying the implementation of RFID technology in the NCPL from the initial research of the technology to implementation and assessment of its performance. Based on the findings, the author provided a model

for RFID implementation in public libraries considering RFID adoption, especially those with demographics similar to the NCPL.

The NCPL is an independent public library located in the city of North Canton, Ohio. The public library was established in 1926 to provide a free public library for North Canton residents and the school district. The library consists of approximately 30,000 square feet of space and circulated 1,107,346 items in 2008 (State Library of Ohio, 2008). According to the U.S. Census Bureau (2006), the city of North Canton had an estimated population of 16,796 residents in 2004. Circulation statistics for the NCPL demonstrate increased borrowing during the last several years at a minimum rate of 4% annually, beginning with 2003 (State Library of Ohio). According to NCPL Director Karen Sonderman, RFID technology is used currently to manage lending growth as well as achieve other goals such as improving customer service and decreasing theft of library materials (personal communication, May 12, 2009).

Relevance and Significance

This study is relevant to public library systems where an RFID technology implementation will be considered. The significant contribution of this study is to provide public library system personnel considering adopting RFID technology with a thorough understanding of implementation considerations, including the benefits, drawbacks, logistical concerns, security issues, and privacy issues that must be addressed prior to implementing RFID.

Findings from this investigation contribute to the existing literature on public library implementations of RFID technology. Guidelines for public library systems implementing RFID systems are examined and explained. Based on findings from this

inquiry, the author developed a model for RFID implementation in public library systems with circulation statistics similar to those of the NCPL, which currently stand at approximately 1 million items per year (State Library of Ohio, 2008). The author also identified RFID implementation considerations such as tagging, assemblage of the RFID database, and equipment requirements. Technical aspects of the RFID implementation and user issues were addressed. For example, the design of the RFID interface used by patrons, the ease or difficulty associated with the RFID implementation from the perspective of public library staff, and strategies for introducing patrons to RFID technologies were examined. Lastly, the author identified the level of library employee knowledge and experience required to implement an RFID solution effectively. Particular attention was paid to the controversial aspects of RFID implementation, specifically the privacy concerns of public library patrons and the known security issues associated with the RFID data (Haley et al., 2007). The author examined how the RFID technology selected for the NCPL addresses privacy and security concerns described in the literature (Haley et al.; Garfinkel & Rosenberg, 2006; Molnar & Wagner, 2004).

In addition to examining technological functioning, security, and privacy issues, the author focused on addressing the question of how RFID technology is implemented and the associated challenges. As Yin (2003) noted, questions of “how” are best addressed utilizing the case study methodology when the investigator has little or no control over the events that affect the subject of the study.

Barriers and Issues

The goals of this research proposal were not accomplished in previous studies for a number of reasons. One reason is that RFID technology is not ubiquitous in public

libraries. According to an estimate by Boss (2009), approximately 1,500 libraries worldwide use RFID solutions, while the majority of libraries still utilize barcode technology. The relatively recent utilization of RFID technology in the public library setting is one possible reason that scholarly research focusing on public library RFID implementations is only now beginning to be published (Golding & Tennant, 2007). The lack of a substantial amount of research focused on RFID in the public library setting was a key barrier to this study.

The lack of a significant amount of public library RFID research was also a positive aspect for this research in that this study would serve as a model for public library systems in which RFID technology is a candidate for adoption. According to Givens and Tien (2004), prior RFID research questions focused on improving the technology in terms of security and effectiveness, but little was done in terms of understanding the challenges and benefits of a public library implementation.

One issue facing public library personnel considering an RFID implementation is that there are few formal standards related to RFID technology for use in the public library setting (Boss, 2009; Curran & Porter, 2007). Library RFID tag standards are in the process of being recommended but have not been ratified as of this writing (Boss). These standards are identified and examined by the author in Chapter 2 of this investigation.

Another barrier faced by the author was that library personnel might be hesitant to discuss topics such as privacy and security candidly, fearing patron backlash similar to that experienced at the San Francisco Public Library when it was announced that RFID was being considered for use there (Molnar & Wagner, 2004). Press coverage of RFID technology use has focused primarily on the potential for tracking consumers without

their knowledge and not on the current widespread use and significant potential of the technology (Garfinkel, Juels, & Pappu, 2005). To overcome this barrier, the author identified the RFID technical components in place at the NCPL and documented the known security and privacy issues associated with the use of the particular technology as described in the literature. The privacy and security policies in place at the NCPL also were evaluated.

Research Question Investigated

The research question investigated was: How can a local, independent public library successfully implement RFID technology to improve business processes while maintaining data security and a high degree of patron privacy? RFID technology implemented in the public library setting is based on the premise that the benefits of implementation outweigh the associated security and privacy risks (Haley et al., 2007). Public library personnel use RFID to improve customer service and inventory management, reduce repetitive stress injuries associated with the checkout process, and maintain item security (Yu, 2007). The NCPL has an in-place implementation of RFID, and Director Karen Sonderman considered it successful (personal communication, May 12, 2009). Sonderman considered potential next steps in the RFID implementation process, such as the implementation of RFID bookdrop readers to facilitate automated after-hours material check-in (K. Sonderman, personal communication, February 8, 2008). The author examined the implementation at the NCPL and identified how RFID technology was implemented, the advantages and disadvantages of the current system, and potential next steps in the RFID implementation process.

The single case study approach in conjunction with the SDLC was used to address the research question. The case study methodology is the methodology of choice when the researcher has little or no control over the subject of the study, as in the case of events in a real-life context (Yin, 2003). Yin also wrote that the case study methodology is preferred when the focus of the investigation is on a contemporary phenomenon within a real-life context and when the relevant behaviors cannot be manipulated.

The RFID implementation at the NCPL became functional September 30, 2004. The vendor chosen by the NCPL stakeholders to assist with the RFID implementation was 3M Library Systems. The RFID implementation consists of over 100,000 items affixed with adhesive-backed rewriteable passive tags that operate in the 13.56 MHz RF range. The 13.56 MHz range is classified as high frequency and is the most common frequency used for public library implementations of RFID (Yu, 2007). The tags utilized at the NCPL have a data capacity of 256 bits of information. The tags contain item identifying information, library location identifying information, and a security bit that indicates if the item was checked out (K. Sonderman, personal communication, October 1, 2004).

The NCPL utilizes five 3M self-checkout stations for patrons to check library items out or in without the assistance of library staff. The self-checkout stations consist of a touch-screen monitor, an RFID reader that takes the form of a rubber mat for placing library materials to be identified, and an attached printer for printing receipts. Patrons are required to scan their library card and enter a personal identification number (PIN) prior to the check-in or checkout process.

RFID security gates are used at the entrances and exits of the NCPL. The gates are equipped with RFID readers that query the RFID tags of items within read-range to make certain that the items have been properly checked out. Items that have not been checked out properly trigger an audible alarm, notifying the patron and library staff of the security breach. The security gates have a read-range of approximately 18 inches, requiring the gates to be no wider apart than 36 inches to ensure proper functioning. In addition to self-checkout stations and RFID-enabled security gates, staff at the NCPL utilize hand-held RFID readers to facilitate item search, inventory management, and proper order of shelved materials (K. Sonderman, personal communication, October 1, 2004).

The five self-checkout stations and security gates used at the NCPL are integrated with the ILS via wireline technology. Communication is enabled via the Standard Interchange Protocol (SIP) developed by the 3M Company to facilitate communication between the ILS and the self-checkout stations (Haley et al., 2007). SIP 2.0 is the current version of the protocol.

The RFID implementation at the NCPL is operational and thus falls under the Operation and Maintenance stage of the SDLC. The author describes maintenance issues experienced by the NCPL staff as well as errors found in the implemented system. Next steps are identified relative to evolving RFID technology, such as consideration by the NCPL director of expanding uses for the in-place RFID solution, such as implementing RFID-enabled bookdrop readers or purchasing automated sorting equipment that works in conjunction with the RFID implementation.

Limitations and Delimitations of the Study

The author describes a single implementation of RFID technology in the public library setting of the NCPL in conjunction with SDLC methodology. The author was dependent on the staff of the library for their cooperation and participation in this investigation. Changes to staff at the library or attitude towards this investigation were variables the author could not control. Another limitation of the study was the evolving nature of RFID technology. The relative newness of RFID technology to the library setting made the investigation timely but also subject to constant change.

A delimitation of this dissertation is that the investigation focused only on RFID technology as it applies to the public library setting, even though RFID technology is gaining popularity in other business sectors such as healthcare, retail, government, and transportation (Brown, 2007). RFID technology in the public library setting exists in a closed system, without the technology requirement of interoperability among organizations, as is the case with RFID used in the supply chain (Haley et al., 2007). Standardization of public library RFID technology could change the closed nature of the systems as noted; however, the standards for RFID technology are still in the developmental stages (Boss, 2009; National Information Standards Organization [NISO], 2007).

Definition of Terms

This section provides definitions of key terms used in this investigation. A list of abbreviations and acronyms is found in Appendix A.

Active tag. An RFID tag that carries a transmitter capable of sending back information to an RFID reader, instead of relying upon reflecting the signal back from the

reader, as is done with passive RFID tags (Ward, 2007). The majority of active tags use batteries for powering the transmitter.

American Library Association (ALA). A membership organization open to any person, library, or other organization interested in librarianship and library service (ALA, 2007). The ALA was formed in 1876 to develop, promote, and improve library services as well as the librarian profession. The ALA provides leadership and guidelines for public libraries considering adoption of RFID technology (ALA, 2006).

American National Standards Institute (ANSI). A non-profit membership organization founded in 1918 that coordinates the development of U.S. voluntary national standards in both the private and public sectors (ANSI, 2007). ANSI promotes the development of standards and specifications by building consensus among diverse public and private agencies and organizations (Littman, 2002). ANSI also accredits organizations whose standards development process meets its requirements. ANSI does not develop standards but does represent U.S. interests in regional and international standardization activities.

Antennas. Used by RFID technology on tags and readers. The tag antenna is the conductive element that enables the tag to send and receive data. The reader antenna is used to emit radio waves in order to communicate with the RFID tag (Ward, 2007).

Barcode. A printed horizontal strip of vertical lines of varying widths used to identify an item. Barcodes work in conjunction with a scanner, using line-of-sight technology (Shepard, 2005).

Closed system. Refers to an implementation of RFID technology in which RFID data are only accessible to those within the confines of that system (Haley et al., 2007).

Electronic product code (EPC). Created as a potential replacement for the barcode. The EPC identification system was designed to enable identification of individual items containing RFID tags, whereas barcodes simply identify the manufacturer and class of products. The EPC identifies manufacturer, category of product, and the specific item (Ward, 2007).

EPCglobal. An organization dedicated to the development of industry-driven standards for the EPC (EPCglobal, 2007). The primary focus of EPCglobal is the creation of international RFID standards.

EPCglobal Network. Accessible via the Internet, this network enables companies to retrieve data associated with the EPC. The network leverages the structure of the domain name service with its own version known as the object name service. The object name service provides a means to connect servers containing information related to items identified by EPC numbers (EPCglobal, 2007).

High frequency. Radio frequency defined as operating between 3 MHz and 30 MHz. RFID tags in this frequency range typically operate at 13.56 MHz (Yu, 2007). Current public library implementations of RFID technology typically use tags operating at 13.56 MHz.

Integrated Library System (ILS). A library database containing information about acquisitions, cataloging, the online public-access catalog, circulation, and serial holdings (Ebenezer, 2003). The RFID tag located on a library circulation item transmits data to the RFID reader, which, in turn, transmits that data to a computer that is interconnected to the ILS.

International Organization for Standardization (ISO). National standards institutes in 157 countries, with each country having one representative to the organization. ISO is the world's largest developer of technical standards (ISO, 2007).

ISO Technical Committee 46, Subcommittee 4 (ISO TC46/SC4). The ISO subcommittee responsible for technical standards that deal with interoperability of information services for such entities as public libraries, publishers, information centers, indexing and abstracting services, and archives (NISO, 2009).

ISO TC46/SC4 Working Group 11 (ISO TC46/SC4/WG11). A working group for TC46/SC4 appointed May 9, 2007 and charged with the task of developing a set of international standards for RFID usage in the library setting (Danish Library Agency, 2007).

Interrogator. A device used to communicate with RFID tags. This device has one or more antennae that emit radio waves and receive data from the RFID tag (Yu, 2007). An interrogator is also known as an RFID reader.

Megahertz (MHz). One million cycles per second. A measure commonly used to identify the frequency of a radio signal or clock speed of a computer.

National Information Standards Organization (NISO). A nonprofit association accredited by ANSI whose purpose is to identify, develop, maintain, and publish technical standards to manage information in digital environments (NISO, 2007). NISO has been designated by ANSI to represent U.S. interests to the ISO TC46 on Information and Documentation.

Open system. An implementation of RFID technology in which RFID data are accessible to partner organizations throughout the supply chain (Haley et al., 2007).

Passive tag. Reflects the energy obtained from the reader in order to respond to the reader's request (Yu, 2007). The energy received from the reader is converted by the antenna into electricity that powers the chip located in the tag. Public library implementations of RFID technology typically use passive RFID tags.

Reader. A device used to communicate with RFID tags. This device has one or more antennae, which emit radio waves and receive data from the RFID tag (Yu, 2007). A reader is also known as an interrogator.

RFID tag. A microchip attached to an antenna that can be applied to an object. The tag is responsible for picking up signals from and sending signals to an RFID reader (Yu, 2007). In the public library setting, the RFID tag contains the item identifying information and security bit and potentially other information that is determined to be necessary by the utilizing library staff.

Semipassive tag. An RFID tag with an integrated battery that runs the chip circuitry. Communication between the tag and the reader is performed by drawing power from the reader's radio waves, identical to passive tag technology (Yu, 2007).

Summary

Chapter 1 explained the problem investigated by the author as well as the goal to be achieved. The relevance and significance of this investigation were described along with the barriers and issues facing an investigation of the NCPL implementation of RFID technology. The method of study used for investigating the research question was presented. The limitations and delimitations of this study were defined, followed by definitions of selected terms relevant to the investigation.

Chapter 2

Review of the Literature

In the review of relevant literature, the author examined previous work related to the topic and established a basis for the proposed investigation (Leedy & Ormrod, 2005). The review focused on literature dated no earlier than 2003, but earlier essential seminal works were examined and referenced accordingly. As noted by D. M. Ward (2007), RFID technology implemented in the public library setting is evolving rapidly; therefore, the literature review was limited to the period of 2003–2009. Literature detailing the case study methodology and the SDLC also is described.

Historical Overview of the Research Literature

In order to understand the evolution of RFID technology and its usefulness in the public library setting, the author begins the chapter with a review of barcode technology. Although barcodes can be replaced by an RFID solution, barcode technology remains in use in a majority of public libraries (Haley et al., 2007). Barcode technology has proven reliable in combining data in the ILS and the physical flow of materials (Lindquist, 2003). A barcode is a set of lines read by an optical laser that requires direct line-of-sight (Ward, 2007). Each barcode is unique and is linked to an item record in the library database. Barcode technology requires that each item be handled physically to be aligned with the optical laser reader (Ward). In addition to potential workflow improvements available via RFID, Lindquist described the security mechanisms in use at most major public library systems. Typically, these mechanisms are electromagnetic based and

separate from barcode technology. RFID is a single solution to both improving material flow and security issues (Lindquist).

The Research Literature Specific to the Topic

According to Whitten, Bentley, and Dittman (2004), an information system (IS) captures and manages data on employees, customers, partners, and suppliers that are critical to day-to-day operations. An IS uses hardware, software, data, processes, and people to support an organization's mission, goals, and objectives (Shelly, Cashman, & Rosenblatt, 2007). At the NCPL, RFID technology is used in conjunction with the ILS to facilitate implementation of an IS.

Benefits of RFID Technology in a Public Library Setting

RFID solutions in the public library setting contribute to improved customer service and inventory management. With RFID deployment, responsibilities for the checkout function shift from the library staff to the patron (Ward, 2007). A reduction in checkout lines at the library associated with patron self-checkout results in improved customer service, because staff are available to patrons when not busy at the checkout desk (Boss, 2009). Instead of performing clerical checkout tasks, the circulation staff can issue new cards, process fines, manage interlibrary loans, provide directions, and answer questions (Yu, 2007). In addition to self-checkout, an RFID solution enables an RFID reader to scan multiple items at once, simultaneously checking out a stack of patron materials up to 6 inches high. Patrons familiar with the RFID self-checkout process demonstrate decreased checkout times for multiple item transactions when compared to library staff who utilize the single-item checkout process used with barcode systems (Haley et al., 2007).

One of the concerns among public library staff members when implementing patron self-checkout is that the technology will reduce the library's personnel requirements, which might result in staff layoffs (Powell, 2006). As Minami (2006) noted, the implementation of RFID in the public library setting has efficiency and cost cutting as two primary goals. As Artz (2005) noted, the potential for staff cuts exists, as demonstrated with staff reduction resulting from the RFID implementation at the Berkeley, California Public Library. Recent staff reductions at libraries where RFID was implemented were attributed to a poor economy instead of RFID technology (Mostad-Jensen, 2009). The automation of library functions previously performed by staff allows administration to examine the need to reduce or retrain employees (Pop & Mailat, 2009).

According to Ayre (2006b), a benefit to library staff of implementing an RFID system in a public library is the reduction in repetitive stress injuries experienced by employees utilizing the barcode checkout system. Between January 2000 and January 2004, staff at the San Francisco Public Library reported 36 cases of repetitive stress injuries, 260 lost workdays due to these injuries, 500 modified or restricted workdays due to the injuries, and a cost to the library system of \$265,000 (SFPL, 2005). To date, a follow-up analysis of injury claims has not been performed to identify potential savings associated with the RFID implementation.

Another benefit of RFID technology in the public library setting is item security (Ward, 2007). The RFID tag applied to each inventory item within a library contains a security bit that is deactivated when an item is checked out of the library and activated when the item is returned (Singh, Brar, & Fong, 2006). The process of activating and

deactivating the security bit on an item is an automatic part of the RFID check-in and checkout process (Singh et al.).

Inventory management is another benefit cited by users of RFID technology in the public library setting (Singh et al., 2006). Typical, time-consuming shelf-management activities, which are common in most public libraries, are reduced drastically following an RFID implementation (Engel, 2006). Stock verification and searching for misplaced books are easier when using RFID technology in conjunction with portable, hand-held RFID readers that can scan sections of library shelves instantly (Jose et al., 2005). For example, administrators at the Vatican Library in Rome inventoried their 120,000 RFID-tagged items in approximately four hours, compared to the one-month timeframe required prior to adopting this technology (Singh et al.).

RFID Limitations in the Public Library Environment

According to Curran and Porter (2007), the benefits of RFID technology in the public library environment are attractive. Nonetheless, limitations of this technology also must be considered. Disadvantages associated with RFID solutions include increased costs, security issues, lack of standards, and privacy concerns (Boss, 2009).

Vendors such as Bibliotheca, Checkpoint, ID Systems, Libramation, 3M, and TAGSYS work with public libraries to implement RFID systems. According to D. M. Ward (2007), the costs associated with implementation vary from vendor to vendor and are dependent on the specific requirements identified by a public library system, such as number of materials to tag and the types of materials to tag. Each library item that will be circulated requires its own RFID tag. Cost for a single RFID tag ranges from \$0.50 to \$1.50, depending on the type of tag selected (Ayre, 2006c; Boss, 2009). Typical RFID

tags used for placement in books range in cost from \$0.50 to \$0.70. RFID tags in other media, such as CDs, DVDs, and tapes, range in price from \$1.00 to \$1.50 (Ayre).

Additional costs associated with public library RFID implementations include purchase of new security gates, circulation readers, self-checkout stations, sorting equipment, and inventory wands (Haley et al., 2007). Cost estimates for a full-scale public library RFID system range from \$70,000 to over \$1 million, with one library reportedly spending \$1.1 million dollars to implement an RFID solution involving 500,000 items (Ayre). The costs of human resources associated with an RFID implementation also must be considered (Haley et al.). Each tag must be programmed and each circulated item must be tagged (Ward). The interfaces between the ILS and the RFID system must be configured as well (Ward). Human resource costs will vary, depending on the requirements for each implementing public library, but they are a cost to consider prior to implementation (Curran & Porter, 2007).

According to Butters (2006), RFID systems implemented within a public library environment are subject to misuse. RFID tags affixed to circulated materials can be torn or damaged, rendering the tag unreadable (Hopkinson & Chandrakar, 2006). An RFID system may be compromised by wrapping an item in household foil, which blocks the RF signal between the item and the reader (Galhotra & Galhotra, 2009). Another method of potential compromise for a public library RFID system is to place two tagged items in close proximity to each other, potentially canceling out the RF signals (Shahid, 2005).

One significant disadvantage of public library RFID technology implementations is the lack of established technology standards (Boss, 2009; Haley et al., 2007). Without technology standards available to guide the development of RFID technology systems in

the public library environment, materials from one library system typically cannot be read by the RFID implementation at another library system (Butters, 2007). This problem eliminates the usefulness and benefits of RFID outside of the implementing public library and maintains reliance on barcode technology for interlibrary loans until all public library systems implement a standardized version of RFID (Haley et al.). The problem of lack of standardization across public libraries implementing RFID technology can be addressed through the adoption of standards (Butters). Standardization of public library RFID technology is addressed in this literature review following the heading, Importance of Standards.

Two issues of importance to this investigation include the security of RFID technology and the privacy questions surrounding the technology. Molnar and Wagner (2004) researched RFID security to determine the integrity of data transferred from an RFID tag to an RFID reader. Molnar and Wagner claimed that the data are not secure and recommended the use of encryption and authentication techniques to improve security. Another potential security problem with RFID technology in the public library setting involves the possibility of an unauthorized individual using an RFID reader to receive transmissions from the RFID tags, thereby exposing the tag information to that person (Garfinkel & Rosenberg, 2006). To eliminate such incidents, Engberg, Harning, and Jensen (2004) proposed that the design of RFID tags include a feature that permits the tag to require password authentication between the reading device and the tag, so that only authenticated devices can access the information embedded on the RFID tag. Another proposed solution to the problem of unauthorized tag reading is to develop a technology that can render an existing RFID tag unreadable after leaving the location where it was

intended to be read (Juels, Rivest, & Szydlo, 2003). Another solution proposed by Ateniese, Camenisch, and Medeiros (2005) is to encrypt read/write tag data so such data are only intelligible to the issuing entity, a process referred to as insubvertible encryption.

Another issue related to RFID security emanates from the wireless nature of public library RFID (Molnar & Wagner, 2004). The wireless nature of the technology in the public library environment makes the technology susceptible to interception. Therefore, RFID transmissions must be encrypted to prevent eavesdropping, modification, replacement, or other misuse (Yu, 2007).

Unauthorized readers (Shahid, 2005) can view public library RFID tags. Two privacy issues associated with unauthorized tag reading are tracking and hotlisting (Galhotra & Galhotra, 2009). Tracking refers to the ability to monitor the movements of materials by determining where the item was located when unauthorized readers received the transmitted item's identifying information. Tracking is possible but requires a number of readers placed throughout the desired coverage area to be effective (Shahid). Hotlisting entails building a database of materials and associated tag numbers on a hotlist and then using an unauthorized reader to determine when and by whom an item is checked out. Public library RFID tags do not carry patron-identifying information, so in order to identify the individual checking out the item, the person with the unauthorized reader also must determine who is checking out the materials (Shahid).

As noted, the perception of privacy issues for patrons utilizing RFID technology in the public library setting remains an area of concern (Boss, 2009). Organizations such as the American Civil Liberties Union, the Electronic Frontier Foundation, and the Center for Democracy and Technology expressed concerns related to privacy and the use of

RFID (Howard & Anderson, 2005). These groups endorse a single RFID position statement that is posted at the Web site maintained by the Privacy Rights Clearinghouse (2009). The statement includes a series of recommendations for implementing RFID solutions.

We are requesting manufacturers and retailers to agree to a voluntary moratorium on the item-level RFID tagging of consumer items until a formal technology assessment process involving all stakeholders, including consumers, can take place. Further, the development of this technology must be guided by a strong set of Principles of Fair Information Practice, ensuring that meaningful consumer control is built into the implementation of RFID. Finally, some uses of RFID technology are inappropriate in a free society, and should be flatly prohibited. Society should not wait for a crisis involving RFID before exerting oversight. (Privacy Rights Clearinghouse, 2009)

Privacy advocates express concern that patron-identifying information will be contained on public library RFID tags, subjecting patrons to identification by individuals with RFID readers capable of reading the tags (Howard & Anderson). Some proponents of RFID technology use in the public library claim that privacy concerns are without merit because the tags used in the public libraries identify only the individual item by serial number and do not provide patron-identifying information, although it is acknowledged that if the library issues RFID-enabled patron library cards, cardholder privacy could be at risk (Howard & Anderson). Limiting the information contained on the public library RFID tag only to allow for identifying the item and for the security-bit

function is recommended by the ALA (2006) in the ALA's Intellectual Freedom Committee document regarding library use of RFID.

Konomi (2004) has detailed a possible future solution to potential RFID privacy and security issues. Konomi proposed a device worn by an individual that serves as a personal RFID firewall. He detailed the requirements for such a device and developed a recommended architecture. The device, similar to a PDA, could be used to intercept outgoing and incoming RFID signals from both readers and tags in order to allow the individual the option of choosing information that is permitted to be received and provided to a reader. According to Konomi, such devices could become important, given the anticipated universal implementation of RFID tags. Konomi did not examine applicability of this device in the public library setting. In order for this device to enable checkout in an RFID-enabled library, the user must permit communication between the tag and the reader (Konomi).

The review of the literature demonstrated the information available on RFID functions in the public library setting. However, the topics of privacy and security in this setting have not received the same depth of coverage in the literature as the requirements for improving the functionality of the technology. Molnar and Wagner (2004) performed one of the scholarly investigations on the topic and identified privacy and security concerns that must be addressed in the area of public library RFID technology. As more public library systems adopt RFID technology, the body of knowledge on privacy and security is expected to expand.

RFID technology has advantages and disadvantages (Yu, 2007). A starting point for librarians researching RFID as a potential technology solution is to learn from the

experiences of others at public library systems similar to their own (Butters, 2006). In fact, a survey of staff at 29 libraries performed by Singh et al. (2006) found that all respondents indicated that the most important factor to consider when researching the feasibility of an RFID solution is information from staff at libraries where the technology was already implemented. This investigation informs administrators considering RFID implementation by providing a case study of the NCPL RFID implementation, featuring details to be examined when considering an RFID solution and describing the advantages, disadvantages, and challenges involved with deploying RFID technology in the public library environment.

RFID Technical Aspects

The primary components of a public library RFID system include the RFID tag programmed with information, an RFID reader, and the RFID application system (Yu, 2007). RFID tags consist of a combination of a chip and antenna (Yu). The chip has a memory capacity of at least 64 bits, encoded with data such as the International Standard Book Number (ISBN), title, and call number (Howard & Anderson, 2005). Public library RFID implementations commonly use read/write tags (Ward, 2007). Read/write tags are capable of having information written to them several times. This solution is appropriate when the tag data are subject to change (Ward). Tag data used in public libraries changes to indicate the circulation status of an item (Howard & Anderson).

RFID tags are available in a range of sizes and shapes. For instance, a 50mm x 50mm tag with paper backing on one side and an adhesive layer on the other typically is affixed to books (Butters, 2006). Generally, RFID tags are affixed on each item in the library that is available for checkout (Butters). Special tags are available to accommodate

other materials, such as CDs, DVDs, and videocassettes (Haley et al., 2007). One type of tag used directly on CDs or DVDs has a hole in the center to accommodate the hole in the center of the disk (Haley et al.). A hole in the center permits the tag to operate without interfering with the operation of the disk.

As detailed in Chapter 1, active, passive, and semipassive RFID tags are available. An active tag requires a built-in power source within the tag in order to broadcast the RF signal (Singh et al., 2006). The batteries used by active tags allow for longer read ranges than passive tags but also add significant cost and bulk to the tags, thereby making active tags inappropriate for the public library setting (Singh et al.). A passive tag does not contain a built-in power source to broadcast the RF signal but relies on the power transmitted from the reader to generate enough power for data transfer to the reader (Jose et al., 2005). Passive tags typically are used in public library RFID implementations and are the type of tags utilized in the NCPL RFID implementation.

RFID readers are the devices used to receive and decode the information transmitted from the RFID tag and to communicate with the automated library system (Mehta, Goswami, Kumar, & Singh, 2004). The readers can be handheld or affixed to a surface, such as a doorway, table, or within security gates at the public library exits (Ward, 2007). As the item containing the RFID tag passes within range of the reader, a signal from the reader activates the RFID tag (Singh et al., 2006). The RFID tag transmits its information to the reader, which, in turn, communicates with a computer that sends the data to the ILS (Haley et al., 2007). The ILS is an enterprise resource planning system used by public library staff (Rubin, 2004). The ILS contains information about acquisitions, cataloging, the online public-access catalog, circulation, and serial holdings

(Rubin). RFID tags used in a public library implementation include a security bit that is activated when a patron returns an item to the library and deactivated when the patron has properly checked out an item (Singh et al.). Gates installed at the exit of the library can be programmed to initiate an alarm when an item passes through the gates without being properly checked out (Haley et al.). While no current standard exists, the majority of RFID technology implementations in public libraries use the 13.56 MHz frequency for transmission (Hopkinson & Chandrakar, 2006; Ward).

Importance of Standards

In the public library setting, RFID technology relies upon a precise identification of each item available to be checked out (Ward, 2007). Public library RFID implementations are unique in that each library's management can establish its own parameters for RFID implementation without being concerned about complying with standards such as those proposed by EPCglobal (Ferguson, 2005).

EPCglobal develops global standards for organizations implementing RFID technology in the commercial supply chain (Miano, 2005). The organization derives its name from the EPC, a family of coding schemes created by the EPCglobal organization as the successor to barcodes (EPCglobal, 2007). The commercial supply chain includes materials, information, and finances as they move from supplier to manufacturer, wholesaler, retailer, and consumer (Miano). Supply chain management involves coordinating these processes within and between companies. EPCglobal established RFID standards to assist organizations utilizing the commercial supply chain to ensure interoperability among users.

The EPCglobal Network identifies and tracks individual items throughout the supply chain by the unique EPC assigned to that item (Ferguson, 2005). The EPC derived from a standardized numbering system capable of uniquely identifying individual objects in motion in the global supply chain (Ferguson). The EPC is a series of numbers that identify the manufacturer, product type, and the unique item (Garfinkel & Holtzman, 2006). The EPC is the key to information about the product that exists in the EPCglobal Network distributed database (Garfinkel & Holtzman).

The EPCglobal Network is used by organizations such as Wal-Mart, which are involved in an open supply chain, whereas public library RFID is implemented in a closed system (Haley et al., 2007). A closed system exists where data are only accessible to those within the organization and those with a government mandate (Haley et al.). Working within a closed system, public library personnel are free to develop their own method of RFID numbering that works within their organization (Haley et al.).

The ability to implement unique RFID numbering creates interoperability problems for public libraries (Haley et al., 2007). Interoperability problems occur when materials from one library system cannot be identified by the RFID implementation at another library system, forcing reliance upon barcode technology, which is interoperable (Haley et al.). Standardization of public library RFID implementations has been proposed by NISO (2007) in the United States as a solution to interoperability problems.

NISO is a nonprofit association accredited by the ANSI. NISO develops, publishes, and maintains technical standards for information retrieval, library management, preservation of information, publishing, and information management (NISO, 2007). NISO formed the RFID for Library Applications Working Group

(LAWG) to develop a set of guidelines to detail current best practices for the use of RFID in library applications. The scope of work for the NISO LAWG is limited to library implementations of RFID at the commonly used 13.56 MHz frequency (Chachra, 2007). Tags operating in the ultra high frequency (UHF) range between 918-926 MHz are being tested for use in library RFID implementations, but high frequency (HF) 13.56 MHz tags are deployed in the majority of U.S. library implementations and are the focus of standardization efforts (Butters, 2006). The demand for UHF tags in the commercial sector increases the possibility of future lower tag costs compared to HF tags, eventually lowering implementation costs for libraries where a UHF tag solution is being considered (Butters). Interoperability among library systems using different tag frequencies is not presently possible, but the benefits related to inventory management, patron self-checkout, and increased customer service exist using either tag frequency (Butters).

LAWG reviews the existing RFID standards, examines and addresses privacy concerns, recommends security and data models for public library RFID tags, addresses patron privacy issues, promotes global tag interoperability, and has developed a best-practices document for those public library administrators considering RFID implementation (Chachra, 2007). The issue of privacy is a primary concern for the NISO LAWG (NISO, 2007). If not handled properly, privacy issues can slow down or derail RFID implementations by frightening patrons away from the technology instead of providing them with the facts about library RFID (Chachra). For example, studies show that some patrons believe that the RFID tag in the library item is used to track their movements wherever they go, instead of understanding that the tag is only read in a limited range within the library (Ward, 2007). Another misconception is that the tag

contains personally identifiable information, when, in fact, library tags only contain item-identifying information (Ward).

Legitimate issues of importance to the RFID LAWG are vandalism and tag destruction. Vandalism, such as modification of security bit information, can result in stolen materials. Viruses are another form of vandalism to which RFID technology may be susceptible (Chachra, 2007). Vandals capable of writing information to RFID tags can permanently lock fields after modification, making tag contents unreadable. Lastly, physical destruction of the RFID tag is possible (Chachra). Physical destruction of the tag is recognized as the easiest method of vandalizing an RFID implementation, but is reported to be a minor issue among libraries where the technology is implemented (NISO, 2008).

ANSI has selected NISO to represent U.S. interests to ISO TC46 on Information and Documentation (NISO, 2007). ISO TC46/SC4 develops technical standards that support the interoperability of information services for libraries, publishers, information centers, indexing and abstracting services, and archives (NISO, 2009). Appointed on May 9, 2007, WG 11 for TC46/SC4 is charged with developing a set of international standards for RFID usage in the library setting (Danish Library Agency, 2007). The WG participants include RFID experts from 13 countries who agreed to develop a set of statements as the basis for a new standard called ISO/CD28560 (NISO, 2007).

While no standard has been established to date, the Danish work related to public library RFID standards serves as a model for countries including China, Bahrain, Finland, Germany, Hong Kong, Malaysia, Norway, Netherlands, Sweden, Switzerland, the United Kingdom, the United Arab Emirates, and the United States, where this technology is

deployed (Hein, 2006). The Danish model is also expected to be followed in Austria, Canada, the Czech Republic, and Taiwan (Hein). In 2005, the Danish National Library Authority established basic requirements for the usage of RFID in Danish public libraries. These requirements were submitted to the leading standards certification organization in Denmark, known as Danish Standard, and accepted as Danish Standard Information Publication 163-1 (Andresen, 2006). According to Danish Standard Information Publication 163-1, RFID must support interlibrary loans, feature a standard interface to public library systems, employ interoperable tags, be compatible with current barcode technology, and comply with established international standards (Andresen).

Case Study Design

The author conducted a single case study. This approach is justified when the case studied is representative or typical of other similar cases (Yin, 2003). The investigation of the NCPL implementation of RFID technology was designed to educate personnel at characteristically similar public libraries on factors affecting the decision to deploy an RFID solution effectively. Descriptions of NCPL demographics, structure, and governance are presented in the segment titled Unit of Analysis in Chapter 3.

Yin (2003) described five important components of case study research design: (a) the study's questions, (b) its propositions, (c) the unit of analysis, (d) linking data to propositions, and (e) the criteria for interpreting the findings. Study questions are critical to the case study method and provide guidance in selecting the necessary research strategy. The next component of the case study is the formulation of propositions. Yin stated that proposition development is essential prior to collecting case study data to guide the researcher in gathering evidence during the investigation and to link this

inquiry to the work of others. Next, the unit of analysis is related to the study's questions and logically can be determined when the questions are accurately identified (Yin). The linking of the gathered data to the study's propositions and the analysis of the data are the final two components described by Yin.

According to Laudon and Laudon (2007), a successful technology implementation such as an RFID deployment, involves administrative support and commitment, user involvement and influence, a level of project complexity and risk, and a well-administered implementation process. The author used the Laudon and Laudon guidelines to develop the propositions used in this investigation and to evaluate the technology implementation at the NCPL. A description of the four factors identified by Laudon and Laudon follows.

A new technology initiative requires management support to increase the chances of success (Laudon & Laudon, 2007). Moreover, management must provide essential resources such as funding, equipment, and personnel. A commitment from management at various levels increases the likelihood that an implementation will be a high priority for employees, thereby improving the probability of success (Laudon & Laudon). The commitment of the NCPL management to the RFID implementation also was examined in this investigation.

Laudon and Laudon (2007) also identified the significance of user involvement in a technology implementation:

If users are heavily involved in the development of a system, they have more opportunities to mold the system according to their priorities and business requirements, and more opportunities to control the outcome. They also are more

likely to react positively to the completed system because they have been active participants in the change process. (p. 380)

The author examined the extent of user involvement in the RFID adoption and implementation at the NCPL through focused interviews with library staff and management. Users of the NCPL implementation included library staff, management, volunteers, and patrons.

As Laudon and Laudon (2007) noted, the level of project complexity and risk also determines project success. Technology implementations that are typically large and complex in terms of costs, staff size, time devoted for deployment, and the percentage of the organization affected by the implementation are more likely to fail than smaller scale projects (Laudon & Laudon). Risk of failure for a technology implementation increases if information requirements are not specified clearly or the solution is complex and requires integration of new technology into the workplace (Laudon & Laudon). RFID technology implemented in a public library is a large expense relative to the budgets of smaller public library systems. However, the technology can be deployed readily, thereby increasing the chances for a successful initiative (Ward, 2007).

According to Laudon and Laudon (2007), effectiveness of the implementation process requires that implementation tasks be completed on time. The groups involved in the project must work effectively together (Laudon & Laudon). Each facet of the implementation must be well managed or the initiative will take longer to complete than expected and exceed the allocated budget. The author examined management effectiveness in implementing RFID at the NCPL.

Proposition Development

The author developed the following propositions based on the work of Laudon and Laudon (2007) and Whitten et al. (2004) to structure the framework for the investigation. Propositions provided guidance in determining the data to collect and a context for analyzing the data.

Proposition 1: Management Commitment

Proposition 1: Management is committed to change and supportive of implementing the technology. A key factor identified by Laudon and Laudon (2007) and Whitten et al. (2004) is management support and commitment. In order for the implementation to be successful, the director of the public library must educate and involve staff and explain the benefits and constraints of RFID deployment (Haley et al., 2007). Without the commitment to change from library management, the RFID deployment will not succeed (Haley et al.). The efforts of the NCPL management in championing the move to RFID are detailed in this dissertation.

Proposition 2: Employee Commitment

Proposition 2: Employees of the organization are committed to technology change and supportive of the new technology. According to Whitten et al. (2004), “Because people tend to resist change, IT is often viewed as a threat. The best way to counter that threat is through constant and thorough communication with owners and users” (p. 88). As suggested by Haley et al. (2007), the benefits of an RFID implementation must be explained thoroughly to library employees to gain their support. Haley et al. maintained that the use of “labor-saving technologies inevitably put a scare into the workplace. Some employees are concerned that they will lose their jobs, while others fear that they are not

sufficiently computer literate to operate a new system” (p. 13). The degree of employee commitment at the NCPL to the technology initiative was examined through focused interviews with library staff.

Proposition 3: A Networked IS

Proposition 3: A networked IS is vital to the success of the organization. The building blocks of an IS are knowledge, processes, and communications (Whitten et al., 2004). Improving business knowledge is a fundamental goal of an IS (Whitten et al.). As Whitten et al. noted, business data are captured, processed, and stored using database technologies. Business knowledge is derived from such processed data and used by the organization to achieve its mission (Whitten et al.). In the case of the NCPL, typical types of data gathered by the organization and stored in the organization’s networked database included patron records, material inventory, loaned materials, and fines due.

Another key building block of an IS involves the process by which work is achieved within the organization (Whitten et al., 2004). The computer network at the NCPL supported the RFID deployment by enabling communication between the RFID readers and a computer interconnected to the library ILS. Library staff perform business processes related to patron services such as answering queries, collecting fines, checking materials in or out, and restocking shelves. Improving the business and service processes is an important goal of an IS such as the ILS deployment at the NCPL (Whitten et al.). RFID at the NCPL was implemented as a turnkey solution that functions as part of the library IS (Rubin, 2004). The administration of the NCPL needed to maintain efficient processes in order to achieve the purpose of the organization. The purpose of the NCPL is to serve the North Canton community by selecting, maintaining, and making available

resources that serve patrons' informational, recreational, and cultural needs (NCPL, 2009). According to NCPL Director Karen Sonderman (personal communication, October 1, 2004), RFID technology can facilitate realization of improved business processes such as material borrowing and return, keeping track of inventory, and preventing theft. While a specific return on investment is difficult to establish for the stated business processes, the author described perceived improvements in these areas.

Lastly, communications are the final building block of an IS (Whitten et al., 2004). A common goal for many organizations is to improve business communications and collaboration between workers and other constituents (Whitten et al.). An important component of business communication is effective and efficient communication between the networked system and system users (Whitten et al.). NCPL patrons and employees interact with RFID checkout stations, which are connected to a computer networked with the ILS. The author examined the interface between the RFID system and the ILS in place at the NCPL, including the interfaces used by library employees and patrons.

Proposition 4: Process of Continuous Improvement

Proposition 4: The organization must have a process to ensure continuous improvement can take place. Technology implementations are rarely perfect; users typically find errors and occasionally design flaws (Whitten et al., 2004). Business and user requirements evolve over time, requiring continuous changes and improvements to the system until it becomes obsolete (Whitten et al.). The RFID implementation at the NCPL is described from conception of the initiative to implementation, as well as subsequent steps to address problems and to improve system functions.

Continuous improvement takes place during the System Operation and Maintenance stage of the SDLC (Whitten et al., 2004). During this stage, user input and continuous monitoring of the system can result in the decision to make changes (Whitten et al.). In addition to fixing known bugs, the Operation and Maintenance stage of the SDLC requires that library staff remain current regarding improvements to the technology and consider implementing changes as necessary. An example of a possible improvement to the RFID implementation at the NCPL includes the potential for migrating from the commonly used HF tags to UHF tags for library materials, resulting in a longer read-range. Another example of possible changes to public library RFID implementations is the movement toward global standards, versus the currently implemented country-specific recommended practices (NISO, 2008). Library administrators at the NCPL eventually must consider whether upgrading the existing RFID implementation to a future recommended standard will result in a greater benefit to staff and patrons than the currently used system.

Proposition 5: User Satisfaction

Proposition 5: User satisfaction is directly related to IS success or failure. As noted by Whitten et al. (2004), a system user is “a customer who will use or is affected by an IS on a regular basis—capturing, validating, entering, responding to, storing, and exchanging data and information” (p. 15). System users are typically not concerned with costs and benefits of a new IS, but with functionality the system provides to their jobs, the system’s ease of learning, and ease of use (Whitten et al.). Internal system users and external system users are the two classifications of customers defined by Whitten et al.

Internal system users are employees of the business for which the IS is built (Whitten et al., 2004). In the case of the NCPL, librarians and staff are the internal system users whose jobs require interacting with the RFID technology implementation. External system users can include customers, suppliers, partners, and employees (Whitten et al.). In the case of the NCPL, external system users include the library patrons who interact with RFID technology during a visit to the library. The satisfaction of internal and external users with the RFID implementation at the NCPL was investigated and compared to the perceived success of the implementation by the NCPL management in order to validate this proposition.

Table 1 presents criteria described by Laudon and Laudon (2007) that are critical to the success of an IS implementation. Each criterion is correlated to one or more of the propositions guiding this study.

Table 1
Criteria and Associated Propositions

Criterion	Associated proposition
Management support and commitment	Proposition 1: Management commitment
User involvement and influence	Proposition 2: Employee commitment Proposition 5: User satisfaction
IT	Proposition 3: Networked IS
Continuous improvement	Proposition 4: Continuous improvement

Note. IS = information system; IT = information technology.

Summary of What is Known and Unknown About the Topic

The introduction of RFID technology in the public library environment is a relatively recent application (Haley et al., 2007). Based on the review of the related literature published between 2003 and 2009, RFID technology in the public library

setting enables reduction of queues at the circulation desk by supporting patron self-checkout and elimination of stress injuries to library staff resulting from the checkout process (Ward, 2007; Yu, 2007). RFID technology also facilitates item security and improved inventory management (Yu). Public library RFID solutions are costly, lack standards, and raise security and privacy concerns (Boss, 2009). Public library administrators considering RFID implementation must weigh the benefits and drawbacks in deciding whether RFID technology is an appropriate choice (Butters, 2006).

Use of RFID technology in the public library requires additional research to understand the role of RFID implementation in the library environment (Butters, 2006; Golding & Tennant, 2007; Singh et al., 2006). Specifically, case studies involving RFID solutions can assist administrators in understanding adoption issues associated with RFID deployment (Butters; Singh et al.).

The relatively recent use of RFID technology in the public library setting is a reason that research into library applications of the technology is beginning to emerge (Golding & Tennant, 2007). The NCPL is not the first library to implement RFID technology but is unique given the market size and demographics served by the library, compared to more common implementations in academic libraries such as Chicago State University library, which serves the university community of scholars, teachers, and students (O'Connor, 2007). The NCPL is an independent library system that serves the community of North Canton, Ohio, with a population of 16,755 (U.S. Census Bureau, 2006).

A key reason to conduct the study of the RFID implementation at NCPL is the lack of significant qualitative research focusing on implementation considerations at

community-based public libraries (Golding & Tennant, 2007). As a result of this research, public library system personnel considering RFID for libraries in markets similar to North Canton have a thorough understanding of benefits, drawbacks, logistical concerns, security issues, and privacy issues faced by the NCPL. The RFID implementation at the NCPL serves as a model for public library systems in which RFID is a candidate for adoption.

Contributions of This Study

The author examined the RFID implementation at the NCPL by using a case study approach in conjunction with the SDLC methodology to determine the capabilities of RFID technology in this setting. Findings from this study can provide public library administrators considering RFID with a framework and foundation for effective implementation. Logistical concerns and security and privacy issues addressed prior to RFID implementation were examined.

Based on findings from this case study, the author developed a model for RFID implementation in public library systems with similar circulation numbers as the NCPL. The NCPL currently circulates approximately 1 million items per year (State Library of Ohio, 2008). The model can assist public library administrators in determining whether RFID deployment is a viable solution for their public library system. The model includes key considerations such as the need for different types of RFID tags for different types of items, tagging logistics, assembling the RFID database, and determining security and equipment requirements. Lastly, the model includes a description of the level of public library staff knowledge and experience required to implement RFID technology.

Particular attention was paid to privacy and security concerns and the benefits and drawbacks of the implementation at the NCPL.

Chapter 3

Methodology

Research Methods Employed

The case study approach was used to address the research question: How does a local independent public library successfully implement RFID technology to improve business processes while maintaining a high degree of patron privacy? According to Yin (2003), the case study methodology is preferable when how or why questions are asked. The case study is also the methodology of choice when the researcher has little or no control over the subject of the study, as in the case of events in a real-life context (Yin). The case study method is commonly used when the subject of an investigation is an IS implementation (Orlikowski & Baroudi, 1991). As stated in Chapter 2, an IS uses hardware, software, data, processes, and people to support an organization's mission, goals, and objectives (Shelly et al., 2007). At the NCPL, the RFID implementation is a technology solution that is a part of the library IS.

The subject of this case study investigation was the RFID technology implementation at the NCPL. The investigation was conducted in real-time at the NCPL. The case study research strategy guided the author in determining how decisions were made and implemented for this study (Schramm, 1971).

Importantly, the single case study is useful when the investigation promotes an in-depth understanding of the topic of the study for those who are interested (Leedy & Ormrod, 2005). In this investigation, interested individuals include public library administrators considering RFID adoption. Another justification for the single case study

is when the subject represents a unique case (Yin, 2003). The RFID technology implementation at the NCPL is unique in that RFID is still relatively new in libraries (Galhotra & Galhotra, 2009). Thus, an examination of the RFID implementation at the NCPL could enable administrators at similar-sized public libraries to determine if RFID would be beneficial in their own libraries. According to NCPL Director Karen Sonderman (personal communication, November 21, 2008), the NCPL consists of 30,000 square feet of space and circulates more than 1 million items annually. The NCPL serves a city population of approximately 16,755 (U.S. Census Bureau, 2006).

The NCPL RFID implementation was examined in relation to the SDLC as described by Whitten et al. (2004). The SDLC consists of Systems Development and Operation and Maintenance stages. Whitten et al. stated that a technology solution is in the Systems Development stage until it is operational, at which point it enters the Operation and Maintenance stage. Eventually, the Systems Development stage is re-entered when a new or modified system is developed (Whitten et al.).

According to Whitten et al. (2004), the SDLC is sometimes confused with the stages of the System Development Process (SDP). The SDLC occurs naturally, whereas the SDP is the set of activities, methods, best practices, deliverables, and automated tools that stakeholders use to develop and maintain the technology solution (Whitten et al.). The five phases of the SDP are (a) the Project Initiation Phase or Phase 1, (b) the System Analysis Phase or Phase 2, (c) the System Design Phase or Phase 3, (d) the System Implementation Phase or Phase 4, and the System Support and Improvement Phase or Phase 5 (Whitten & Bentley, 2007).

In the Project Initiation Phase (Phase 1), the project scope, goals, schedule, and budget are established (Whitten & Bentley, 2007). This phase begins with the identification of the problem by the project stakeholders. This phase also includes planning for the solution to the problem. The stakeholders for a project commonly include system owners, project managers, system analysts, and system users (Whitten & Bentley). The stakeholders for the NCPL include the board of directors, library director, library technical support staff, librarians, and patrons (K. Sonderman, personal communication, October 1, 2004).

According to NCPL Director Karen Sonderman (personal communication, October 1, 2004), a key reason for considering a new technology solution at the NCPL was the prolonged wait times for patrons to speak with a staff member. While working the combined reference and circulation desk, library personnel spent what was deemed a disproportionate amount of time in the checkout process, leaving little time for patron questions. The steps involved in identifying the problem of increased patron wait times and planning for the solution are part of Phase 1 of the SDP.

The System Analysis Phase (Phase 2) provides the stakeholders with a thorough understanding of the problem and the needs that triggered the project (Whitten & Bentley, 2007). The scope of the project determined in Phase 1 is analyzed to gain a detailed understanding of which parts of the current system work, which parts do not, and what is needed (Whitten & Bentley). It is important at Phase 2 to include system users to assist in defining the expectations for any new system that may be developed (Whitten & Bentley). Priorities must be established at this phase in the event that budget and schedule are insufficient to achieve all of the project goals (Whitten & Bentley). The author

detailed the requirements of the System Analysis Phase of the SDP in relation to the steps taken at the NCPL to complete this phase.

During the System Design Phase (Phase 3) of the SDP, all potential solutions to the business problem are examined (Whitten & Bentley, 2007). The best option is selected and approved. The technical blueprints and specifications are developed to implement the chosen solution, including required software, hardware, and networks. Integration of the new system with the current system is planned at this phase. The first three phases of the SDP fall under the Systems Development stage of the SDLC (Whitten & Bentley).

RFID was the chosen solution for the NCPL. Alternative technology solutions, such as patron self-checkout enabled by barcode technology were examined, but the benefits of RFID outweighed the benefits of other solutions for the NCPL stakeholders (K. Sonderman, personal communication, October 1, 2004). A benefit of RFID for NCPL stakeholders is the ability for patrons to checkout multiple items at once, a significant speed increase over barcode technology in which each item must be scanned individually (Golding & Tennant, 2007).

The new technology solution is constructed, tested, and put into operation during the System Implementation Phase (Phase 4) of the SDP (Whitten & Bentley, 2007). New hardware, software, and networks are installed and tested in this phase. Interoperation with current systems is determined. At the completion of testing, all components of the chosen solution are placed into operation. At the end of this phase, training of system users takes place and the plan for transitioning from past business processes to new ones is implemented (Whitten & Bentley).

Once the system is operational and Phase 4 of the SDP is complete, the system enters the System Support and Improvement Phase (Phase 5) of the SDP (Whitten & Bentley, 2007). Design flaws or system errors discovered during system operation are addressed in this phase. In addition, business and user requirements can change over time and must be addressed. In order to keep the system functioning properly, maintenance is also required during Phase 5 (Whitten & Bentley). As a component of Phase 5 of the SDP, the author detailed system flaws, errors, and maintenance issues for the NCPL RFID implementation NCPL.

Unit of Analysis

According to Yin (2003), the unit of analysis logically can be selected when the primary research questions are specified accurately. As stated, the research question answered by this investigation was the following: How does a local independent public library successfully implement RFID technology to improve business processes while maintaining a high degree of security and patron privacy? The unit of analysis logically derived from the research question was the NCPL.

The NCPL is an independent library system founded in 1926 in North Canton, Ohio (NCPL, 2009). Opened on January 27, 1928, the library was designed to serve the citizens of North Canton and the school district. The library serves the community and enhances the quality of life of the patrons by selecting, maintaining, and making available resources that serve the patrons' informational, recreational, and cultural needs (NCPL). The latest population estimate for the city of North Canton is 16,755 (U.S. Census Bureau, 2006). As stated, the NCPL consists of 30,000 square feet of space, employs 35

individuals, and circulates more than 1 million items annually (K. Sonderman, personal communication, November 21, 2008).

Specific Procedures Employed

According to Yin (2003), a strength of the case study methodology is the use of multiple sources of evidence when collecting data. Findings in a case study are more likely to be accurate if based on multiple information sources. The six sources of evidence that can be used are (a) documentation, (b) archival records, (c) physical artifacts, (d) findings from interviews, (e) direct observation, and (f) participant observation (Yin). Two or more of these sources of evidence must be used in order to ensure convergence on the same set of findings. The sources for obtaining evidence for this investigation included documentation, direct observation, participant observation, and focused interviews.

Documentation as a Source of Evidence

Documentation in a case study corroborates and augments evidence gathered from other sources (Yin, 2003). Two categories of documentation used in this case study were design documentation and program documentation (Whitten et al., 2004). Design documentation includes flowcharts, system diagrams, and training and vendor manuals. Program documentation includes policy manuals, organizational charts, and strategic plans (Whitten et al.).

Direct Observation as a Source of Evidence

Evidence from direct observation provides additional information about the subject of the case study (Yin, 2003). The author determined the effectiveness of the RFID implementation at the NCPL by direct observation. The primary findings enabled

the author to determine the merits and constraints of the implementation. The author observed the use of RFID by library staff and patrons and recorded these activities in real time (Whitten et al., 2004). Silent observation of users is useful to determine how a technology works under real-world conditions and is essential to avoid bias (Nielsen, 2002). NCPL employees knew they were observed performing their jobs, but patrons of the library were not informed of the research. Unobtrusive techniques were used to observe library patrons (Hernon & McClure, 1987). Data collection conformed to the requirements of reliability, validity, and utility (Hernon & McClure). Typical patron interaction with RFID technology was observed at the NCPL and not scrutinized in a potentially invasive or embarrassing way, making unobtrusive measures appropriate (Leedy & Ormrod, 2005).

Participant Observation as a Source of Evidence

In contrast to direct observation, the author assumes a role within the case study situation in participant observation (Yin, 2003). The author takes part in the events studied and thereby provides the viewpoint of a case study participant (Yin). In this study, the author assumed the role of a library patron who had not used RFID technology at the NCPL. The library staff instructed the author on the use of the technology, similar to the instruction provided to the majority of patrons who used the technology for the first time.

Focused Interviews as Sources of Evidence

Interviews are one of the most important sources of case study information (Yin, 2003). The researcher elicits information from a respondent, using open-ended questions that encourage the subject to talk and provide salient details (Nielsen, 2002). The

interview questions in a case study investigation must follow the intended line of inquiry while being posed in a conversational tone (Yin). In this investigation, interview questions were developed relative to each proposition (Appendix B) using the expert review method detailed by Shneiderman and Plaisant (2005). Since the author could not be dependent on a single research subject, the subject-related interview questions were asked of multiple informants to verify the authenticity of the data collected (Yin).

In order to determine how RFID technology was implemented at the NCPL and the opinions of interviewees on the RFID implementation process, the author used focused interviews. In conducting the focused interview, the author met with respondents for a relatively short period and asked specific questions related to the RFID implementation (Merton, Fiske, & Kendall, 1990). In this study, the questions formulated were based on the propositions detailed in Chapter 2. The questions included a mixture of closed-end queries to corroborate certain facts and open-ended interview queries designed to yield insight into the implementation process. Responses to open-ended questions were expected to enable the author to identify corroborating or contrary sources of evidence (Yin, 2003). The three populations interviewed for this dissertation were (a) library administration, (b) public services staff, and (c) technical services. Interviews were conducted with two representatives from each primary job category for a total of six interviewees. Each interviewee met with the author for approximately 45 minutes.

Table 2 lists the propositions used to guide the evidence collection as part of this investigation. The sources of evidence associated with each proposition were also detailed.

Table 2
Propositions and the Associated Sources of Evidence

Proposition	Sources of evidence
Proposition 1: Public library management is committed to change and is supportive of implementing the RFID system. ^a	Direct observation Documentation: Strategic plans Policy manual
Proposition 2: Users of the system are committed to technology change and supportive of the new system. ^a	Direct observation Focused interviews
Proposition 3: A networked information system (IS) is vital to the success of the organization. ^b	Direct observation Focused interviews Documentation: Strategic plans
Proposition 4: The organization must have a process by which continuous improvement can take place. ^{b c}	Direct observation Focused interviews Documentation: Policy manual Strategic plan Organizational chart
Proposition 5: Users' satisfaction is directly related to the success or failure of the system. ^a	Direct observation Participant observation Focused interviews

^a *Essentials of Business Information Systems* (7th ed.), by K. C. Laudon and J. P. Laudon, 2007, Upper Saddle River, NJ: Prentice Hall.

^b *Systems Analysis and Design Methods* (6th ed.), by J. L. Whitten, L. D. Bentley, and K. C. Dittman, 2004, New York: McGraw-Hill Irwin.

^c *Information Technology for Management* (5th ed.), by E. Turban, E. McLean, and J. Wetherbe, 2006, Hoboken, NJ: John Wiley & Sons.

The Informed Consent Form, as approved by the Nova Southeastern University Institutional Review Board (IRB), was administered to each informant prior to the interview. The interviews took place at the NCPL to provide an atmosphere familiar to the interviewees in accordance with the recommendation by Shneiderman and Plaisant

(2005). NCPL employees interviewed included the library director, two representatives from the library staff, and the technical services director. Additional sources of evidence such as direct observation, documentation, and interviews conducted with the other library staff members were used to corroborate the interview findings of each interviewee.

The author used a variation of the expert review method described by Shneiderman and Plaisant (2005) to determine the questions asked of interviewees. Expert reviews involve consulting individuals with a specialized knowledge in the field being studied (Shneiderman & Plaisant). Such experts are asked their opinions of the subject matter to determine appropriateness for the intended purpose. One advantage of the expert review method is that expert reviews can be conducted rapidly. These reviews typically range in time from a half day to a week (Shneiderman & Plaisant). Another advantage of the expert review method is that the expert panel can identify areas of importance overlooked by the author (Shneiderman & Plaisant).

A variety of expert review methods exists, including heuristic evaluation, guidelines review, consistency inspection, cognitive walkthrough, and formal usability inspection (Shneiderman & Plaisant, 2005). The expert review methods detailed by Shneiderman and Plaisant focus on computer-interface design but also are applicable to interview question formulation. The method chosen by the author for this investigation was formal usability inspection.

Formal usability inspection involves a meeting with the expert panel and a moderator to present the subject of the review and to discuss merits and weaknesses (Shneiderman & Plaisant, 2005). In this investigation, experts in the field of RFID

technology use in libraries examined the proposed interview questions, suggested question modifications, and posed additional lines of inquiry. Communication among the panel members and the moderator occurred via e-mail. Following receipt of all expert-proposed additions, deletions, and modifications to the list of interview questions, the author compiled the revised list of questions and returned the list to the panel for further review. All experts agreed with the appropriateness of the changes and approved the list of questions.

The group of experts included in the expert review of interview questions ensured that the questions to be asked of the interviewees were relevant to the goals of this case study. The panel consisted of Executive Director Don Barlow of the Westerville Public Library in Westerville, Ohio, where RFID technology has been implemented; Associate Director of Support Services Jessi Weithman of the Westerville Public Library; Diane Ward, author of *The Complete RFID Handbook* (2007), a manual that details assessing, implementing, and managing RFID technology in libraries; and Director Carmen Zampini of the Kent Free Library in Kent, Ohio, where RFID technology is also implemented.

The author utilized the Delphi method to structure the expert review of interview questions. This method is an effective tool for structuring group communication and interactivity for complex problems (Linstone & Turoff, 2002). The Delphi method includes feedback on individual contributions, assessment of the group's judgment, an opportunity to revise views, and a degree of anonymity (Linstone & Turoff). The first stage of the Delphi process allows for exploration of the subject. In this stage of the Delphi method used in this investigation, the author forwarded the draft list of questions

to be asked of NCPL employees to members of the expert review panel. Members of the panel reviewed and evaluated the questions, making suggestions for modifications, deletions, and additions. The second stage of the Delphi method involves reaching an understanding of how the group as a whole views the issue. The author received feedback on the questions from each panel member and determined that only minor changes to the questions were recommended. If the panel members disagreed, the third stage of the Delphi method would have been implemented. The third phase of the Delphi method involves an analysis of issues underlying the disagreement. The third phase of the Delphi method was not necessary for this expert review process. In the final stage, the information gathered previously is analyzed, and the group provides feedback regarding the initial evaluation (Linstone & Turoff). In the final stage of the Delphi method for this investigation, participants agreed upon the modified list of questions. The interview questions agreed upon for this investigation are presented in Appendix B.

Format for Presenting Results

Case studies typically deal with abstract concepts such as implementation and group interaction (Wolcott, 2001; Yin, 2003). Therefore, a recommended method for reporting results from a single case study investigation is the narrative format. The format for the narrative method of reporting case study results begins with an introduction followed by an analysis of the gathered data (Wolcott). The narrative includes an analysis based on triangulation of the evidence gathered for each proposition. The SDLC served as a framework for the discussion of the results of this case study.

Study Outcomes

The primary outcome of this study was to advance professional practice and knowledge in the area of public library applications of RFID technology. Based on the findings from this investigation, the author designed a model for RFID implementation in public library systems. Advantages and disadvantages, logistical concerns, and privacy and security issues are described. The author focused on development of implementation guidelines for public library systems similar in size to the NCPL. According to recent U.S. government statistics available from the Public Library Survey performed by the Institute of Museum and Library Services (IMLS) Library Statistics Program in accordance with guidelines established by the National Center for Education Statistics, the NCPL had a circulation of 1.08 million items from a legal service area of 28,706 individuals in 2005 (IMLS, 2005a). The legal service area is defined as the number of individuals in the geographic region for which the public library is established to offer services and from which the library derives revenue (IMLS, 2005b).

Resource Requirements

The resources required for this research included access to NCPL personnel in order to conduct interviews and to observe their interaction with library patrons. Additionally, a panel of experts was required to assist with the development of the questions to be asked of the NCPL personnel. The author also used design documentation and program documentation acquired from the NCPL director to identify goals for the RFID implementation, review the strategic plan for the library, and assess the technical functioning of the specific RFID technology chosen for implementation.

Reliability and Validity

According to Yin (2003), the quality of a research design can be determined by using a series of four tests to ascertain the (a) reliability, (b) construct validity, (c) internal validity, and (d) external validity of the investigation (Yin). Reliability is defined as the ability to demonstrate that the operations of a study, such as data gathering procedures, can be repeated with the same results (Yin). Yin recommended the use of a specific research plan in order to ensure reliability. The research plan for this investigation included the use of propositions to guide the collection of evidence.

Validity is defined as the extent to which an instrument measures what is intended in its design (Leedy & Ormrod, 2005). The three measures of validity defined by Yin (2003) are (a) construct validity, (b) internal validity, and (c) external validity.

Construct Validity

Construct validity is achieved when the investigation uses operational measures in the performance of research, thus increasing the accuracy of the findings (Whitman & Woszczyński, 2004). Construct validity is defined by Leedy and Ormrod (2005) as the extent to which a measurement instrument accurately measures a characteristic that cannot be directly observed. Instead, the construct must be inferred from patterns in the behavior of investigation participants. The constructs measured in this investigation were the propositions presented previously. Construct validity can be achieved through the collection of multiple sources of evidence that provide multiple measures of the same phenomenon (Yin, 2003). As noted, the author collected multiple sources of evidence relative to the propositions stated in the study. Findings were based on evidence obtained

by the author through documentation, direct observation, participant observation, and focused interviews to ensure construct validity.

Internal Validity

Internal validity refers to the extent to which the research design and the data collected allow the author to draw accurate conclusions about the relationships within the data (Leedy & Ormrod, 2005). In order to ensure internal validity, steps must be taken to eliminate alternative explanations for the results reported. One method to ensure internal validity is to employ triangulation.

Triangulation involves using multiple sources for data collection to enhance the validity of research findings (Leedy & Ormrod, 2005). The type of triangulation used for this study is data triangulation. Sources of evidence for data triangulation include documents, archival records, open-ended interviews, observations, and structured or focused interviews (Yin, 2003). The author gathered multiple sources of evidence through documentation, direct observation, participant observation, and focused interviews. Case studies in which multiple sources of evidence are collected are more reliable than those inquiries that rely on a single source of evidence (Yin).

External Validity

External validity addresses the issue of whether the results of a study can be generalized to situations beyond the study itself (Leedy & Ormrod, 2005). Analytic generalization is utilized in case study research to address this issue (Yin, 2003). In analytic generalization, the author generalizes a particular set of results to predefined propositions (Yin). Data gathered during this investigation were assessed against the framework of the established propositions and described in relation to the SDLC.

Summary

The author presented the methodology used for this investigation in Chapter 3. The role of the NCPL as the unit of analysis for this case study was clarified. Specific procedures employed for collecting evidence were presented. The importance of proposition development was discussed and the propositions for this case study were indicated. The format was delineated for presenting the results of this investigation and the projected outcomes. Procedures were described for ensuring the validity and reliability in the case study.

Chapter 4

Results

This chapter presents the results of the investigation of the NCPL RFID implementation. The author conducted the study with the approval of NCPL Director Karen Sonderman (see Appendix C) utilizing a single case study methodology in conjunction with the SDLC to determine how a local, independent public library successfully implemented RFID technology to improve business processes while maintaining data security and a high degree of patron privacy. Yin's (2003) five important components of case study research design were employed to provide the boundaries of the investigation: (a) the study's questions, (b) its propositions, (c) the unit of analysis, (d) linking data to propositions, and (e) the criteria for interpreting the findings. Propositions were established through the literature review. Multiple sources of evidence were collected to increase the accuracy of the findings (Yin). Sources of evidence included documentation, direct observation, participant observation, and focused interviews.

The author evaluated documentation as a source of evidence. The documentation available to the author included the NCPL privacy policy, information provided by library RFID vendor 3M, and internal NCPL memos. The NCPL privacy policy (Appendix D) states that the library supports confidentiality relative to all library records that identify patrons by name or that link patrons to specific library materials. The NCPL administration employed library RFID vendor 3M to assist with the implementation. A checklist for libraries to use in preparing for a 3M RFID implementation was used at the

NCPL and evaluated by the author (3M, 2004). Other documents evaluated by the author included internal NCPL memos detailing implementation timelines and statistics related to the initial material tagging project, such as the average number of items tagged per hour and the total number of items tagged. A strategic plan for the NCPL related to the RFID implementation does not exist.

The author used direct observation to understand the process by which a NCPL patron utilizes RFID to check materials out of the library. For example, during one observation session a library patron who previously never used the RFID self-checkout process walked up to the checkout station for the first time. A staff member approached and offered assistance, but the patron stated that she wanted to learn it by herself. After approximately two minutes, the patron had checked her materials out, turned to the library employee, and said, "This is very nice, thank you."

Participant observation was used in this investigation to assist the author in understanding the process a patron experiences when introduced to the technology. This source of evidence was helpful in understanding how to use the RFID readers and the method employed by NCPL staff in teaching patrons how to use the system. For example, patrons are shown how to use the self-checkout stations without an explanation of the underlying technology. According to NCPL Director Karen Sonderman (personal communication, May 12, 2009), in the rare circumstance when a patron inquires about how the technology works, the employee offers a brief explanation of how the RFID tag in the item is read by the self-checkout station. To date, no patron has expressed concern about the technology or inquired further after receiving the initial explanation.

Focused interviews were an important aspect of this investigation and used to gather information related to the propositions and corroborate information obtained from other sources such as documentation, participant observation, and direct observation (Yin, 2003). Interview participants were selected based on their role in the organization and an understanding of the RFID implementation. Interviewees represented the primary job categories of NCPL employees, including administration, public services staff, and technical services. Interviews were conducted with two representatives from each primary job category for a total of six interviewees.

The interviews took place at the NCPL when the library was closed for remodeling. As stated by Shneiderman and Plaisant (2005), it was important for the interviewees to be in a known environment. The remodeling closure of the library allowed all interview participants to be available to the author without interruption. Each interview session lasted approximately 45 minutes and was recorded digitally as approved by the Nova Southeastern University IRB (see Appendix E).

A link between interview participants and information provided was maintained during the study. Confidentiality of interviewees was maintained by not using participant names in the dissertation report. Interview participants are identified throughout the report by number, such as Interviewee 1. The findings are presented below, organized within the framework of the SDLC.

Proposition 1: Management Commitment

Proposition 1 stated that public library management was committed to change and was supportive of implementing the RFID system. A technology implementation requires commitment from management at various levels of the organization to increase the

chances for success and to ensure that sufficient budget resources are allocated to the project (Laudon & Laudon, 2007). Evidence gathered from documentation, direct observation, and focused interviews support this finding.

The author examined documentation that demonstrated management commitment to the RFID implementation. The documentation consisted of meeting minutes from NCPL board of trustees meetings. The meeting minutes showed board support through initial approval of the funds required for the implementation as well as continued support approximately four years later through the approval of RFID-enabled material return chutes (NCPL, 2004; NCPL, 2008).

Evidence gathered through direct observation also indicated management support for the technology implementation. The author observed the library director discussing the benefits of the implementation with staff and coordinating the initial implementation to ensure a smooth transition to RFID. The director further demonstrated management commitment to the project by identifying a process improvement achievable by implementing RFID-enabled return chutes. She convinced the board of trustees that the chutes were beneficial and implemented two chutes in summer, 2009.

Focused interviews provided considerable evidence for management's commitment to change and support of the RFID implementation. All interviewees agreed that management commitment was demonstrated for the RFID implementation through verbal and financial support and commitment to subsequent upgrades to the system. Interviewees 3 and 4 described evidence of management's commitment to the project as simply that the system was implemented. As noted by the interviewees, without support of the library director and the library's board of trustees, the RFID implementation would

not have occurred. Interviewee 6 stated that support of the board of trustees was obtained through a series of steps. The first step involved a proposal by the library director to the board demonstrating the benefits of library RFID, specifically the benefits of enhanced security and increased library staff availability for patrons. Beginning in March 2004, the library building committee analyzed details of the proposal (NCPL, 2004). In May 2004, the building committee recommended to the board of trustees an expenditure of \$113,000 to contract with the 3M corporation to cover costs of the initial RFID implementation, including hardware, software, staff, and tags (NCPL). The board of trustees approved the plan, allowing the project to proceed. Interviewee 6 stated that the choice to use 3M as the vendor was based on more than project cost. Specifically, “Reliability and reputation were probably more important to us than cost.”

Interviewee 1 cited the significant budgetary commitment by management required to accomplish the implementation. The most expensive aspect of an RFID implementation is the cost of the tags (Haley et al., 2007). Figure 1 shows a typical book tag used for library RFID implementations.



Figure 1. Basic 3M™ radio frequency identification (RFID) book tag used for typical library implementations (actual size). Photo of 3M product reprinted with permission.

According to Interviewee 6, the tags used in the initial tagging project cost \$0.65 per tag. The cost of the RFID implementation at the NCPL was approximately \$113,000, with approximately \$74,000 spent on tags.

Interviewee 6 described a continued commitment to the project on the part of management through the recent purchase of two RFID-enabled return slots. The return slots enable materials to be checked in automatically without the intervention of a library employee. The slots became operational in summer 2009. The management commitment to support and to improve the in-place RFID implementation demonstrates that the NCPL RFID project entered Phase 5 of the SDP, the System Support and Improvement Phase (Whitten & Bentley, 2007).

Proposition 2: User Commitment

Proposition 2 stated that internal users (library employees) of the system were committed to technology change and supportive of the new system (Laudon & Laudon, 2007). Internal users of an IS are more likely to react positively to a technology implementation if they were active participants in the change process (Laudon & Laudon). Case study evidence revealed that employees of the NCPL were involved in the Project Initiation Phase (Phase 1 of the SDP) of the RFID implementation project. Direct observation, participant observation, and focused interviews were used to gather evidence of user commitment to the project.

Direct observation provided evidence of internal user commitment to technology change and support for the new system. The author observed library employee interaction with the system, patrons, and each other to determine if Proposition 2 was satisfied. All observed library employee interactions provided evidence of internal employee support

for RFID. Employees were knowledgeable when describing the new processes with patrons and able to answer any questions that arose. Additionally, library employees demonstrated enthusiasm when describing the benefits of self-checkout with patrons and when discussing the system with each other.

Participant observation was used to gather evidence of user commitment to technology change and support for the new system. The author participated in an orientation that is available to all patrons using the self-checkout system for the first time. The library employee was unaware of the author's identity or purpose for requesting the orientation. The employee was enthusiastic when discussing the benefits of the self-checkout system. The staff member provided a thorough and easily understood explanation of the process and capably answered all questions. The employee displayed what appeared to the author to be a genuine sense of support for the technology and the benefits it provided.

Focused interviews revealed user commitment to technology change and support for RFID technology. According to Interviewees 3 and 4, the initial discussions regarding the possibility of an RFID implementation project occurred after the problem of prolonged patron wait times to speak with a library staff member was identified. The discussions were first held informally among the library director, library managers, and staff. During these meetings, input from employees was gathered and questions were answered. Formal introduction of the RFID proposal occurred at a meeting of department managers.

According to all interviewees, the RFID implementation made aspects of their jobs more efficient than the previously used barcode system. For example, patron self-

checkout enabled library staff to have available more time for patrons with questions. The initial implementation of RFID at the NCPL utilized patron self-checkout as an option. According to Interviewee 5, patron self-checkout was utilized an average of 16% of the time, with staff-assisted checkout occurring the remaining time. Beginning in May 2009, the NCPL made patron self-checkout mandatory, freeing up more time for library staff. Patrons who ask a library employee to assist in the checkout process are guided to one of the five available RFID self-checkout stations and are taught how to use the technology. Interviewees 3 and 4 reported being pleased with the efficiency of the new checkout process. Interviewees 3 and 4 also stated that the new processes associated with the RFID implementation were easy for staff and patrons to learn.

Interviewee 6 described a benefit of the RFID implementation as improving the efficiency of performing item inventory. The annual inventory process using barcode technology took approximately two days, versus half a day using RFID. All interviewees involved in the inventory process expressed satisfaction with the new inventory process.

In addition to library employee satisfaction with a new system, patron satisfaction was as important or more important, according to Interviewee 4. Patrons were introduced to the new technology by the library newsletter, a handout explaining the new process, signs at the self-checkout stations, and explanations of the technology by staff. Observation by the author of patrons utilizing the system revealed no observable problems in learning or using the system. Several patrons were observed using the system without problems. Patrons new to the technology were observed receiving instruction from library staff, and each patron demonstrated the ability to use the system without incident.

At the outset of the investigation, the topics of privacy and security of patron information were believed by the author to be a primary concern of patrons and a potential area of resistance to the implementation (Shahid, 2005). Surprisingly, the case study investigation at the NCPL revealed no evidence of patron concern. All interviewees with direct patron contact stated that no questions were asked related to privacy or security. According to Interviewee 6, "Maybe the biggest unexpected thing was that no one said boo about it. When we implemented it, we never heard a peep out of any of the patrons. I was fully ready for it and expecting it, but it never happened, which was lovely." All interviewees stated that they were prepared to deal with patron resistance to the technology by explaining that the RFID tag used at the NCPL only contains the barcode information for the material and a bit used for security. No patron-identifying information is available on the tag, so unauthorized tag readers could identify only the material, not the identity of the patron.

An issue related to user commitment and support of the new system was a potential concern by library employees that the RFID implementation would create job loss. This concern has been common at libraries where the technology has been implemented (Haley et al., 2007). The NCPL demonstrated no loss of jobs or reduction in hours for any employees at the NCPL. Interviewees 1–4 acknowledged initial concern in 2004 for the effect of the implementation on jobs but were eventually satisfied that job cuts were not the reason for the implementation, since no jobs were lost related to the arrival of the technology.

Following the completion of this investigation, the NCPL Board of Trustees announced layoffs of eight full-time employees and the reduction in hours of one full-

time and one part-time employee (Pritchard, 2009). The layoffs were attributed to potential state funding cuts due to lower than expected tax revenue collections. Hourly employees represented by the American Federation of State, County, and Municipal Employees union held the positions eliminated (Pritchard). Library Director Karen Sonderman announced her retirement effective June 30, 2009.

Prior to the job cuts and retirement of the director, the library employed 55 people, 30 of whom belonged to the union. The story was reported in the online version of the Canton, Ohio, newspaper, which allows posting of anonymous comments regarding the article. Some of the comments posted referred to the possibility that the RFID implementation might have made staff cuts possible (Pritchard, 2009).

Proposition 3: Importance of Networked Communication

Proposition 3 stated that a networked IS was vital to the success of the organization (Whitten et al., 2004). Evidence gathered in support of the importance of networked communication included documentation, direct observation, and focused interviews. The NCPL utilizes the Polaris ILS to automate functions such as circulation, acquisitions, and cataloging.¹ The RFID implementation at the NCPL integrated with the ILS as a turnkey solution, adding increased functionality (Rubin, 2004). Software provided by 3M created the interface between the self-checkout stations and the library ILS. According to documentation obtained through 3M, 3M developed SIP to facilitate communication between 3M self-checkout stations and any library ILS (3M, 2006a).

¹ An ILS is an enterprise resource planning system used to integrate library functions such as circulations, acquisitions, and cataloging (Rubin, 2004). Polaris Library Systems based in Syracuse New York sells the Polaris ILS. Over 1,000 libraries in the U.S. use the Polaris ILS (Polaris, 2009).

Other major manufacturers of self-checkout RFID equipment, including Checkpoint Systems, Bibliotheca, IDSystems, and Libramation subsequently adopted the same protocol (3M). SIP 2.0 is the current version (3M).

Use of SIP 2.0 allows adoption of automated devices and services for the library with minimal change to the ILS in use (3M, 2006b). Additionally, the library ILS can be changed without the need to replace the equipment or services that utilize the SIP 2.0 protocol (3M). Interviewees 5 and 6 stated that because of SIP 2.0 compliance, the RFID implementation provided by vendor 3M, integrated seamlessly with the Polaris ILS.

Documentation evidence revealed that RFID tags used by self-checkout systems provided by 3M were originally proprietary, meaning that only 3M equipment could read the tags (3M, 2008c). The 3M Corporation now provides nonproprietary RFID tags, using industry-standard protocols (3M). Administrators at libraries where RFID is considered for adoption must understand that proprietary tags work only with a specific company's self-checkout systems (3M). If multiple library locations within a system adopt RFID, interoperability between the purchased readers and tags across the system is important (Haley et al., 2007). Vendor 3M recently announced a software upgrade for their self-checkout stations that allows for reading of proprietary tags provided by some other RFID vendors (Bacheldor, 2008b).

Interviewees stated that tags compatible with the 3M self-checkout stations were purchased for the NCPL implementation through OHIONET. OHIONET (2009a) is a membership organization of academic, public, school, and special libraries in Ohio, western Pennsylvania, and West Virginia. OHIONET (2009b) provides a variety of resources to member institutions, such as discounts on RFID supplies.

Interviewees stated that one of the features of the RFID implementation often not used is the RFID portable wand. The wand is a handheld tag reader with an antenna and rechargeable battery that locates shelved items, identifies filing errors, and can be used for inventory (3M, 2008a). Figure 2 shows the 3M RFID wand, known as the Digital Library Assistant. Interviewees 1 and 2 expressed an interest in using the device but cited lack of time as an impediment to learning all of the features of the wand to be able to use it efficiently.



Figure 2. 3M™ Digital Library Assistant. Photo of 3M product reprinted with permission.

In addition to patron self-checkout technology, the NCPL Board of Trustees approved the purchase of two RFID-enabled return chutes in September 2008. The chutes are known as 3M SelfCheck System, C Series book drops (3M, 2008b). The cost of each RFID-enabled chute was \$11,899, and purchased through OHIONET (NCPL, 2008). The chutes are located inside of the main library entrance and used only during library open hours. According to Interviewee 5, items are checked in instantly upon return and cleared from the patron's account. Figure 3 shows the RFID-enabled return chute available

through RFID vendor 3M. The chutes connect to a computer that is hard-wired into the library network, providing access to the ILS (K. Sonderman, personal communication, May 12, 2009). Interviewees 1 and 6 stated that library staff trust in the accuracy of return chutes to update patron account information correctly will likely be low during initial use, but they expected staff to develop trust in the system, similar to the trust that developed in the initial RFID implementation.



Figure 3. 3M™ SelfCheck™ System item return chute. Photo of 3M product reprinted with permission.

The author used participant observation of the self-checkout process to gather evidence of the importance of networked communication at the NCPL. The process utilized for self-checkout relies on a network infrastructure. The patron library card is scanned at the self-checkout station and a personal identification number entered. The patron credentials are verified against the patron database via wireline network technology. Once verified, the library materials are placed on the RFID-enabled mat at the self-checkout station. The reader reads the RFID tags and uses the networked communication system to relay the identity of the materials to the patron database. The patron record updates immediately and a record of the transaction saved. The process for returning materials is similar, with the exception of scanning the patron library card and

entering a PIN. As observed by the author, the self-checkout and return process relied on a network communication system to function.

Proposition 4: Continuous Improvement

Proposition 4 stated that the organization must have a process by which continuous improvement can take place (Turban et al., 2006; Whitten et al., 2004). Case study evidence revealed an informal, but efficient, continuous improvement process at the NCPL. Evidence gathered as proof of continuous improvement included documentation, direct observation, and focused interviews.

Documentation examined by the author provided evidence of a process by which continuous improvement took place. One example was a flyer prepared by NCPL management that described the purpose of the RFID tag that patrons found in borrowed materials. A sample tag was affixed to the flyer and a general description of the purpose of the RFID tag stated. Within the flyer, patrons were given direction regarding what to do if they found a problem with a tag. The flyer stated, "If you find a torn or defaced tag in an item you are checking out, please bring it to the attention of the staff."

Direct observation also provided evidence of a process by which continuous improvement was implemented within the NCPL. The author witnessed an employee who found a section of books without tags during the initial tagging project. The employee identified the materials and notified the main circulation desk. The appropriate employees were notified and the books were removed from the stacks and sent to a tagging station. The employee who discovered the missing tags informed the author that all employees were notified by library management of the process to follow when items without tags were found. The process ensured that the items were tagged immediately

and that responsibility for correcting the problem resided centrally with employees at the main circulation desk.

Focused interviews provided another form of evidence of a process by which continuous improvement could take place. All interviewees stated that problems identified by employees of the NCPL are first reported to the appropriate department manager. The department manager decides whether to identify a solution and to implement it or to bring the matter to the attention of the library director. Interviewees understood that the library director must approve any solution involving a budget expenditure. All interviewees reported that problems not requiring immediate action are discussed in the monthly meeting of department managers. All interviewees reported that problems related to technical functioning of the RFID equipment are relayed to the technology coordinator. The technology coordinator assesses the issue and determines whether an NCPL employee can fix it or if the 3M representative must be notified. All interviewees expressed satisfaction with vendor 3M and the response received when a problem arose. No complaints about 3M were recorded during the interview process.

As reported by Interviewees 3 and 4, occasionally an RFID tag problem was identified. These problems ranged in scope from a missing tag to a tag that could not be read by the reader. Tag problems are resolved at the circulation desk. Tags can be reprogrammed or a new tag can be programmed and affixed to an item immediately, eliminating the additional step of sending the item to the technical services department for resolution.

According to Interviewees 1 and 6, one issue identified following the RFID implementation concerned library books that also contained compact discs (CD).

Initially, library management decided that the book and the CD would be tagged separately. As reported by Interviewee 6, this was done to be certain that the CD was returned with the book. One problem with using two tags at the NCPL is both tags were unreadable by the RFID interrogator because they were located in close proximity to each other, a situation known as tag canceling (Galhotra & Galhotra, 2009). A problem with tag canceling is that a book with a CD requires a staff member to check the items manually rather than relying on self-checkout. Additionally, when the item is returned, an employee must scan the two items individually. Individual scanning of the items reduced the RFID benefits of automated check-in and checkout and lessened the availability of staff for patrons. Following discussions with department managers, the NCPL director decided to eliminate the use of multiple tags in books. The solution allows for patron self-checkout but requires a staff member to follow-up with a patron when it is determined that a CD was not returned with a book.

Interviewee 6 stated that during the initial RFID implementation in 2004, some problems existed that since have been resolved by advancements in the technology. For example, one solution for tagging CDs at the library was to place a tag on the CD case. A tag could not be placed on a CD because it interfered with its ability to be read by the CD player. A tag on the CD case allowed for theft of the CD by removing it from the case, preventing the security gates at the exits from detecting it. In response to this problem, RFID tag manufacturers produced donut-shaped tags for CDs and DVDs (Haley et al., 2007). Figure 4 shows the types of donut tags in use at the NCPL. The donut tags are placed around the hole in the center of the media, allowing the tag to be read without interfering with the ability of the CD or DVD to be played.



Figure 4. 3M™ donut-shaped radio frequency identification hub tag applied directly to CDs and DVDs. Photo of 3M product reprinted with permission.

Proposition 5: User Satisfaction

Proposition 5 stated that users' satisfaction is directly related to the success or failure of the system (Laudon & Laudon, 2007). Evidence of user satisfaction was obtained through direct observation, participant observation, and focused interviews. As stated previously, the author gathered evidence as a participant in the orientation to RFID provided to new users of the technology at the NCPL. Following the orientation, the author correctly utilized the technology and realized the improved convenience of RFID compared to barcode technology.

Direct observation of patrons and library employees provided another source of evidence of user satisfaction. All observed patron orientations to the technology resulted in every patron able to utilize the technology without incident. As one patron stated after using the technology for the first time, "This is very nice, thank you." The patron comment was typical of observed patron reactions following usage of RFID. The focused interview process detailed below also revealed evidence of employee satisfaction with the technology.

Case study evidence revealed an initial concern among some library employees that the automated RFID check-in and checkout process might not be accurate. Regarding employee distrust of the system, Interviewee 6 stated, “They needed to understand that they could trust it and I think that was our biggest issue.” Initial trust in the system was low, as reported by two interviewees. Both interviewees stated that trust developed within a short time, following manual checks to verify the system accurately identified materials checked out and returned.

According to Interviewees 1, 3, 4, and 6, the system is easy for patrons to learn and no patron has been unable to learn the process. Case study evidence revealed that some patrons asked questions regarding how the technology functions, but no one expressed concerns regarding privacy. The questions were answered with a brief explanation of how the tag is read by the pad where the patron places their materials and the information is relayed to the database where their account information is maintained. The explanation satisfied every patron who queried. Additionally, the library director developed a handout that described the self-checkout process for patrons. The handout briefly addressed the topic of privacy and security by stating, “The tags do not store any information about your library activity, nor do they transmit a signal once the item has been successfully checked out of the library.”

According to case study evidence, success metrics for the implementation included inventory time reduction, a functioning RFID security system, functioning automated checkout and return, and increased time available for staff to answer patron questions instead of checking out materials. Interviewees agreed that each of these metrics was achieved. For example, Interviewee 6 stated that prior to the RFID

implementation, taking inventory required closing for two days. Inventory with RFID took half a day to accomplish.

Interviewee 6 stated that the security features of the RFID implementation work, although it was reported that the security system is not perfect, similar to any security system the library implemented in the past. One of the problems with RFID security is the inability of a reader to identify a tag when placed under a metallic wrapper, such as the foil wrappers commonly used for some book covers (Haley et al., 2007). One solution to this problem employed by NCPL was to replace the foil cover with a paper copy of the original cover.

The automated checkout and return features of the implementation functioned properly, according to Interviewees 3 and 4. As discussed previously, initial trust in the system was low, but trust in the technology increased following manual checking for accuracy. Interviewees 3 and 4 expressed satisfaction with the RFID checkout and return system. The initial RFID implementation at the NCPL allowed for patron self-checkout, but returns were still made to the return desk or to non-RFID return slots. Library staff were responsible for properly checking in the items using the RFID implementation. Beginning in summer 2009, the NCPL patrons used either RFID-enabled returns slots located inside the library or the non-RFID return slots at the after-hours return drop accessible outside of the library.

The success metric of increased time available for library staff to answer patron questions was described as being accomplished by all interviewees responsible for this function. The NCPL RFID implementation was in-place before the beginning of this study, therefore time measurements could not be taken prior to or following the

implementation to demonstrate actual time saved. Interviewee 6 stated, “We never bothered with that stuff but I know we checkout a lot faster... and things get checked in a lot faster too.” According to Interviewee 6, time saving was the primary reason for implementing RFID and made the investment worth the cost. Interviewee 6 stated that circulation increased at least 4% each year since RFID implementation, but circulation desk staffing was not increased. Stable staffing levels were attributed to the time savings realized by implementing RFID.

Documentation available from the NCPL was limited, so the author examined reports from other libraries where RFID was implemented to determine if time savings was experienced. The NCPL administration did not verify actual time savings but other library administrators did, such as those at California Public Libraries, Utah’s Salt Lake County Libraries (SLCL), and the University of Pune Library.

A survey was conducted in 2006 of California libraries where RFID was implemented (Engel, 2006). Administrators at 18 libraries responded to the survey. A primary or secondary goal for 78% of responding libraries was the reduction in costs of circulation desk staffing (Engel). Four of the libraries surveyed provided details regarding circulation staff levels. All of these libraries reduced the number of circulation staff assigned per hour. The circulation at two of these libraries increased since introduction of RFID with no increase in circulation staff hours required (Engel). One of the libraries reported a decrease in circulation desk staffing of one staff member per hour (Engel). Circulation figures were not reported by the responding libraries.

SLCL have used RFID since 2005. Prior to RFID, the libraries utilized patron self-checkout with barcodes. RFID self-checkout is approximately three times faster than

barcode self-checkout, according to Gretchen Freeman, Associate Director for Technology at SLCL (personal communication, December 22, 2009). Staff at the SLCL assist patrons with fines, item limits, and questions about self-checkout, but the majority of time spent scanning items has been eliminated.

A study was conducted of circulation time savings at the Jayakar Library in Pune, India (Bansode & Desale, 2009). Circulation staff perform the checkout function at the library. The researchers reported the time taken by staff to scan 13 items borrowed by patrons and 10 items returned to the library. The 23 transactions were completed in 115 seconds using RFID, an average of 5 seconds per item. The same transactions completed using the barcode system took 5 minutes and 45 seconds to complete (Bansode & Desale).

One feature of the RFID implementation that did not work as planned was the wireless connection between the self-checkout stations and the ILS computer system. Interviewees 3, 4, 5, and 6 reported this wireless communication problem. Interviewee 5 described the problem as the wireless connection intermittently terminating throughout a typical day, but the cause was not discovered. Interviewees 5 and 6 attributed the terminated connections to interference from other wireless devices used in the library. As suggested by Interviewee 5, "I think there was just too much congestion on our wireless network." Specifically, the NCPL offers wireless Internet access to patrons. Anecdotal evidence suggested to Interviewees 5 and 6 that as the number of patrons utilizing the wireless Internet service increased, the connection between the self-checkout stations and the library ILS terminated more frequently. Library management determined that the wireless connections between the self-checkout stations and the ILS be eliminated and

replaced with wired solutions. According to interviewees, there are no plans to reimplement the wireless connection.

Initial user interaction with the implementation began with the conversion project. The conversion of all barcoded materials to RFID tagged materials began with closing the library for a week to work through the process of scanning all barcodes into one of four conversion stations rented from vendor 3M. Figure 5 shows the conversion station available for purchase or rental from 3M. The NCPL purchased one of the conversion stations for permanent use following the initial tagging project.



Figure 5. 3M™ Conversion Station. Photo of 3M product reprinted with permission.

The conversion process required that each item containing a barcode be scanned into the conversion station barcode reader and a new RFID tag placed on the conversion station pad to have the barcode information written to it. The tag was affixed to the library item when the tag writing process was complete. Rolls of RFID tags were used in the process, and the rolls contained some defective tags. Interviewees reported that defective tags were identified and marked by the manufacturer. Initially, the tags had a hole punched in them to signify a defect, whereas tags used recently contained a black dot to identify a defect. Interviewees 1 and 2 reported mild frustration with defective tags prior to learning the meaning of the markings made by the manufacturer. Prior to

understanding the meanings of the markings, some taggers attempted to use the defective tags, only to learn that effort was wasted. A memo (Appendix F) from the library director with instructions detailing the process to use to tag items circulated to all departments prior to the initial tagging project. The memo described the existence of defective tags and explained that the tags would have a hole punched in them. The memo also contained detailed instructions explaining proper tag placement for items including books, CDs, DVDs, VHS tapes, and audio tapes.

Following the initial tagging project, library materials checked out prior to the closing of the library had to be tagged upon return. According to case study documentation, the entire project of tagging items initially and tagging items as they returned to the library took approximately one month. All interviewees reported no significant problems learning or executing the item tagging process.

The initial tagging of items at the NCPL occurred on Thursday, August 5, 2004, and Friday, August 6, 2004. Eight full-time staff members, 30 part-time staff members, and 8 volunteers worked eight hours each day to tag items. The individuals were divided into eight teams. Appendix F identifies the statistics for the initial tagging project. The number of library items tagged over two days totaled 37,279. The largest number of items tagged in any hour was 482 and the smallest amount was 61. The average number of items tagged by the eight teams over two days was 291 items per hour. Teams with the highest number of tagged items per hour were awarded prizes, and all teams received lunch on both days paid for out of the library budget. Items returned by patrons after the completion of the tagging project were tagged upon receipt, and additional time was

required to finish tagging the approximately 11,000 untagged items remaining in the stacks.

Prior to project implementation, library management discussed the implementation informally with employees. A formal meeting introducing the technology project to department managers and staff followed the informal meeting. NCPL RFID vendor 3M provided a training session for library employees. According to all interview subjects, the training provided by the vendor was thorough and important in teaching the basics of utilizing the technology and completing the implementation project. Computer skills were required of all participants involved in the initial tagging project to utilize the software provided by 3M to program the tags. Interviewees described the technology skills required of all participants in the RFID implementation as basic data input capabilities.

According to interviewees, the NCPL Technical Services Department experienced no problems during the initial RFID software installation or with subsequent software maintenance. The degree of difficulty in configuring 3M software at the self-checkout stations and configuring the software to interface with the NCPL ILS was described as minor by interviewees. According to case study evidence, software setup primarily consisted of installation wizards that guided the installation. Installation manuals also were described as a helpful resource in answering questions related to technology issues. Minor issues that required assistance from 3M were handled expeditiously by the vendor. All interviewees praised the responsiveness of vendor 3M to questions asked throughout the implementation and maintenance stages of the project.

Summary of Results

The goal for the RFID implementation at the NCPL was to improve operational processes such as asset tracking, maintenance of patron records, and customer service, while maintaining patron privacy and the security of data (K. Sonderman, personal communication, October 1, 2004). The implementation was studied in Phase 5 of the SDP, allowing for an accurate assessment of progress toward the goal. Case study evidence revealed that the goal of the implementation was met.

Efficiency of asset tracking at the NCPL was accomplished as evidenced by the decreased time required to perform inventory of all library materials. Interviewees reported accomplishing item inventory using RFID in approximately four hours and conducting the inventory process while the library was open. Prior to the implementation, item inventory required two full days to complete and required that the library be closed. RFID usage is also an improvement over barcode use for library staff because patrons perform the checkout function without the assistance of a staff member. During SDP Phase 4 of the RFID implementation project, patrons were permitted to utilize self-checkout or ask an employee to checkout their materials. An evolutionary improvement to the RFID project implemented during Phase 5 of the SDP required all patrons to utilize self-checkout, except for limited circumstances. According to Interviewee 6, it became evident that all patrons could learn the self-checkout process without great difficulty, so usage of the self-checkout stations was required of patrons in summer 2009.

Evidence revealed that maintenance of patron records was more efficient using RFID because staff members were no longer tasked with performing the majority of item checkouts. Self-checkout patron records are automatically updated with items borrowed.

When RFID was initially implemented at the NCPL, employees were responsible for checking items in, but RFID automated that process as well, through automatic item identification and the ability to check-in multiple items simultaneously. Patron record maintenance became more efficient when the RFID-enabled return chutes were implemented in summer 2009.

Customer service at the NCPL has improved as stated by Interviewees 3, 4, and 6. According to case study evidence, available time for assisting patrons increased subsequent to the implementation of RFID technology. Exact measures were not available, but interviewees estimated that the amount of time available for assisting patrons increased dramatically during a typical workday. According to NCPL Director Karen Sonderman (personal communication, October 1, 2004), the key objective of the RFID implementation was to increase the amount of time library staff had to assist patrons. Evidence revealed that this objective was achieved.

Patron privacy was maintained throughout the RFID implementation, as revealed by case study evidence. The RFID tag technology used at the NCPL includes only the item barcode and a security bit. As recommended by the ALA (2006), no patron identifying information is contained on the tag, eliminating the tag as a potential privacy concern. As discussed previously, case study documentation revealed an existing privacy policy for the NCPL stating that confidentiality is maintained relative to all library records that identify patrons by name or link patrons with specific library materials. The privacy policy does not mention RFID technology specifically, but the statement was written in general terms to cover future technological developments without requiring the document to be rewritten (K. Sonderman, personal communication, May 12, 2009).

In the case of the NCPL, an individual using an unauthorized RFID reader could obtain barcode information from an item. Using a barcode lookup, the item could be identified. It is possible to compromise patron privacy by using an unauthorized RFID reader to identify materials borrowed by a patron if the reader is physically close enough to read the tag. Other options for obtaining the same information exist, thereby making this scenario unlikely (Haley et al., 2007). For example, viewing a patron's materials while standing in close proximity at the library circulation desk is an easier method for determining materials a patron borrowed (Haley et al.).

The security of patron data is maintained throughout the self-checkout process involving RFID use at the NCPL. The process required to utilize patron self-checkout at the NCPL involves a sequence of steps to ensure patron security. These steps include scanning the patron library card barcode and entering a unique PIN. Although not implemented at the NCPL, additional security of tag data is possible using passwords or data encryption to prevent unauthorized users from changing data maintained on a tag (Ateniese et al., 2005). 3M, the NCPL RFID vendor, did not view passwords or tag data encryption as necessary given the absence of any reported cases involving tampering with library tag data to date (3M, 2008d).

Chapter 5

Conclusions, Implications, Recommendations, and Summary

Conclusion

This chapter presents the conclusions, implications, recommendations, and summary for the case study investigation of the NCPL RFID implementation. The guidelines for the research were based on the single case study methodology and the SDLC framework. The literature review provided propositions used as the boundary for the investigation.

The RFID implementation project at the NCPL was well executed by management and staff from the Project Initiation Phase through the System Support and Improvement Phase. An important problem of prolonged wait times for patrons to speak with staff was identified by library employees, which lead to the decision to adopt an RFID technology solution. The planning, analysis, design, implementation, and support phases of the project were handled efficiently and professionally, resulting in a successful project implementation. The RFID project achieved the key goal of increasing library staff availability for patrons and satisfied management's other objectives, such as item security and increased efficiency in conducting item inventory.

A goal of this investigation was to develop a model for use by administrators at libraries with similar demographics as the NCPL where RFID was considered a potential technology solution. The NCPL implementation model is presented below, using the SDP as the framework.

Project Initiation Phase, Phase 1 of the NCPL RFID Implementation Model

During the Project Initiation Phase (Phase 1), project stakeholders identified the problem. Typical stakeholders for a project include system owners, project managers, system analysts, and system users (Whitten & Bentley, 2007). The stakeholders for the NCPL included the board of trustees, library director, library technical support staff, librarians, and patrons (K. Sonderman, personal communication, October 1, 2004). Stakeholders provide valuable insight during Phase 1 of the SDP (Whitten & Bentley).

As stated, the problem identified by the NCPL stakeholders was the prolonged wait times for patrons to speak with a library staff member. Patron usage of the NCPL increased over the last several years and the problem of increased patron wait times worsened (K. Sonderman, personal communication, October 1, 2004). Library RFID implementations provide several benefits including improved customer service, improved inventory management, reduced employee claims for repetitive stress injuries, and item security (Yu, 2007). As described by Interviewee 6, the benefit of improved customer service was a key factor in deciding to implement RFID at the NCPL.

In addition to identifying the problem in Phase 1, it is important to define the scope of the project, establish goals, create a schedule, and establish a budget. In the case of the NCPL RFID implementation, the project scope included all library materials, departments, and employees. A tentative schedule was created and a proposed budget was established, as revealed by case study documentation and presented in Chapter 4.

Planning for the solution to the problem is also a part of Phase 1 of the SDP. At the NCPL, patron self-checkout was determined to be the solution to the problem identified by stakeholders. Patron self-checkout was accomplished by implementing

RFID, but other solutions also were considered in this phase. For example, self-checkout is possible using self-service barcode readers that are implemented in some libraries, such as the Brecksville branch of the Cuyahoga County Public Library system in Ohio (Kroll, 2008). Additional benefits of RFID, such as the ability of staff to utilize the technology for item inventory, appealed to NCPL stakeholders.

System Analysis Phase, Phase 2 of the NCPL RFID Implementation Model

In the Systems Analysis Phase, the scope of the project is analyzed to understand what is needed to achieve a resolution to the problem identified in Phase 1. Consideration is given to which parts of the current system work, which do not, and what is needed for the new implementation (Whitten & Bentley, 2007). It is important for all stakeholders, especially users, to be represented in this phase (Whitten & Bentley). In the case of the NCPL, it was determined that the barcode method of checking materials in and out decreased time that library staff had to spend with patrons. Instead of assisting patrons with questions, library staff served as checkout clerks.

In order to implement an RFID solution at the NCPL, all materials were tagged, new security gates with RFID readers installed, and patron self-checkout stations implemented. Additionally, staff RFID stations were installed, an RFID conversion station purchased, and the software interface between the RFID implementation and the Polaris ILS installed and configured. The NCPL implementation also involved the use of in-place personal computers to attach to the RFID self-checkout stations, resulting in a cost savings. Priorities also were established in Phase 2 in the event that the budget and schedule were insufficient to achieve all of the proposed goals for the project (Whitten & Bentley, 2007).

System Design Phase, Phase 3 of the NCPL RFID Implementation Model

During Phase 3 of the SDP, all potential solutions to the problem identified in Phase 1 were evaluated (Whitten & Bentley, 2007). The best option was selected and approved. In the case of the NCPL, the solution selected to remedy the problem of prolonged wait times for patrons to speak with a staff member was RFID. In order to implement this technology, library management chose 3M, a company with expertise in the implementation of RFID in the library setting. Other organizations with expertise in this area included Bibliotheca, ID Systems, Libramation, and TAGSYS. According to NCPL Director Karen Sonderman, it was important to find a vendor with whom management felt comfortable, that offered a solution that satisfied library requirements, and was affordable (personal communication, October 1, 2004).

The technical requirements for the project were identified in Phase 3. Required items such as blueprints, hardware, software, and networks were identified as well (Whitten & Bentley, 2007). Integration of the NCPL RFID system with the existing system was planned as well. According to case study evidence, the 3M RFID solution was instrumental in achieving the objectives of Phase 3 of the SDP. Interviewees 5 and 6 agreed that NCPL personnel could not plan and execute the RFID implementation project without the assistance of a qualified vendor.

One item of importance was the type of RFID tags utilized on library materials. Standard book tags commonly used in public library implementations are rewriteable, passive tags that operate in the 13.56 MHz RF range (Ward, 2007). CD and DVD media required a special tag so that patron use of the item was not hindered. RFID tag

manufacturers produce donut-shaped tags for these items that fit around the hole in the center of the disk (Haley et al., 2007).

System Implementation Phase, Phase 4 of the NCPL RFID Implementation Model

During Phase 4 of the project, the selected solution was constructed, tested, and placed into operation (Whitten & Bentley, 2007). The hardware, software, and networks identified in Phase 3 were installed and tested. Interoperability with the in-place ILS was implemented and tested. When testing was complete for all of the components installed in this phase, the system became operational. According to all interviewees, RFID vendor 3M provided invaluable assistance in determining hardware, software, and network requirements for this implementation.

The initial tagging of all NCPL-owned items was an intensive undertaking and required significant planning (Haley et al., 2007). Appendix F identifies important considerations for libraries where RFID deployment is considered, based on the process utilized for the NCPL tagging project. Tag placement instructions and tag troubleshooting instructions are detailed in Appendix F as well. Moreover, statistics recorded for the initial tagging project are presented in Appendix F. Teams of four individuals were used for the NCPL tagging project, and each team averaged 291 tags placed per hour. This statistic is useful for other libraries with similar demographics to the NCPL where RFID will be implemented in determining approximate staff requirements for the initial tagging project.

Representatives of vendor 3M performed initial software installation and configuration. 3M provided the software, technical assistance, and configuration

expertise to achieve an operational interface between the RFID hardware and the library ILS. The NCPL technical services coordinator currently performs periodic updates.

Two important components of Phase 4 of the SDP were training of system users and implementing the plan for transitioning from old business processes to new ones (Whitten & Bentley, 2007). As described in Chapter 4, 3M provided training for all NCPL employees. All interviewees stated that the training was important. This training enabled library personnel to use the RFID solution effectively. According to interviewees, RFID utilization required the use of basic computer skills of librarians, library staff, and patrons. Based on case study evidence, vendor training of users and accessibility of the chosen vendor in the event of problems were critical to a successful RFID implementation.

System Support and Improvement Phase, Phase 5 of the NCPL RFID Implementation Model

During Phase 5 of the SDP, design flaws or system errors are addressed (Whitten & Bentley, 2007). According to case study evidence, no design flaws were identified in the RFID implementation at the NCPL. As detailed in Chapter 4, the issue of wireless communication errors between the wireless self-checkout stations and the computers attached to the library ILS was discovered and resolved during this phase of the project.

Business and user requirements can change over time and are addressed during Phase 5 as well. In the case of the NCPL, the RFID implementation was successful, as described by interviewees. Due to the success of the initial implementation in 2004, additional self-checkout stations were added in 2009. NCPL library administration mandated patron self-checkout after determining that almost all patrons were capable of

utilizing the features of the system. To increase the benefits of the RFID implementation, library management also installed two RFID-enabled return chutes in summer 2009.

Phase 5 of the SDP requires periodic maintenance of the system to ensure optimal performance. According to Interviewee 5, periodic software updates for the RFID implementation constituted the primary maintenance activity required. Typically, the library technology coordinator and on occasion a 3M representative installed these updates.

Library administrators considering implementation of RFID must weigh the benefits and problems associated with the technology to make an informed decision. An issue not addressed at the NCPL was whether a relatively expensive technology solution should be considered, given recent data suggesting that the era of books being primarily physical objects might be ending (Wolverton & Burke, 2010). According to Wolverton and Burke, acquisition of electronic resources (e-resources) account for the majority of new library materials. E-resources include such things as electronic access to journals, electronic books (e-books), and online reference resources (Wolverton & Burke). Desktop computer access to e-journals is already popular and expected to grow as publishers open their content to indexing by search engines such as Google (Rowlands et al., 2008). Some researchers have even predicted that the extinction of printed works will occur in our lifetime (Nikam & Rai, 2009).

RFID technology in the library setting facilitates patron self-checkout, automated returns, and item security of physical objects available to patrons. The majority of items tagged at the NCPL were books in the traditional physical object format. Books in electronic file format do not utilize RFID technology. The digital media equivalent of a

conventional book is an e-book (Nikam & Rai, 2009). E-books are read on a personal computer, PDA, smart phone, or on a device designed specifically for reading these digital files, such as the Amazon Kindle, Sony's PRS-500, or Apple iPad. E-book readers recently gained a degree of acceptance and commercial success and libraries are actively involved in a resurgence of e-book licensing (Shelburne, 2009). Given the recent rise in acceptance and popularity of e-books, Nikam and Rai believe that printed matter will almost be foreign to the next generation of children. As Heath (2010) states, "Old vessels, such as books and journals, often confused by librarians with the information that they contained, may fall away."

According to Vasileiou, Hartley, and Rowley (2008), "The growing availability of e-books and the improvement in e-book reader technologies will increasingly bring e-books to the attention of information users. Libraries will need to be proactive in their response to e-books." Wolverton and Burke (2009) recommended that library staffs spend less time processing print materials and more time marketing and managing e-resources, which they claim will be of greater benefit to library patrons. Wolverton and Burke suggested that library administrators give printed materials the staff time they deserve based on circulation statistics. For example, if printed materials account for 10% of circulation at a library, 10% of staff time should be allocated for the tasks associated with print materials.

The future relevance of libraries, especially academic libraries, depends on the acceptance and use of innovative technology (Dougherty, 2009). The future of libraries is unknown, but a need exists to redefine the library business (Law, 2009). Distinct from academic libraries, public libraries appear to have a more stable role in a community

based on patron perception (ALA, 2009). A recent survey found that 92% of respondents view their local library as an important educational resource (ALA). Descriptions in the survey of the physical library building include 72% who view the library as a pillar of the community, 71% who view the library as a community center, 70% who view the library as a family destination, and 69% who view the library as a cultural center. In the academic setting, digitization of library materials is contributing to a shift from the library as a physical space to a virtual digital environment (Rowlands, et al., 2008). According to Sennyey, Ross, and Mills (2009), "...digital collections do not require a building, which is no longer the sole point of distribution." Other threats to libraries exist, including the availability of e-books and other e-resources through outlets such as Google, which allow individuals to bypass the library as a destination (Rowlands, et al.) Libraries are no longer the sole starting point for research. As stated by Sennyey et al., "At the same time that the universe of information is growing, discovery is becoming a greater challenge, yet libraries are no longer associated with that critical service. Google is."

If major transformation is believed to be forthcoming for libraries in the form of electronic material formats, what role will RFID have in this scenario? The future of libraries is difficult to know, but library administrators should be aware of the possibility of a shift to e-resources and the impact on an RFID implementation. The expense of RFID makes it important for those considering it as a viable technology solution to investigate alternative technologies as well as possible future scenarios that could affect the implementation.

Implications

This case study involved the investigation of the RFID implementation at the NCPL. Case study findings indicated that the technology was implemented successfully and achieved the objectives library management set forth. The findings were used in conjunction with the SDLC methodology to develop a model for RFID implementation at public libraries with demographics similar to the NCPL.

The author advanced professional practice and knowledge in the area of public library applications of RFID technology and contributed to the foundation for future studies in this space by examining in detail the RFID technology implementation at the NCPL. Administrators working at public libraries where RFID is considered as a potential technology solution can utilize the findings of this research to understand important considerations prior to adopting this technology.

Additional research is required to identify precise benefits in the area of library RFID implementations. Exact measures are required to identify and quantify these benefits. This investigation detailed how RFID was implemented at the NCPL but did not provide a critical analysis of user benefits of RFID.

The data sources for this case study included direct observation, participant observation, focused interviews, and documentation. As the study progressed, it became evident that documentation was the weakest data source for the investigation. Conversations between the author and library administration prior to the start of the study led the author to believe that a sufficient source of documentation existed. Design documentation related to the RFID implementation project was notably absent. For example, flowcharts, system diagrams, and training manuals were not part of the

documentation prepared by NCPL administration in preparation for the RFID project, but are typically found in related system implementation projects. Program documentation is commonly another important component of studies of this type. Program documentation such as a strategic plan, organizational chart, or policy manual was not available to the author.

The inclusion of relevant data sources such as quality documentation could have strengthened the findings of this study. However, the author set out to examine the RFID implementation at the NCPL using the case study methodology. As noted by Yin (2003), the case study methodology is appropriate when the focus is on a contemporary phenomenon within a real-life context and when the relevant behaviors cannot be manipulated. Although the author preferred better data sources, the findings are based on what was available in the real-life context of the RFID implementation at the NCPL. A strategic plan, policy manual, and flowcharts related to the implementation were not required of library administration by the library board of trustees. A determined library director who had the support of the board of trustees championed the implementation. The author would have liked to see a formal plan with data to prove the necessity or benefits of an RFID implementation at the NCPL, but it did not exist and was not required of the library director.

Recommendations

Case study evidence gathered at the NCPL confirmed current literature cited in Chapter 2 in identifying RFID as a relatively recent application in the library setting. Evolving technologies and few recognized standards confronted early adopters of the technology. Interviewees perceived the implementation project as successful, based on

the achievement of the primary goal of providing more time for library staff to answer patron questions. Improved item security and decreased time required for item inventory were additional benefits of the implementation.

The author recommends additional formal studies measuring exact time savings achieved through RFID implementation at libraries where RFID will be implemented. The study of the NCPL was unable to determine exact time savings because RFID was implemented prior to the beginning of the research, making it impossible to know the amount of time spent by staff on the checkout process prior to implementation. Further study is recommended to determine if library RFID implementations reduce the number of repetitive stress injury claims by library workers, as claimed by supporters of the technology (Yu, 2007). Further study would benefit other libraries where RFID is considered as a potential technology solution. As case study evidence suggested, a library RFID implementation project requires a significant expenditure. Further study of the issues previously stated could be beneficial for library administrators to justify the cost of an RFID technology solution.

The author also recommends determining the cause of wireless connectivity problems at the NCPL. One problem identified by interviewees was intermittent loss of wireless connectivity between the self-checkout stations and the computers connected to the ILS. Interviewees speculated the reason for the periodic loss of functionality. Determining the exact cause for the problem would be beneficial for other libraries where RFID adoption is a consideration. Wireless connectivity may be important at other libraries, and understanding the underlying issue at the NCPL could prove helpful.

Lastly, consideration should be given to the future of library operations and the impact on RFID implementation. As stated in the conclusion, the trend toward e-resources is strengthening. Administrators at libraries where RFID is considered as a potential technology solution should weigh the benefits associated with the implementation in light of current trends.

Summary

RFID technology gained the attention of public library personnel in recent years as a potential replacement for barcode technology currently in use at the majority of public libraries (Ward, 2007). Benefits associated with RFID implementation include improved staff productivity, reduced time required for item inventory, and item security (Ward). While benefits of the technology are significant, there are key issues to consider prior to adoption. Potential issues associated with the technology include patron privacy, security, system cost, and current lack of standards (Boss, 2009; Ward).

A key problem identified at the NCPL was the increase in patron borrowing in recent years led to long lines of patrons at the circulation desk waiting to check out items. As a result, library staff had little time to answer patron questions while their time was spent functioning as checkout clerks. Patron self-checkout was identified as a solution to the problem and technologies were investigated. RFID was chosen as the technology solution and implemented in 2004.

The goal of this research was to advance professional practice and knowledge in the area of public library applications of RFID technology. The research contributed to the foundation for future studies in this realm by examining in detail the RFID

technology implementation at the NCPL. The case study methodology was used in conjunction with the SDLC (Whitten & Bentley, 2007) to frame the investigation.

An extensive review was conducted of current and seminal literature related to the topic. The role of RFID in the library environment was documented, including the benefits and limitations of the technology. Security and privacy were identified in the literature as two important issues related to library RFID implementation (Yu, 2007). The importance of technology standards was described in Chapter 2. Standards for library RFID implementations are under consideration but have not been adopted (Boss, 2009).

The author used the case study methodology in conjunction with the SDLC to perform the study (Whitten & Bentley, 2007). The role of the NCPL as the unit of analysis for this case study was clarified and the specific procedures employed for collecting evidence included documentation, direct observation, participant observation, and focused interviews.

The research conducted is timely, as the NCPL director receives several requests by other library administrators to tour the NCPL facility and discuss the RFID implementation (K. Sonderman, personal communication, May 12, 2009). The results of the study described a successful RFID implementation that achieved NCPL management objectives. All interviewees expressed satisfaction with the technology in relation to their role in the library. The concerns expressed in the literature regarding library RFID security and privacy issues and their potential to delay or cancel a library implementation project were not experienced at the NCPL but consideration of these issues is important for libraries where RFID is considered.

Appendix A

List of Abbreviations and Acronyms

ACM	Association for Computing Machinery
ALA	American Library Association
ANSI	American National Standards Institute
ASRS	Automated Storage and Retrieval System
EPC	Electronic Product Code
HF	High Frequency
IEEE	Institute of Electrical and Electronics Engineers
ILS	Integrated Library System
IMLS	Institute of Museum and Library Services
IRB	Institutional Review Board
IS	Information System
ISBN	International Standard Book Number
ISO	International Organization for Standardization
IT	Information Technology
LAWG	Library Applications Working Group
mm	Millimeter
NCPL	North Canton Public Library
NISO	National Information Standards Organization
PDA	Personal Digital Assistant
PIN	Personal Identification Number
RF	Radio Frequency

RFID	Radio Frequency Identification
SDLC	System Development Life Cycle
SDP	System Development Process
SFPL	San Francisco Public Library
SIP	Standard Interchange Protocol
SIP 2.0	Standard Interchange Protocol, Version 2.0
TC46/SC4	Technical Committee 46, Subcommittee 4
UHF	Ultra High Frequency
WG11	Working Group 11

Appendix B

Interview Questions

Target Population: Administration

Proposition 1:

Public library management is committed to change and is supportive of implementing the RFID system (Laudon & Laudon, 2007).

1. Why was RFID implemented?
2. What benefits are associated with the implementation?
3. What options in addition to an RFID solution were investigated prior to deciding on RFID?
4. Who was involved in the decision to implement RFID?
5. How was the approval of the library Board of Trustees earned?
6. What equipment was used for the initial tagging? Was the equipment owned by the library or rented and returned to the vendor?
7. How long did the initial tagging take?
8. Do you have an estimate on the number of materials that were tagged per hour?
9. Which library items are tagged?
10. Are any items not tagged?
11. Were you surprised by any of the costs associated with RFID or maintenance of the RFID implementation?
12. How was the RFID vendor selected?

Proposition 2:

Users of the system are committed to technology change and supportive of the new system (Laudon & Laudon, 2007).

1. What sort of learning curve can be expected by management, staff, volunteers, and patrons in learning how to use the new technology?
2. What is the tagging process for new library materials that are purchased?
3. Has library staffing changed in any way related to the RFID implementation?

Proposition 3:

A networked IS is vital to the success of the organization (Whitten et al., 2004).

1. What additional hardware and software are required for implementing RFID?
2. Are the RFID tags selected proprietary and, if so, with which vendor?
3. Which protocol is used for the implementation?
4. Are the data encrypted between the RFID system and the ILS?
5. What information is stored on the RFID tag?
6. Are there features available with your RFID implementation that are not implemented? If yes, why were the features not implemented? Do you have plans to implement the features?
7. Did the RFID technology integrate well with the ILS?
8. If the ILS is changed, what is the effect on the RFID implementation?

Proposition 4:

The organization must have a process by which continuous improvement can take place (Turban et al., 2006; Whitten et al., 2004).

1. What challenges were presented with the implementation of RFID?
2. Were there any unexpected occurrences during or after the implementation?
3. What, if any, unexpected occurrences slowed the initial tagging?
4. What technical issues were experienced with the implementation?
5. What technical issues arose since the implementation?
6. In regard to continuous process improvement, describe the process to correct a problem that has been identified with the RFID implementation?
7. Describe the process to suggest improvements to the RFID implementation when staff, patrons, or volunteers identify a possible enhancement.

Proposition 5:

Users' satisfaction is directly related to the success or failure of the system (Laudon & Laudon, 2007).

1. Describe the process in which you learned to utilize the RFID system.
2. How was the RFID implementation introduced to staff?
3. How do you know if the implementation is successful? (What "success metrics" are used to determine success?)
4. Has the return-on-investment been calculated for the implementation?
5. What percentage of library materials is checked out using the RFID self-checkout machines?
6. Do you know what the failure rate is for the different types of tags you are using?
7. What kind of support was/is provided by the RFID vendor?
8. Have you been pleased with the vendor's service and response to questions?
9. Would you recommend RFID for other similar libraries?

10. Is there any case in which you would not recommend that a library convert to RFID?
11. What concerns were expressed by library staff, volunteers, or patrons concerning RFID implementation?
12. How were the concerns addressed?
13. Did staff, patrons, or volunteers regarding privacy or security raise any questions?
14. What steps were taken to introduce patrons to the technology and associated new processes?
15. Is there a patron privacy policy in-place?

Target Population: Staff

Proposition 1:

Public library management is committed to change and is supportive of implementing the RFID system (Laudon & Laudon, 2007).

1. Why was RFID implemented?
2. What benefits are associated with the implementation?
3. Does library management demonstrate commitment to the implementation of RFID? If yes, how is that commitment demonstrated?
4. Who was involved in the decision to implement RFID?

Proposition 2:

Users of the system are committed to technology change and supportive of the new system (Laudon & Laudon, 2007).

1. How was the RFID implementation introduced to staff?
2. What sort of learning curve can be expected by staff, volunteers, and patrons in learning how to use the new technology?
3. Has library staffing been changed in any way related to the RFID implementation?
4. What is the tagging process for new library materials that are purchased?
5. What steps were taken to introduce patrons to the technology and associated new processes?

Proposition 3:

A networked information system is vital to the success of the organization (Whitten et al., 2004).

1. Are there features available with your RFID system that are not implemented?
2. Did the RFID technology integrate well with the ILS?

Proposition 4:

The organization must have a process by which continuous improvement can take place (Turban et al., 2006; Whitten et al., 2004).

1. What challenges were presented with the implementation of RFID?
2. Were there any unexpected occurrences during or after the implementation?
3. What, if any, unexpected occurrences slowed the initial tagging?
4. What technical issues were experienced with the implementation?
5. What technical issues arose since the implementation?
6. Concerning continuous process improvement, describe the process to correct a problem that has been identified with the RFID implementation?
7. Describe the process to suggest improvements to the RFID implementation when staff, patrons, or volunteers identify a possible enhancement.

Proposition 5:

Users' satisfaction is directly related to the success or failure of the system (Laudon & Laudon, 2007).

1. Describe the process in which you learned to utilize the RFID system.
2. How do you know if the implementation is successful? (What "success metrics" are used to determine success?)
3. What concerns did library staff, volunteers, or patrons concerning RFID implementation express?
4. How were the concerns addressed?
5. Were questions raised by anyone regarding privacy or security?
6. What kind of support was provided by the RFID vendor?
7. Have you been pleased with the vendor's service and response to questions?
8. Do you know what the failure rate is for the different types of tags you are using?

9. Would you recommend RFID for other similar libraries?
10. Is there any case in which you would not recommend that a library convert to RFID?

Target Population: Technical Services

Proposition 1:

Public library management is committed to change and is supportive of implementing the RFID system (Laudon & Laudon, 2007).

1. Why was RFID implemented?
2. Does library management demonstrate commitment to the implementation of RFID? If yes, how is that commitment demonstrated?
3. What benefits are associated with the implementation?

Proposition 2:

Users of the system are committed to technology change and supportive of the new system (Laudon & Laudon, 2007).

1. What sort of learning curve can be expected by technical services employees in learning how to use the new technology?
2. What concerns did library staff, volunteers, or patrons concerning RFID implementation express?
3. How were the concerns addressed?
4. Has library staffing changed in any way related to the RFID implementation?
5. What is the tagging process for new library materials that are purchased?

Proposition 3:

A networked information system is vital to the success of the organization (Whitten et al., 2004).

1. What additional hardware and software are required for implementing RFID?
2. Are the RFID tags selected proprietary and if so, with which vendor?
3. Which protocol is used for the implementation?
4. Are there features available with your RFID implementation that are not implemented? If yes, why were the features not implemented? Do you have plans to implement the features?
5. What information is stored on the RFID tag?
6. Did the RFID technology integrate well with the ILS?

7. If the ILS is changed, what is the effect on the RFID implementation?
8. Are the data encrypted between the RFID system and the ILS?

Proposition 4:

The organization must have a process by which continuous improvement can take place (Turban et al., 2006; Whitten et al., 2004).

1. What challenges were presented with the implementation of RFID?
2. Were there any unexpected occurrences during or after the implementation?
3. How was the RFID vendor selected?
4. What kind of support was provided by the RFID vendor?
5. What, if any, unexpected occurrences slowed the initial tagging?
6. What technical issues were experienced with the implementation?
7. About continuous process improvement, describe the process to correct a problem that has been identified with the RFID implementation?
8. Describe the process to suggest improvements to the RFID implementation when a possible enhancement is identified by staff, patrons, or volunteers.

Proposition 5:

Users' satisfaction is directly related to the success or failure of the system (Laudon & Laudon, 2007).

1. How was the RFID implementation introduced to technical services staff?
2. Describe the process in which you learned to utilize the RFID system.
3. How do you know if the implementation is successful? (What "success metrics" are used to determine success?)
4. Have you been pleased with the vendor's service and response to questions?
5. Do you know what the failure rate is for the different types of tags you are using?
6. Were questions raised by anyone regarding privacy or security?
7. Is there a patron privacy policy in place?
8. Would you recommend RFID for other similar libraries?
9. Is there any case in which you would not recommend that a library convert to RFID?

Appendix C

NCPL Approval



December 29, 2008

To whom it may concern: ✓

This letter signifies that I have reviewed the research proposal put forth by Keith Lyons and that I approve the research he would like to conduct at the North Canton Public Library in regards to RFID implementation. Mr. Lyons has consistently kept me informed of the progress of his dissertation and the library is prepared to assist him with his research.


Karen Sonderman
Director

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Appendix D

Library Confidentiality Policy

Confidentiality of Records

Policy: The Library supports and adheres to confidentiality relative to all library records which identify patrons by name or which link library patrons with specific library materials.

Regulations: In compliance with Ohio Revised Code section 149.432, the Library holds confidential all library records and patron information, except in the following circumstances (per ORC section 149.432):

- 1) Library information pertaining to a minor child is requested by the minor child's parent, guardian, or custodian
- 2) In accordance with a subpoena, search warrant, or other court order or to a law enforcement officer who is acting in the scope of the officer's law enforcement duties and who is investigating a matter involving public safety in exigent circumstances
- 3) Upon the request or with the consent of the individual who is the subject of the record or information
- 4) When for use in various administrative library purposes
- 5) To document improper use of the Internet at the library so long as any patron information is removed from those records (excludes age and gender of an individual)

In the above named circumstances, the Library will cooperate in a reasonable fashion and to the fullest degree within its scope to do so. Questions about patron records should be referred to the Director.

Appendix E

IRB Approval



NOVA SOUTHEASTERN UNIVERSITY
Office of Grants and Contracts
Institutional Review Board

MEMORANDUM

Keith Lyons, M.A.
9445 Frost Lane
Brecksville, OH 44141

From: Teri Hamill, Ph.D. *Teri Hamill*
Chair, Institutional Review Board

Date: February 17, 2009

Re: *An Analysis of the Radio Frequency Identification (RFID) Technology Implementation within an Independent Public Library System: A Case Study of the North Canton, Ohio Public Library – Research Protocol No. SCIS01290910Exp.*

I have reviewed the revisions to the above-referenced research protocol by an expedited procedure. On behalf of the Institutional Review Board of Nova Southeastern University, "*An Analysis of the Radio Frequency Identification (RFID) Technology Implementation within an Independent Public Library System: A Case Study of the North Canton, Ohio Public Library*" is approved in keeping with expedited review category #6. Your study is approved on **February 17, 2009** and is approved until **February 16, 2010**. You are required to submit for continuing review by **January 16, 2010**. As principal investigator, you must adhere to the following requirements:

- 1) **CONSENT:** You must use the stamped (dated consent forms) attached when consenting subjects. The consent forms must indicate the approval and its date. The forms must be administered in such a manner that they are clearly understood by the subjects. The subjects must be given a copy of the signed consent document, and a copy must be placed with the subjects' confidential chart/file.
- 2) **ADVERSE EVENTS/UNANTICIPATED PROBLEMS:** The principal investigator is required to notify the IRB chair of any adverse reactions that may develop as a result of this study. Approval may be withdrawn if the problem is serious.
- 3) **AMENDMENTS:** Any changes in the study (e.g., procedures, consent forms, investigators, etc.) must be approved by the IRB prior to implementation.
- 4) **CONTINUING REVIEWS:** A continuing review (progress report) must be submitted by the continuing review date noted above. Please see the IRB web site for continuing review information.
- 5) **FINAL REPORT:** The Principal Investigator is required to notify the IRB Office 30 days after the conclusion of the study that the study has ended via a final report.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Dr. Ling Wang (email only)
Dr. Marlyn Littmann (email only)
Mr. Jaime Arango

Appendix F

Library Tagging Memos

Tagging – August 5 & 6, 2004

On all materials the long side of the tag should be placed along and parallel to the spine at least one inch from the bottom. Tags should be staggered (not always placed in exactly the same position on each item); but tags should not be placed more than 5 or 6 inches from the bottom of the material. The tag should be close to but not right up against spine, at least ¼ inch away from spine).

Make sure to choose the correct conversion type by clicking on bar at top left of screen (ie. book, video, audio tape etc.)

Remember that a tag can be reprogrammed.

Don not use a tag with a hole punched in the center.

New materials that have already been tagged have a dot on the barcode. (Audio books on tape will have a dot on the top of the spine label.)

Tag placement:

Adult & Young Adult hardcover nonfiction – on inside of back cover, lower left

All Adult & YA fiction and cataloged soft cover Adult & YA nonfiction – on front of last page of book at lower left (on nonfiction, if the paper is extremely thin, place the tag on the back cover as for hardcover nonfiction)

Compact discs – on front descriptive insert on back along right side

DVD – On inside of back of descriptive insert at lower left

VHS – On inside of back of descriptive insert at top left ? ? ?

Audio books on cd – On back inside of packaging lower left corner

Audio books on tape – On back inside of package insert at lower left

Children's hardcover fiction and nonfiction books – on inside back cover, lower left

Children's soft cover fiction and nonfiction books – on front of last page of book at lower left

CD-ROM – On inside of packaging at lower left of back

Note: Magazines and paperbacks will not be tagged.

If a tag cannot be programmed set it aside to be tried again

Problem items (set on designated tables)

Items with multiple barcodes

Multiple VHS sets



A memo from:
Karen Sonderman

TAGGING STATISTICS

TOTAL TAGGED: 37,279

Largest amount tagged in 1 hour: 482

Smallest amount tagged in 1 hour: 61

**Average amount tagged per hour
by Teams 1-8: 291**

**Amount checked in and tagged
by Team 9 over 2 days: 1,112
(note: Juv items, pbks and mags were also
checked in during this time, but not tagged)**

**CONGRATS AND THANKS TO EVERYONE WHO
TAGGED OR HELPED IN OTHER WAYS WITH THE
TAGGING PROJECT!**

**Everyone and anyone who has ANY spare time
should check with Linda Hackworth about helping
tag RETURNS or check with Janet about helping
tag remaining untagged items in the stacks.**

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