

# **Radio Frequency Identification Systems at Universities: Current Status and Future Applications**

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## **ABSTRACT**

Radio frequency identification is widely used technology for collecting data in various industries, but it seems to be not widely spread technology among universities. Universities and other educational institutions are involved in RFID research but do not implement the system campus wide. The study focuses on the potential reasons for the limited use of RFID, such as high cost, security and privacy issues. After technological overview, author discusses the growth of RFID market and how it causes decrease in cost of RFID technology and supports further developments of the technology. The architectural design as it applies to universities is proposed as well.

## **INTRODUCTION**

Technology or the use of tools instead of pure human labor has been driving force of change in the world ever since the prehistoric times. Technology supports the general way tasks are done, and so helps to improve the efficiency and effectiveness of these tasks. Technological advances have been usually at the bottom of the cultural and developmental change of any particular society. Once the technology is implemented in the process of production across many industries, the structure of businesses changes and leads to higher productivity, efficiency, effectiveness, and so to higher level of development of a society as the positive changes become reflected on the society as a whole. The information technology (IT) has been gaining an importance since 1960s simultaneously with the growth of an importance of information and greater interconnectedness of the world. IT combines classical machine technology with computing and networking technologies, and so allows for utilization of available information (Jessup & Valacich, 2008). As any other technology, IT keeps evolving and gaining significance as the new concepts are developed and old systems innovated, so as to better fit the current needs of business and potentially improve the operations. Computers have become an important part

of the IS/IT systems and created truly globalized world. The main purpose of computers is the analysis, sorting and storage of great amount of data about the real world that was collected through various devices and tools.

Radio frequency identification (RFID) is one of the wireless tools used to collect data about the real world, decode it and make it computerized. RFID is an automated identification without any need for manual screening that is primarily used for security reasons, and for better asset management control. Even though RFID is used mainly by retailers and manufacturers, it has a potential to be used across variety of industries with various applications. The current limited use of RFID in other industries can be explained (1) by the cost of RFID that is still relatively high, and (2) by the privacy issues that arise from using RFID, because the tag can be used as a tracking device, and a mean of obtaining personal data about somebody, and so breaching their privacy.

The paper examines the use of RFID at universities, and the benefits it can bring while considering the security and privacy issues of students and faculty. There are several implications for RFID on campus, and so in order to decrease the cost of implementing the various systems, they should all be synchronized, make compatible in order to limit the number of databases needed to sort out the data. The decreasing cost of RFID in general due to the recent improvements seems to only support the use of RFID campus-wide. RFID improves collection of data about students, and so can improved the decision making processes by the university officials. RFID is known for its tracking ability, and so its use in the libraries, lounges, and laboratories across campus is highly recommended. It can make the process of borrowing books speedier and the allocation of books easier and more effective than the regular screening. RFID tags can be placed on the items in the laboratories and lounges in order to limit thefts. These are just few of the possible uses of RFID in the university setting that are going to be discussed in the later parts of the paper.

In the first part of the paper, the technological concept of RFID is explained in order to gain the complex understanding of the types of RFID systems and how they operate. The various uses of RFID are mentioned in this section so the reader sees the flexibility of uses of RFID. The second part evaluates RFID systems from various perspectives in order to determine whether they are viable solutions for universities. It looks at the past examples of the successful RFID implementations because they help to clarify the potential for the success of RFID at universities. Expected growth of the market for RFID tags and the continued improvements to RFID technology are discussed because they both lead to lower cost of the RFID tags and other needed IS/IT components, and so make it more plausible for universities to adopt RFID systems. A significant portion of the section is devoted to the privacy issue that is connected with the use of RFID since the question of privacy seems to be the most bothering aspect about RFID. Privacy of students and faculty needs to be protected; therefore, the possible solutions for securing the data from being breached are proposed in this part. Last but not least, the third section of paper draws the conclusion and proposes some ideas about potential future research regarding RFID use at universities.

## **RFID TECHNOLOGY**

The RFID existence can be dated back as far as the WWII when the radio waves were used to carry information about aircraft, technology known as “identification, friend or foe” (Landt, 2001, p.4). For few decades after then, RFID technology was experimented on but did not receive widespread recognition until the late 1980s when the commercial applications of RFID started to be used by private businesses and enterprises. Since the end of the 20<sup>th</sup> century, RFID has been gaining significance as the wireless technology has been widely used around the world.

RFID is a wireless data collection technology that uses radio frequency waves transmitted from a tag to a reader to obtain data that has been previously stored on the chip within the tag. The data usually contains information regarding the item the tag is attached to, such as the origin of shipment, storage requirements, and further specifications. The reader recognizes the presence of the RFID tags, obtains data from the tag through the radio signals, decodes the signal and then sends the information through the middleware software to another computer system within the company (Glover & Bhatt, 2006). Once the data is received by the computer system, the system initiates required operation based on the information, and stores the information for later use by the ERP, company databases and other enterprise systems.

RFID technologies can be distinguish based on the frequency used, the communication method between the tags and the reader, and the type of the tags. The type of tag depends on the proposed use but the most general designs include passive, active and semi-passive tags. Passive RFID tags are the most often used and the least expensive alternative because they do not have own power supply. They are activated by the close proximity to the reader since they use the received signal to power their operations (Djuric & Athalye, 2008). Active tags have a battery to power the communication with the reader, and so can support transmission for a longer range relative to passive tags. They are also more sensitive and accurate. Semi-passive tags have transmission range between passive and active tags, have own battery, and behave as passive tags in using power of reader signal for communication (ABCs, 2007; Glover & Bhatt, 2006). Because active and semi-passive tags contain battery they are relatively big in a size as compared with passive tags. The size factor influences the widespread use of passive tags especially in the retail industry, because the tag can be very thin, easily attachable to every product and basically unnoticeable by the customer. Active tags and semi-passive tags are used more often during the transport of pallets or when there is a need for the tag to do complex, independent operations, such as storing data about temperature and communicate with the reader if there is any problem.

It is believed that RFID tags were first intended to replace barcodes in retail because of problems with readability of barcodes. The educational video by *Intermac Technologies, Inc.* (2005) clarifies that RFID are not designed to replace barcodes but to make them more convinible. In a comparison with barcodes, RFID allows reading the tags even if they are out of sight, in cold, or in the rain. In order to read barcode, the reader must be directly pointed at the code, and the code needs to be clearly visible. The feature of an easy access allows for faster transport, storage, and collection of data about storage of inventory, shipments, production batches and alike. Other advantage of using RFID reader is that it can receive data from more tags at one time. The collection of data using the RFID system is more accurate, more efficient and more secure than the barcode technique. Some of the tags are rewritable which creates yet another feature that prefers RFID over barcodes and other data collection techniques because

information about the product or item can be updated when necessary and new information can be written on the chip when it becomes available.

Because of the previously mentioned advantages, the primary applications of RFID systems used in the enterprises are security/access control with 57%, supply chain management with 37%, inventory control, shipping/receiving both with 29%, and asset tracking with 26% (Cox, 2007). RFID improves all these processes because it brings more accuracy, flexibility and time efficiency to the operations. For example, RFID tags can be embedded in the wristbands to allow access to the designed area to the limited personnel for a security reasons. If the person with the wristband approaches the reader on the door to the restricted area, the reader activates the tag, receives a signal that it decodes, and if the decoding provides the correct information, the door unlocks and the person is let. However, if the person does not have the tag or the data stored on the tag is not programmed to open that particular door, person is not let in. The inventory control is simplified by placing the reader directly on the forklift which simplifies the storing procedures because it is not important which way the items are stored since the tag is recognized right by placing them in a storage area. When using another inventory management system, it is essential that the items are displayed in the storage area with their barcodes clearly visible so they can be scanned by the reader. The scanning takes place usually after the items are placed on the shelf not simultaneously as with the RFID method, which contributes to the greater time needed for inventory control. And the more time is needed, the more money or resources company uses.

RFID is not limited to the uses described above (retailing or manufacturing industry), but can find successful application in other types of industries and even in the every day life of people. The use of RFID seems to be important for the airports and transport industry because it helps with the identification, distribution and transportation of passengers' luggage, which causes a decrease in lost and unclaimed luggage since the bags are moved through the controls and various checking points based on the RFID tags attached to them. Under the old system, many luggage got lost because the barcodes would get destroyed, became unreadable, or the whole luggage identification tag would get lost. The travel documents that have RFID chips containing biometric data about travelers embedded in them are another use of RFID technology at the airports. It speeds up the check-in process and increases the security. The various access control applications are used in the every day life in a form of dining cards, bus cards, insurance cards, parking lot permits, and so on. RFID technology is unique also based on the fact that the RFID tags can be implemented in the skin of living beings in order to keep track of them and store viable information about the being. The living beings can be both animals (especially in agriculture to keep track of the cattle, etc.) and humans (patients in the hospital, little kids, workers working under hazardous conditions, etc.). (Lu, 2008)

Even though the ubiquitous use of RFID as examined in the previous paragraph brings obvious benefits both to individual people and the companies, the extensive use of RFID raises several concerns among the general public. The examination of these concerns is to be described in the research section of the paper, but the concerns should be introduced now because they are necessary for the understanding of the complexity of RFID systems. The first concern involves the perceived lack of international standards about RFID, second involves feasibility issue because of high cost of implementing the RFID systems, and the third one deals with the security

and privacy mainly due to the tracking ability of RFID. There is widely accepted belief that there are no worldwide accepted standards regarding RFID, because of multiple types of RFID used as described above, different frequencies used worldwide, and so on (Wen, 2008). However, as the further research shows that RFID standards are actually in place and are the same across national boundaries for the same industry, while they differ from one industry to another. For example, if one frequency is used for agricultural items, the same frequency is used for agricultural items abroad, but different frequency is used for building materials within the domestic country. People assume that the cost of implementing RFID is high and so it is not worth it to invest in the RFID implementation. However, it is important to notice that the cost of RFID systems is actually going down, and that RFID brings benefits in the long run. Last but not least, the privacy issue is to a great concern of people, because they feel that the use of RFID reveals their private information, can be used to track them, and so establishes the environment of uncertainty who is watching whom (Want, 2008).

The brief discussion about disadvantages of the widespread use of RFID technology concludes the first part of the paper that establishes the basic framework for the research.

## **RESEARCH**

The growth of RFID market is discussed because it shows that RFID is becoming more and more influential technology on a daily basis, and so universities should go with the flow and reorient themselves toward ubiquitous RFID systems. The previous successful implementations of RFID in some industries are mentioned in order to learn from their experience and be able to establish general guidelines for implementation of RFID system on campus. The implementation of any new technology requires a company to pay high set-up cost which needs to be seen as an investment that is going to bring benefits in the long run. The discussion about the cost of RFID system is done because of their relevance to adoption of RFID systems by universities. Last but not least, research focuses on privacy issue and what possible protections can be considered by universities.

### Growth of RFID market

The first boom of commercial applications of RFID was triggered by Wal-Mart in the early 2003 when it mandated its suppliers to send only tagged items by 2005 (Djuric & Athalye, 2008, Weinstein, 2005). Wal-Mart has become an early adopter of RFID retail application, and so it had to face several problems with the first not yet very efficient RFID systems. Wal-Mart case helped not only the whole RFID development industry, but also the retail industry and other businesses to learn about the challenges of RFID systems and the possible solutions to these problems. Ever since the first use by Wal-Mart, RFID has been on a move having a two-digit growth rate per year. It doubled its value from \$2.7 billion in 2003 to \$5.3 billion in 2008. The trend is predicted to prevail in the following years, reaching \$9.8 billion by 2013 (RFID market, 2008). The other study predicts the growth to be even more exponential reaching \$12.3 billion in 2010 (Jessup & Valacich, 2008). In any case, RFID is the fastest expanding wireless technology since the cell phone boom in late 1990s. Because of the flexibility and various applications, RFID has a promising future of becoming ubiquitous wireless technology affecting every aspect of human life, at work, at school, and even at home. The growth of RFID market is not

homogenous, but differs for varying applications, and the introduction of new applications tends to increase the overall growth rate. The most likely sectors of RFID market to grow are: the asset management control, ID documents, ticketing and contactless payment applications (RFID market, 2008).

Even though some experts point out the defects and unreliability of international RFID platforms and missing standards (Zhang et al., 2008), RFID is influential across national boundaries because it eases transport, communication and transport of data. There are standards set up by the International Organization for Standardization (ISO) for data and system protocols (such as air interface protocol), frequency of waves, and automatic identification. The problems associated with the standardization of RFID are the result of mismatch between the Electronic Product Code (EPC) developed by the Auto-ID Center, the business and academic pioneers in the RFID global infrastructure, and ISO's ultra-high frequency protocol based on collaboration of European Article Number International and the Uniform Code Council (Summary, 2008). The other protocols and standards are undergoing the approval process.

### Cost of RFID systems

One of the main reasons that RFID is not widely used is the cost of implementing the RFID systems. The initial cost can be relatively high because of a need for the whole RFID system with multiple readers (handheld devices, gates), middleware, and tagging technology. The prices of tags differ depending on the type (active are the most expensive, passive the least expensive) and even though price can be only from \$.50 to \$1 per tag, tagging of each individual item in the storage adds up. The high initial cost can actually discourage companies from investing in the technology because they do not foresee the future benefits that RFID is going to bring. Cost-benefit analysis shows that the initial investment is greatly outweighed by increased profits in the long run due to increased productivity, more effective and efficient operations; more effective operations mean lower production cost and higher profits. The constant improvements that have been done to existing RFID systems and infrastructure can make the technology more reliable, more effective, more accurate, and more durable, and so lower operational cost of the system in the long run due to the lower maintenance requirements. However, as a study done by Korean researchers proves, the monetary approach to evaluating RFID does not account for the value of information obtained thanks to RFID systems, and so companies need to evaluate practical effects of RFID as well, not just the obvious monetary effects (Kim et al., 2008).

Furthermore, comparing RFID technologies with other recognition devices such as barcodes, biometrics, optical character recognition, and their respective advantages and disadvantages, one can draw a conclusion that the higher price charged for RFID is justifiable. Table on page eight in *RFID Handbook* by Finkenzeller and Waddington (2003) provides the complex overview of the benefits of each of the different systems, but it is not further discussed in the paper because of the limited area of study.

Last but not least, the growth of the RFID market with increasing demand for RFID technology (tags and readers), and the further standardization cause the price per tag to decrease, and so make it more affordable to small scale companies (Williams, 2004). The price of tags is

going to be driven down also by the development of new technologies in the production of the actual tags. Suzanne Deffree (2008) discusses the new technology designed by the Kiovo Inc. that uses silicon inks and high quality graphics printing technology to make printed electronics. The silicon-ink based RFID is one of their first commercial applications. The technology allows the development of lower-priced item-level FRID tags for a variety of markets, anything from retail, transit, logistic, asset management, to consumer. As a result of lowering price of RFID tags and improvements of RFID systems, more companies will be willing to implement RFID in their operations.

### Security and privacy

There are two concerns regarding personal privacy and they are the identity theft, and the tracking. It is reasonable to use tracking devices to keep track of a people under certain conditions, like in the hospitals, for people that work in a risky environment (mines, fishermen...), to keep track of kids on playground, and so on. Tracking is done either by providing a person with a temporary RFID tag, such as bracelet, chain pendant, or by implanting RFID chips in human bodies. In 2002, the FDA approved use of VeriMed, the human implantable chip that contains a unique identification number for each patient and allows for an easy access to medical records (Want, 2008).

RFID deals with a lot of personal data, and so it is obvious that it raises concerns about one's privacy. There are two main ways through which the personal data can be obtained unknowingly by the third party: (1) during the transmission process between the customer and the second party be it merchant, security guard at the airport, or doctor, and (2) from the enterprise system after the decoded data was submitted by the reader. The second type of breach is usually prevented by having a variety of security applications on computers and limiting the access to that information. The theft of data as it is being sent has a potential to occur because of use of wireless technology. Finkenzeller and Waddington (2003) compare different scanning systems and find out that RFID systems have higher reading speed compared to barcodes, biometrics, and alike, and that unauthorized copying and modification is impossible. Therefore, the theft of transmitted data seems to be highly unlikely.

RFID tags are composed of a microchip with information written on it, and an antenna that is used to capture a signal from a reader. The information on the chip is encoded using encoding algorithms and multiple encryption techniques. Therefore, if a hacker manages to receive the data from the tag, he/she will not be able to have any use of it because it is encoded and requires knowledge about the encryption key. One of the newest applications of RFID is the contactless card with embedded RFID chip that is used to make payment at some retailers. The advantages of the contactless card is that it makes the process of check out faster, more accurate, and customers do not need to give the card to a cashier but can just wave it in front of the reader (Amato-McCoy, 2007). There seems to be nothing wrong about the contactless payment, because customers control the amount charged, and they hold their card at all times throughout the transaction, but RFID-skeptics argue that thieves can use wireless reading devices to steal the data from customer at the point of payment. They overlook the detail that the RFID chips are protected by encryption codes and have multiple layers of protection that serve as a satisfactory safeguard against such criminal activity.

Each tag has a unique identifier that assures that the tag is correctly identified by the reader. Tags can have an identifier modification that increases security from unwanted recognition by overwriting the identifier after each protocol cycle (Henrici & Mueller, 2008). Authentication is another important task of RFID technology since the unique identifier can be manipulated and some of the security issues can arise from the illegitimate data being received by the reader, or data can be accessed by an illegitimate reader. As Syamsuddin, Dillon, Chang and Han (2008, p 563) conclude in their study, current RFID authentication protocols do not satisfy an integrated security and privacy solutions for RFID because they help to solve one issue, but cause another one to appear. Further research and innovation of existing RFID protocols is recommended.

## **RESULTS**

The purpose of the study is the application of RFID on university campuses because the use of RFID on campuses is very limited, if any. And since RFID technology has wide range of applications and is beneficial for increasing efficiency and effectiveness of business operations in other industries, it is highly debatable why there is such a low use of RFID. Research focuses on the aspects of RFID technology that are generally considered as hindering the ubiquitous use of the technology (high cost, privacy concern), and proves that these aspects are either eliminated or diminished, and so there is no reason for universities to lack RFID systems.

As research shows, the market for RFID has been growing greatly, causing the prices of the technology to go down. As prices drop, more companies can adopt the systems and implement them in their operation. The higher affordability of a system by smaller businesses from various industries provided for further development and innovation of RFID applications, so they can serve various uses. But the benefits of RFID do not have only monetary value, but have also practical value. RFID is designed to collect data and send it to company's database, where it is stored and used for strategic planning, inventory management, and alike. Information is a driving force behind many industries, because if companies have an access to accurate and current information, and know how to use it, they can gain competitive advantage over their competitors by better serving the customers. Therefore, it is very practical for universities to implement RFID systems campus-wide, for protection of their equipment, for more efficient collection of data about students, and for greater security on campus in general.

The use of RFID creates a problem regarding privacy because it collects personal data about individuals, and so raises concerns among some of them because they feel that their privacy is violated and they are spied on. Many also fears identity theft as the third unauthorized party can access their data and abuse it. However, all RFID tags have multiple layers of protection and the data stored on them is encoded, which makes it virtually impossible for hacker to have any use of the encoded data sent on the radio wave from a tag to a reader. Universities are already fully computerized and have efficient security software in place which prohibits hackers to access the decoded information as it was transmitted from a reader. Therefore, student and faculty can be sure that their personal information is not going to be violated or misused by any party, whether it being university official or hacker.

## IMPLICATIONS

The flexibility and adaptability of RFID applications makes it possible to successfully launch RFID campus-wide. The primary purpose of RFID on campus should be an increased level of security of both people, including students, faculty and staff, and material objects, like equipment in the labs or books in the library. It can be also used as a parking control and for setting up automated payment systems. Because of the variety of potential uses of RFID, universities need to focus on the architectural structure in order to synchronized all of their various RFID and make the system truly integrated.

The proposed infrastructure for widespread campus RFID involves hardware, middleware and connecting networks to other campus applications and databases. The figure below schematically shows the architecture of such a system that should be considered by universities. The model is based on study done by Wey Chen (2005).

**Figure 1 Proposed structure of RFID system**



RFID hardware consists of tags and readers. Identification cards for students and faculty should be RFID enabled, having RFID tag with chip embedded in them. The ID card will then be used primarily for security access control to laboratories, private offices, or dorms. It could be also used as a dining card or game ticket. Another form of tags would be implemented in the parking decal to control parking management. As Yuan-Bo Chen, Chih-Jen Yang, and Gwo-Jia Jong (2008) propose in their study, tags can be also used as a tracking device for items in laboratories and school lounges to prevent thefts. Libraries on many campuses are already using RFID because it does not only improve inventory control, but speeds up the checking out system, and brings better service to students. Because of the connection to the campus database` and network, e-mails regarding approaching return deadlines can be sent to students to make the whole process of borrowing more efficient. The allocation of RFID in libraries needs to be optimized to improve the existing system and make them more integrated in the newly implemented RFID system (Fennani & Hamam, 2008). Readers will depend on the type of RFID tag they communicate with. There will be readers by the doors to labs, offices, rooms to prevent an unauthorized access. The gate reader would be in the library and laboratories to catch

any book or item being carried out without previous checkout, and by the parking lot entrances to regulate parking.

Middleware of RFID should have a synchronizer for all sources of data, because the variety of amount of received data would be tremendous. The software will need capability to manage the flows of data, decode them, sort them out, and resend them to desired destination at university network. Connector to these other applications will be another building brick of RFID system, because it will enable communication between RFID middleware and campus management system, such as library management, inventory management or parking management. The arrows in the figure show the flow of information between RFID middleware and various management systems on campus and signal that the flow of information occurs both ways.

## **CONCLUSION**

RFID technology represents tremendous achievement of wireless technology because it positively affects the productivity of businesses. The commercialization of RFID did not occur until the beginning of the new millennium but ever since then it is progressing by a mile shoes. New developments and RFID enabled technologies are on a daily schedule. It is predicted that RFID will become ubiquitous wireless technology that is going to be inseparable from one's life. Therefore, universities should not miss the train but should join the RFID move right now before it is too late. The earlier they adopt it, the better it is for them. Even though RFID technology has been around some time and is recognized as necessity for companies for success in new millennium, universities seem to be reluctant to their use. The report showed that the growth of RFID market and falling prices of RFID technology makes the widespread adoption of RFID more feasible. The security of system is being advanced by constant developments and innovation.

Future research regarding RFID at universities should be aimed at designing the proper architectural schemes, determining the specific frequency used, and so on. Due to increasing efficiency and capacities of RFID systems, new ways of implementing RFID on campus will certainly be emerged. These will the directions of our future studies on this technology.

(References are available from the first author upon request)