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RFID AND ITS APPLICATIONS IN MANAGEMENT

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ABSTRACT

This paper provides a simple understanding of RFID (Radio Frequency Identification). It is written to complement the informal conversation that currently exists about this new technology. The paper is structured in a logical fashion. It begins with a conversation about the RFID system that breaks the system down into its three main components. The three main components are the tag, the reader and the host computer. The paper then moves to a discussion that compares and contrasts RFID with its competitor technology, the barcode. The paper then touches upon the topic of RFID standardization, and the current efforts of EPCGlobal to establish a world-wide platform for tag reading. Finally, the paper ends with visitation to interesting RFID applications that are taking place around the world, and a timeline that highlights major moments in the progression of RFID technology.

INTRODUCTION

RFID technology is important because it is ubiquitous. To substantiate this claim Dr. Peter Harrop, Chairman of IDTechEx, a knowledge-based consultancy company in England says (Harrop, 2004):

"Consider a technology as fundamental as paper, but with a diversity of forms and applications.

Paper can be used for writing, printing, wrapping confectionery, and even creating origami sculptures. RFID should be thought of as being as fundamental as the seemingly endless uses of paper."

THE THREE MAIN COMPONENTS IN THE RFID SYSTEM

The online dictionary *webopedia.com* describes RFID as a system with three main components. The multi-component nature of RFID is an important concept to grasp for those who want to gain more understanding about the technology. It is especially important in light of the fact that a majority of people, those who have visited the topic for a brief period, are popularly convinced that RFID technology is embodied in a single component, which they often refer to as a "chip." Perhaps you have heard your colleagues or peers say, "Yeah, I've heard about RFID. Did you see how small the new Hitachi RFID chip is?" Dialogue is always a good place to start. If the goal is to establish a mental model, however, it benefits to supplement conversation with a well-aimed inquiry into the RFID system's three main components.

Webopedia.com defines the RFID system as consisting (Webopedia, 2007):

"of an antenna and a transceiver, which read the radio frequency and transfer the information to a processing device, and a transponder, or tag, which is an integrated circuit containing the RF circuitry and information to be transmitted."

Tags

Newcomers to RFID will find this sentence difficult to comprehend because it contains technical terminology, and because it is poorly worded. The most popularly discussed component of the RFID system is the “tag” or “transponder.” Tags are available in many shapes and sizes. As of 2006, the smallest-sized tags are .15 mm x .15 mm. Tags at this end of the spectrum are thinner than paper, and can be inserted into stickers or under the skin of humans and animals. Tags at the larger end of the spectrum are as small as the size of a coin or as large as a small paperback book (Technovelgy, 2007).

There are two main types of RFID tags. There are passive tags and active tags. Passive tags are usually smaller than active tags because they do not carry a battery. There is also a third type of tag called the semi-passive or semi-active. This tag contains active and passive qualities (Wikipedia, 2007A).

Tags vary greatly in price. Passive tags can be bought for five cents per tag by large stores such as Wal-Mart, Target, Tesco (UK) and Metro (Germany). Active tags, on the other hand, sell on average for a few dollars per tag (Wikipedia, 2007A). Price is very important when dealing with orders from large companies. For example, in 2003 Gillette placed an order for 500 million passive tags (Harrop, 2004).

Most media coverage today revolves around the passive tag. A lot of the intrigue about the passive tag is due to the tiny size of these tags.

In the last few years there has been a lot of media coverage linking RFID to Wal-Mart. In 2004 Wal-Mart mandated its largest 100 customers to RFID-enable pallets and crates of shipped goods. The mandate spurred activity among companies such as Proctor and Gamble, Gillette, Johnson & Johnson, Goodyear, and Hewlett – Packard. Since 2004 the list of companies has grown to 600. Wal-Mart first began to use RFID at one of its distribution centers in Dallas-Fort Worth in 2004 (Hachman, 2004), and last September announced that they aimed to have 1,000 (out of close to 4,000) stores integrated into their RFID system by January 2007 (Spangler, 2006).

Passive tags are sufficient for supply chain purposes, but are not as capable as active tags. Active tags transmit at a higher level of power, and this enables them to communicate from greater distances. Passive tag systems are set up to read cases and pallets within roughly 10 feet. The passive tag referred to above, the Hitachi μ-Chip, has an average read distance of about one foot. Active tags, on the other hand, can communicate from an indefinite distance. The main number that is reported for commercial use is 350 feet (Wikipedia, 2007A). But increasing transmitting power allows the potential to communicate at even greater distances.

Active tag read rates are typically higher than passive tag rates because active tags carry batteries and passive tags do not. Batteries allow the active tag to transmit at a higher level of power, which enables active tags to communicate more effectively in areas that are "RFID challenged." Challenged areas are zones where signals encounter metal or water. For example, reading tags attached to shipments of shampoo, canned goods, or electronics might qualify as an area of challenge. But situations where tag read rates are lowered because of metal or water can be overcome by extending the antenna on the tag or increasing the power of the transmission. (Wikipedia, 2007A).

Developing an RFID system is very challenging because spaces vary in dimension. An RFID system designer has to ask himself/herself a myriad questions in order to foresee and therefore avoid encountering obstacles. *If I install two RFID readers instead of one at the shipping dock will I get a better read rate? Is the reader too far away to read the tags? Is the warehouse too humid for these tags, and do I need tags with a longer antenna to overcome the* *humidity? What if the tag is too low on the crate to be read when it comes through on the conveyor belt? Should I place the tag higher up on the crate?* Passive tag placement on crates and pallets is becoming a science; different goods, for instance tag placement on a crate of soups, might require lower placement than the placement on a crate of paper towels.

RFID system design requires a balance of innovation and conservatism. In order to design an efficient system, Best Buy (750 chains) utilizes a slow-and-steady implementation approach. In 2004 when Best Buy began to plan its RFID system, Bob Willett, executive vice president of operations said, “This is all about trial, evaluate, rollout. No one isn’t embracing RFID. But at the end of the day, no one is absolutely sure where this will all lead. RFID is not RFID on its own. How do you use the technology? For example, how does it get used in space optimization (Schuman, 2004)?”

New technologies are starting to bring the price of passive tags down. For example, the conventional passive tag - a silicon chip with an antenna - is starting to face competition from a new tag that is printed on paper like a magazine. The printed tag is a polymer-based chip with a metallic ink antenna; the new printing technology prints the chip and the tag together; whereas the conventional method requires the additional step of fastening the antenna to the chip (O’Connor, 2006).

Passive tags can store data about item location, color, weight, DOS (date of sale), and price, etc. Active tags are able to store the same data as passive tags, but also more technical data such as humidity, shock/vibration, light, radiation, temperature and atmospherics, etc (Wikipedia, 2007A).

Passive tags have more longevity than active tags. Commercial active tags have an operational life of up to 10 years, but the life of a passive tag is virtually limitless (Learning Space, 2007).

There are many techniques for disabling a tag. Some of these techniques include physical trauma (i.e., striking a tag with a hammer), shielding the chip with a metallic shield (Faraday cage), breaking the antenna, or microwaving the chip (Wikipedia, 2007A).

RFID Readers

The Second major component in the RFID system is the reader. It is more technically referred to as the “interrogator.” *Webopedia.com* says of RFID readers that they consist “of an antenna and a transceiver, which read the radio frequency and transfer the information to a processing device.” Readers transmit radio waves (in the kilohertz, megahertz, and gigahertz ranges) to RFID tags through an antenna. The transceiver inside the reader contains both a transmitter and a receiver (or “decoder”), which share a common circuitry. A reader can write to a read/write tag, but cannot write to a read only tag. Read/write tags are RFID tags that all able to modify data as they pass through various stages in a process. Read only tags are cheaper than read/write tags.

RFID readers are either handheld or fixed. Handheld readers allow the user to roam through a facility. Fixed readers are strategically located to optimize the zone of activation for tagged pallets and crates, etc. When tagged pallets and crates pass through the zone, they receive a signal from the reader and transmit a response. The reader then receives (decodes) the information and passes it to the host computer (Wikipedia, 2007A).

Host Computer

The third and final major component in the RFID system is the host computer (or “back-end computer”). The host computer receives data from the reader through either wireless or hard wired connectivity. The host then processes the data, and sorts it into a database according to management’s discretion. The host updates the database when new data arrives, sorting it accordingly. A host system can have multiple monitoring terminals each of which is able to monitor system status in real time, and also monitor other systems and video cameras (Active Wave Inc., 2007).

RFID VERSUS THE BARCODE

RFID Advantages

In its definition of RFID, *whatis.com* says that “RFID is coming into increasing use in industry as an alternative to the bar code (Whatis, 2007).” The main advantage that RFID offers over barcode is item serialization. RFID is able to assign a unique number to each tagged item, which allows management to track at the item-level (i.e., a jar of mayonnaise); this produces a more granular set of data. Programming every tag with a unique serial number is the domain of EPCglobal; EPCglobal is discussed below. A second main advantage for RFID is that it does not have to be scanned at a line-of-sight. With barcode scanning an employee often has to flip or rearrange, for instance boxes, in order to find the barcode label on that box. This extra effort is necessary because bar code technology uses lasers instead of radio waves. Lasers cannot travel through solid objects, but radio waves can; therefore, rather than waste time flipping boxes looking for a bar code, a reader is able to flood an area with radio waves, and receive transmissions immediately. In this capacity, RFID will save a lot of time and hassle, and help companies cut labor costs.

Another benefit for RFID is its ability to withstand harsh conditions. RFID is more suited for exposure to chemicals, heat, abrasion, and dirt and grease buildup than barcodes. Heartiness is one reason why railroad companies use RFID instead of barcodes to track rolling stock (Piasecki, 2007).

RFID tags can store more information than barcodes, and can update information according to real time measurements of temperature, humidity or location, etc. Tags can hold up to 512 kBytes or more of information (Piasecki, 2007).

RFID Disadvantages

RFID's main disadvantage is high cost. Barcodes cost less than a cent per barcode, but the cheapest tags cost five to ten cents per tag. High costs create a certain degree of disinterest toward RFID among potential users. Many companies are quite content with their well-oiled barcode system, and find it unnecessary to change. If a company needs a new level of visibility, then its motivations to adopt RFID are increased. But if a company is just tagging mayonnaise jars, and the system is already sufficient, then why change it?

Another disadvantage that ranks on par with high cost, is the simple fact that the technology is still in an embryonic state of development. Although EPCglobal is working to create a single standard, the industry currently consists of too many protocols and too much proprietary technology. Until standardization advances, users will have to overcome hurdles of compatibility, and will find little motivation to embrace a technology that presents a high probability of hardware and software obsolescence. The barcode, on the other hand, has had standardization in the US for decades.

Another disadvantage for RFID is the read rate attenuation that occurs when radio waves encounter metal or water. There are ways around this disadvantage, however. The designer can relocate the tag's placement on a crate or pallet, lengthen the antenna, or increase the power of the radio signal.

Lastly, not being line-of-sight is also a disadvantage. It means that an employee cannot scan a specific item without reading all of the tags within the zone of activation. (Piasecki, 2007).

STANDARDIZATION OF RFID TECHNOLOGY

There is no single, world-wide agency that oversees a single RFID standard. In theory, every country in the world could allocate a unique RFID standard. In the US the central body is the FCC (Federal Communications Commission). Canada, China, Japan, South Africa, Australia, Europe, and other countries and zones all have their own separate agencies that govern RFID. The main organization attempting to create a single standard for RFID is EPCglobal (Wikipedia, 2007A).

EPCglobal

EPCglobal is working to create a single RFID standard so that supply chains around the world can run more efficiently. Its Board of Governors consists of members from Procter & Gamble, Johnson & Johnson, Wal-Mart, Gillette, Dow Chemical, Hewlett-Packard, and RFID technology innovators such as Auto-ID Labs (Cambridge, Massachusetts) and Checkpoint Systems (Thorofare, New Jersey). In 2004, EPCglobal approved the family of coding schemes called "Gen 2." Gen 2 is the platform where future global standardization will take place. EPCglobal is a global organization with over 100 offices world-wide (including offices in Brussels, Belgium and Princeton, New Jersey). (Wikipedia, 2007D).

EPC Network

EPC (Electronic Product Code) is the coding technology within the Gen 2 family that promises to become the standard for globalization. It is the technology at the core of EPCglobal.

EPC technology assigns each tag a unique serial number. Barcode technology does not offer serialization (Wikipedia, 2007A).

RFID APPLICATIONS AROUND THE WORLD

Most of the dialogue in the US about RFID consists of conversation about passive tags in the tracking of pallets and crates, etc. by retail chains and consumer goods suppliers. RFID technology, however, offers a diverse array of applications, and can be found in 85 countries around the world (Harrop, 2006).

RFID in Africa

In Namibia, a group of companies and government agencies are working together to monitor shipments of beef en route to London. Namibia meat shipments encounter occasional pirates; therefore, meat officials are adopting the new technology to gain better visibility into meat tampering. Specifically, this project employs the use of an active RFID bolt; the bolt is used to seal meat containers, and notifies meat trackers if tampering occurs (Collins, 2004). In South Africa, coal ore boilers at a Hendrina power station are running their boilers at an optimal level with RFID- tracked coal; passive RFID tags enable plant managers to allocate specific grades of coal to specifically tuned boilers (Lauf, 2007).

RFID in Asia

In China, Chinese authorities issue ID cards with an embedded integrated circuit (silicon chip). e-Ids (electronic identifications) include information such as full name, photograph, age, date of birth, address, identification number, profession, and citizenship status. e-IDs have the capacity to store biometric information, such as measurements of the face, hand or iris, or fingerprints (Wikipedia, 2007B). In the Philippines, shoppers are able to use “buddy” cards or

Stored Value Cards (SVC) to purchase goods. The SVC works like a debit card, but the holder of the SVC is not able to put money on his/her card through normal banking channels; rather, it is that individual's employer or parent who typically fills the card with money. SVCs theoretically shorten the length of queues at stores (Philippine News, 2006). In Japan, sushi restaurants offer conveyor belt sushi. Conveyor belt sushi uses RFID to track sushi plates as they circulate through the restaurant past customers who pluck a plate from the conveyor belt when they see one that they want. After a sushi plate has traveled a particular distance restaurant managers pull the tray from the conveyor belt (Wikipdeia C, 2007).

RFID in Europe

In Glasgow, Scotland a publican at Bar Soba now offers patrons the option of paying for alcoholic drinks with a chip that is implanted in their arm. The chip acts as a "digital wallet," which proponents argue eliminates the need to carry cash (Martin, 2005). In Sardinia, smart mooring buoys allow sailors to pay for rental without going ashore (Martinelli, 2007). At the Louvre in Paris, active RFID tags are mounted to the back of paintings, and notify officials if a painting moves (RFIDSB, 2007).

RFID in North America

In Seattle, graduate students at the University of Washington's Precision Forestry Cooperative are tagging genetically grown trees with RFID to improve forestry conservation techniques. As the tree expands in girth the tag eventually submerges itself into the tree, and remains in the tree for its life (Texas Instruments, 2004). In Las Vegas, gambling casinos deter chip counterfeiting with RFID embedded chips. The US State Department now issues e-passports with embedded integrated circuits (silicon chips). These chips store personal and biometric information. The State Department says that the chip will store the same information displayed on the photo page of the passport, but will also store a digital photograph for the purpose of biometric scanning (State Department, 2007).

RFID in South America

In Santiago, Chile in 2004 a pilot program began for testing the temperature of blueberry cases en route to Miami via both boat and plane. During the test, active and semi-active tags were inserted into cases of blueberries, and temperature readings were taken every five minutes. After arrival in Miami, fixed readers in the unloading area received the temperature readings, and the host computer downloaded the readings to a Microsoft Access database for review by management (O'Connor, 2005).

HISTORY OF RFID

RFID Enters the Public Sphere

RFID entered the public sphere in the late 1970s when users implanted dairy cows with active tags. The University of Chicago implanted cows to track identification and temperature. RFID-tagged cows enabled automatic feeding without overfeeding, and also determined animal health and ovulation (Eagle's Nest, 2002).

RFID and WWII

The British Army employed RFID in WWII to determine the identity of planes that were flying back to Britain. The British were understandably concerned about plane identity because France was only 20 miles away. British officials attached tags to planes, and interrogated them with radio waves when they were flying toward Britain. If the plane emitted the appropriate response, then officials knew that it was a "friendly." If it did not, then officials knew that it was a "foe" (Allen and Hartman, 2007).

RFID Transferred to Private Sector

After WWII, RFID technology remained in the public sector. Through the 1960s and 1970s the public sector used it to monitor nuclear technology. The technology which had been developed in government labs was eventually released to private industry through Los Alamos Scientific Laboratories (LASL) in 1977. The first companies to receive the technology were Amtech (in New Mexico) and Identronix (in Santa Cruz, California) (Allen and Hartman, 2007).

Toll Collection

Norway launched the first ever toll collection system in 1987. The US launched its first toll collection system in Dallas, Texas on the North Turnpike in 1989 (FDIS, 2004).

E-ZPass Popularized

In 1993, the Northeast US launched the E-ZPass toll collection system (Wikipedia, 2007A).

The 1990s

In the 1990s there is an explosion - albeit embryonic - of RFID activity. Passive tag proliferation in supply chain management moves to the fore of commercial applications. Auto-ID Center opens in 1999, and is replaced by Auto-ID Labs in 2003; Auto-ID Labs is responsible for the funding and development of EPC technology, and conducts research at major research institutions around the world. Auto-ID Labs and EPCGlobal represent the emergence of a global RFID coding scheme (Wikipedia, 2007E).

The 2000s

In 2004, Wal-Mart issued a mandate to its top 100 suppliers to adopt RFID (Ferguson, 2006). Wal-Mart’s act catalyzed the growth of RFID.

CONCLUSION

This essay seeks to provide the reader with basic insight into RFID, and the three main components in an RFID system. It also seeks to construct a plain picture of the current RFID climate, one that is still very young, expensive, and in pursuit of standardization. Finally, the essay takes the reader on a brief visit to different countries around the world where RFID is in action, and closes with a timeline that highlights major events in the progression of RFID.

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