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## RADIO FREQUENCY IDENTIFICATION IN SUPPLY CHAIN MANAGEMENT

### 10.1 INTRODUCTION

Supply chain management is the management of material, information and finance through a network of organizations (i.e. suppliers, manufacturers, logistic providers, whole sales distributors and retailers) that aims to produce and deliver products or services for the consumers [8]. It includes the coordination and collaboration of processes and activities across different functions such as marketing, sales, production, product design, procurement, logistics, finance, and information technology within the network of organizations. The desire to cut supply chain costs has pushed radio frequency identification. Technology, an e-tagging technology that can be used to provide electronic identity to any object. RFID is not a new technology. It was first used in the Second World War to identify aircraft. But the application of this technology (described in the paper) in supply chain management is new.

The aim of the paper is presentation of possibility of using RFID technology in supply chain management. Especially paper concentrate on examples of using this technology in various industries and also on benefits of RFID.

### 10.2 THE HISTORY OF TECHNOLOGY

The service sector has been using barcode technology since the mid-1970s. Barcodes appear on almost every purchase, from soft drinks to automobiles. The code itself is made up of the series of wide and narrow parallel lines and spaces and can store as many as 20-30 characters per inch of coded information's. Research and development in barcoding technology has led to the development of the new two-dimensional code which contains a stack of as many as 90 one-dimensional barcodes each just three-hundredths of an inch high. New developed barcodes allows user to maintain a large block of information about each product – manufacturer, cost price, order size, weight, etc. High-speed laser scanners read the new barcode quickly and retrieve the information for continual monitoring [20].

But not in all cases this technology was the best solution. Sometimes the barcodes a unreadable and we can't use scanner. Because of that there is a new technology – RFID – radio frequency identification. This technology originated in the 1940 when the US government used transponders to distinguish friendly aircraft from enemy aircraft [5]. Also, in the 1950s, other technical developments in radio and radar along with the IFF

exploration of long range transponder systems for identification was conducted. These development also led to future patents for RFID technology [20]. Through the 1970s, the federal government primarily used the systems for tracking livestock and nuclear material. Radio tags have been used commercially in so-called closed loop systems for delivering packages, handling luggage, tracking food in supermarkets and monitoring highway tolls in the 1980s and 1990s. In 1997 Mobil installed an RFID system called "Speedpass" the lets you wave tag in front of the gas pump to record your transaction and debit your credit card [14]. In 1980 the Bay Area Rapid Transit (BART) installed RFID system to provide equal access to the system for disabled individuals. Under the new system disable people were issued an ID tag at no charge [11]. To operate the system, the disabled person holds the tag close to the reader to activate station elevators [5]. In 1999 with the help of scientist at the Massachusetts Institute of technology a consortium companies formed center for continued research into the nature and use of radio frequency identification. The consortium had a new idea about how organizations could identify and track their assets. The new vision underlying automatic identification of objects.

Today the RFID technology can not only be enterprise assets, but also the movement of products, containers, vehicles and other assets across vast geographical areas. [29]. The RFID method is considered by many experts to be the successor of OMR systems, especially in the area of bar codes applications. Already for a few years, there are implementations of RFID methods, which successfully complete or replace the bar codes methods [9]. Between 1999 and 2003, the Centre gained industry acceptance of the passive RFID tagging system with the support of more than one hundred large end-user companies. The industry support is evidenced in the fact that some of the biggest retailers in the world – Albertsons, Metro, Targret, Tesco, Wal-Mart and U.S. department of defense have initiated plans to use this technology to track goods in their supply chain [20].

### 10.3 THE USE OF TECHNOLOGY

Barcoding technology has become very important to all industries including manufacturing and services. But there were some problems witch this technology. Some situations have environmental condition, such as temperature, dirt or hazardous contamination, that make optically scanning the barcodes on a label ineffective. In those cases a different technology, called radio frequency identification (RFID), is often preferred. RFID does not require the tag or label to be seen to read its stored data.

For a nominal price a RIFD tag is attached to the product in the initial stages of manufacturing that follows the product down the supply chain all the way to a retail setting, and finally into the hands of the customer. There, it can again be scanned while in a box or crate, saving labor. In a retail setting, the tag can serve as the price tag count on the tag for warranty information after purchase. Consumers can RFID does not require the tag or label to be seen to read its stored data. RFID uses radio waves to capture data from tag, rather than optically scanning the barcodes on a label. RFID

systems have three primary components:

- the tag or transponder,
- the reader,
- the computer.

An important promise of RFID technology is to cut costs and deliver a wealth of information that helps firms more effectively understand, predict, and respond to customer demand. RFID not always is the best solution. It is an enabler that allows firms to change their supply chain processes for the better. RFID technology is used in a range of applications. More specifically, it has useful applications in the following industries (Table 10.1):

- shipping and distribution,
- retail industry,
- manufacturing sector,
- agriculture, cattle and food production;
- health care,
- pharmaceutical,
- government,
- gaming industry,
- security industry.

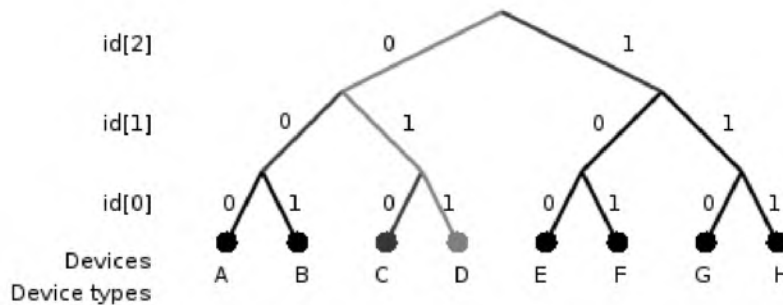
**Table 10.1 The use of RFID technology in various industries**

Industry	The use of technology
<b>Shipping and distribution</b>	In this industry, RFID technology enables suppliers to accurately determine the location of a pallet, to track its journey through the supply chain, and to make instantaneous routing decisions. At a major trucking and logistics provider company, RFID tags are embedded in the fleet of 2600 trucks. At the service center, the tag automatically determines what loading/unloading activities are needed and assigns an appropriate crew to service the truck [16]
<b>Retail industry</b>	RFID technology offers a very significant advantage over bar coding. Wal-Mart's initiative and move in using the technology was heralded as the most important tech development for retailers since the barcode. RFID tags continually gather information as products move from shelves to the checkout counter. The technology not only helps the retailer to reduce labor and manual costs, it also curbs shoplifting and boosts store [13].
<b>Manufacturing sector</b>	This sector has been finding different ways to derive value out of this technology. For example, manufacturers are using RFID product tracking mechanisms to ensure accuracy. Parts can be individually tagged and tracked throughout the manufacturing process while on the production line. Parts received from the production plant can be tracked throughout the assembly process. This certainly helps manufacturers with their carefully scheduled just-in-time (JIT) assembly lines. Tags containing equipment specifications can be attached to enable easy upgrading. Similarly, tags can be used to keep track of usage, availability, location, and maintenance of material handling equipment. Procter & Gamble (P&G), for example, believes that RFID technology can help the company to track where every item is in the manufacturing process and supply chain [25].
Health care	RFID technology can be used in health-care industries to improve quality and reliability. In the US Navy, RFID tags, embedded in wristbands, are used to identify patients and update their status automatically. A British firm is using RFID tags to match blood samples to patients [21].

Industry	The use of technology
<b>Agriculture, cattle and food production</b>	Increased government regulation about food traceability in the USA and a mandate from the European Union (EU) for tightened traceability requirements beginning in 2005 has pushed RFID technology into food sourcing. RFID can help these traceability requirements at a reasonable cost. The technology should also reduce recall costs by increasing the ability of the manufacturers to identify and recall only the affected items. Similarly, RFID technology is used to secure the identification of cattle by means of inserting a tag into the stomach of an animal, enabling accurate records for automated farm management [15, 17]. The tag may be attached to animal in one of three modes, namely ear tags, subcutaneous injection, or ruminal bolus. The bolus has been identified as the best tamper proof animal identification tag provided it is implanted at the right age and weight of animals [4].
<b>Pharmaceutical</b>	The drug industry uses RFID technology to self-police in the fight against thieves and counterfeiters. For example, Purdu Pharma, the manufacturer of the popular painkiller OXYContin, is using RFID tags to track shipment of its theft-prone drug. Pfizer is planing to put the radio tags on bottles of its widely counterfeited Viagra drug by the end of 2005. With RFID tags, pharmacists will be able to identify counterfeit drugs and law enforcement officers also will be able to quickly check whether bottles they recover have been reported stolen [5].
<b>Government</b>	This sector is another emerging application area for RFID. Government agencies are using RFID technology for supply chain management, inventory, security, and military strategies. The Army uses tags on supply containers for detecting shock and variances in temperature. These tags have a range of up to a mile to enhance supply management capabilities. The Navy, on the other hand, uses RFID tags for weapon management, with a range of less than six inches to protect sensitive data. Weaponry data collected by RFID tags reveal anything from materials to capabilities and mission details [3, 6].
<b>Gaming industry</b>	This industry has been finding other ways to derive value out of this technology. For example, the Wynn Las Vegas Casino is using radio tags on Betting chips to deter counterfeiting, card-counting and other illegal behavior. Casino executives envision RFID transforming the way they operate table games. The casino is installing RFID readers and PCs at game tables. Dealers can take a quick inventory of chips that have been wagered. In addition to monitoring wagers, the technology will let dealers or cashiers see when the value of the chips in front of them does not match the scanners' tally. The casino industry is also planning to use the technology to help casinos keep tabs on how much players bet and how long or often they play for incentive programs [12].
<b>Security industry</b>	Giant retailers and manufacturers aren't the only adopters of RFID technology. RFID seems to be moving quietly into the people-tracking realm, especially in the area of monitoring children. Lauren Scott of California, the \$2 million-a-year apparel company, will launch a line of pajamas with RFID tags sewn into the hems. RFID readers installed at various points throughout a house will be able to scan the tags within a 30-foot radius, and will trigger an alarm when boundaries are breached [28].
<b>Timber</b>	In Brandenburg the RFID technology is tested for its performance in low distance positioning and data transfer outdoor condition. RFIDE tags complement the route description and help carriers to localize the exact position of the lorries and of woodpiles. Additionally, RFID can be used for pile identification and data exchange all along the timber transport chain [27]
<b>Library</b>	The application of RFID system speeds effectively the work of a library by combining the activation of antivol RFID label and the registration of book's lending into one operation, even in case of several books at once, what had to be done sequentially in case of using of bar codes readers. The popularity of RFID among librarians is caused mainly by facilitating to conduct the inventory of the library methods [9].

Signaling between the reader and the tag is done in several different incompatible ways, depending on the frequency band used by the tag. Tags operating on LF and HF bands are, in terms of radio wavelength, very close to the reader antenna because they are only a small percentage of a wavelength away. In this near field region, the tag is closely coupled electrically with the transmitter in the reader. The tag can modulate the field produced by the reader by changing the electrical loading the tag represents. By switching between lower and higher relative loads, the tag produces a change that the reader can detect. At UHF and higher frequencies, the tag is more than one radio wavelength away from the reader, requiring a different approach. The tag can backscatter a signal. Active tags may contain functionally separated transmitters and receivers, and the tag need not respond on a frequency related to the reader's interrogation signal [10].

An Electronic Product Code (EPC) is one common type of data stored in a tag. When written into the tag by an RFID printer, the tag contains a 96-bit string of data. The first eight bits are a header which identifies the version of the protocol. The next 28 bits identify the organization that manages the data for this tag; the organization number is assigned by the EPC Global consortium. The next 24 bits are an object class, identifying the kind of product; the last 36 bits are a unique serial number for a particular tag. These last two fields are set by the organization that issued the tag. Rather like a URL, the total electronic product code number can be used as a key into a global database to uniquely identify a particular product [19].



**Fig. 10.1 An example of a binary tree method of identifying an RFID tag**

Source: [24]

Often more than one tag will respond to a tag reader, for example, many individual products with tags may be shipped in a common box or on a common pallet. Collision detection is important to allow reading of data. Two different types of protocols are used to "singulate" a particular tag, allowing its data to be read in the midst of many similar tags. In a slotted Aloha system, the reader broadcasts an initialization command and a parameter that the tags individually use to pseudo-randomly delay their responses [23]. When using an "adaptive binary tree" protocol, the reader sends an initialization symbol and then transmits one bit of ID data at a time; only tags with matching bits respond, and eventually only one tag matches the complete ID string [7]. Both methods have drawbacks when used with many tags or with multiple overlapping readers. Bulk reading is a strategy for interrogating multiple tags at the same time, but lacks sufficient precision for inventory control.

RFIDs are easy to conceal or incorporate in other items. For example, in 2009 researchers at Bristol University successfully glued RFID micro-transponders to live ants in order to study their behavior [1]. This trend towards increasingly miniaturized RFIDs is likely to continue as technology advances. Hitachi holds the record for the smallest RFID chip, at 0.05mm × 0.05mm. This is 1/64th the size of the previous record holder, the mu-chip's. Manufacture is enabled by using the silicon-on-insulator (SOI) process. These dust-sized chips can store 38-digit numbers using 128-bit Read Only Memory (ROM) [30]. A major challenge is the attachment of antennas, thus limiting read range to only millimeters.

#### 10.4 BENEFITS OF TECHNOLOGY

Organizations who take the time to understand the technology's capabilities and limitations can increase their revenue growth, lower costs, reduce inventory, better utilize fixed assets and gain favor with retailers. The main benefit of using RFID technology is reducing human intervention. Because of that the benefit of having fewer humans hands involved is reduced errors, which produces reduced costs, faster throughput, and reduced damage and returns. The overall implication of reduced human intervention, given the high cost of salaries, benefits and the cost of management associated with crews of human workers, is a dramatic reduction in operating costs. Automated toll systems are a prime example of how the lack of human intervention saves both time and money [29]. Some of the most important benefits that business is able to gain by using this technology are [2, 5, 18]:

- enhanced visibility into customer needs;
- enhanced visibility along the supply chain;
- accurate and timely asset tracking;
- smart product recycling;
- streamlined or better managed business processes within the company;
- improved productivity by generating the fastest and lowest;
- cost method of acquiring the data;
- improved velocity by responding to demand signals faster;
- better utilization of fixed assets, resulting in lowered;
- capital asset requirements;
- reliable and accurate order forecasts;
- reduction in inventory costs including stock-out and holding costs;
- improved technology return on investment;
- improved accuracy by reducing the opportunity for human error;
- increased productivity and dramatically reduced operating costs;
- improved product quality and reliability including traceability;
- improved supply chain management by better tracking transportation and warehousing channels;
- improved counterfeiting identification, theft prediction, and faster recalls;
- gaining favor with retailers to better position products on shelves,

- increased efficiency,
- higher information storage,
- automated stock control,
- very durable,
- possibility of tags reusable.

The advantages of RFID vs. barcode technology [2]:

- no line of sight requirement,
- the tag can stand a harsh environment,
- long read range,
- portable database,
- multiple tag read/write,
- tracking people, items, and equipment in real-time.

But there are a few important social and ethical risks [31] that must be realized, especially in regard to the healthcare environment. Monahan and Fisher researched the ethical and social risks of RFID devices being implanted into humans via observational studies and staff interviews in twenty-three United States hospitals using RFID technology. The first risk they identified in their study was that patients who opted to receive the RFID tag were receiving expedited care. Secondly, Monahan and Fisher found that doctors tended to trust the information obtained from the RFID tags over the information the patients themselves provided. This raises a large concern pertaining to the accuracy of the information on the tags. If the information on a patient's tag were to be incorrect, it is possible that the care administered to the patient could be doing him or her harm. The third and final risk discovered in this study was that patients who do not know the extent of the capabilities of the RFID tags may actually be endangering themselves. A patient's ignorance of the chip's capabilities may cause them to assume that the chip can do things that it cannot, leading to a very false sense of security [22].

## CONCLUSION

Nowadays the RFID technology is increasingly using in various industry as: shipping and distribution, retail, manufacturing, agriculture, health care, pharmaceutical, government, gaming, security, timber, library etc. in supply chain management process. Many benefits described in the paper causes the possibility of wide use of this technology. Because of benefit of having fewer human errors it can lead to reduced costs and faster throughput. Also reduced damage and returns are important problems from logistic and also quality management point of view. On this basis we can say that the RFID technology will develop and will be implemented to other industries. But there are some concern regarded to RFID relevant to cost of the technology and also social and ethical risks' that must be realized.

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## RADIO FREQUENCY IDENTIFICATION IN SUPPLY CHAIN MANAGEMENT

**Abstract:** Presented paper concentrate on using RFID (Radio Frequency Identification) technology in supply chain management. Today the RFID technology can not only be enterprise assets, but also the movement of products, containers, vehicles and other assets across vast geographical areas. Supply chain management is the management of material, information and finance through a network of organizations (i.e. suppliers, manufacturers, logistic providers, whole sales distributors and retailers) that aims to produce and deliver products or services for the consumers. The aim of the paper is presentation of possibility of using RFID technology in supply chain management. In the paper there is a presentation of the history of RFID technology, the possibility of use of RFID in various industries and the analysis of benefits of RFID from supply chain management point of view (as fewer humans hands involved reduced errors reduced costs and so on). Also there is a brief description of potential risk of the technology especially in regard to the healthcare environment. Nowadays the RFID technology is increasingly using in various industry as: shipping and distribution, retail, manufacturing, agriculture, health care, pharmaceutical, government, gamin, security, timber, library etc. in supply chain management process. Many benefits described in the paper causes the possibility of wide use of this technology.

**Key words:** RFID, supply chain management, RFID benefits, RFID risks

## IDENTYFIKACJA RADIOWA W ZARZĄDZANIU ŁAŃCUCHEM DOSTAW

**Streszczenie:** W artykule skoncentrowano się na wykorzystaniu technologii RFID (ang. Radio Frequency Identification) w zarządzaniu łańcuchem dostaw. Obecnie technologia RFID może być wykorzystywana do wspomaganie procesów logistycznych organizacji, takich jak w szczególności: przepływ towarów, kontenerów, pojazdów i innych aktywów na terenie rozległych obszarach geograficznych. Zarządzanie łańcuchem dostaw jest zarządzanie materiałami, informacją i kwestiami finansowymi poprzez sieć organizacji (np. dostawców, producentów, dostawców usług logistycznych, hurtownie dystrybutorów i sprzedawców detalicznych), którego celem jest produkować i dostarczać produkty i usługi dla konsumentów. Celem publikacji jest przedstawienie możliwości wykorzystania technologii RFID w zarządzaniu łańcuchem dostaw. W pracy przedstawiono historię technologii RFID, możliwość wykorzystania RFID w różnych branżach i analizę korzyści zastosowania RFID do zarządzania łańcuchem dostaw. W publikacji zawarto również krótki opis potencjalnego ryzyka omawianej technologii, zwłaszcza w odniesieniu do środowiska naturalnego i zdrowia. Obecnie technologia RFID jest coraz częściej wykorzystywana w różnych branżach takich jak: transport morski i dystrybucja, handel detaliczny, produkcja, rolnictwo, opieka zdrowotna, przemysł farmaceutyczny, bezpieczeństwo, produkcja drewna, biblioteki itp., w procesie zarządzania łańcuchem dostaw. Wiążące się z nią liczne korzyści, opisane w publikacji powodują możliwość szerokiego stosowania tej technologii.

**Słowa kluczowe:** RFID, zarządzanie łańcuchem dostaw, korzyści RFID, ryzyko RFID

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