



**UNIVERSITY  
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**The Mode of RFID Towards Idea to Practice**

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Zhang Yaoqing

## Dedication

*"We dedicate our thesis to our parents who always are with us in every difficult and tough situation of life. Thanks to them for giving us unconditional support with our studies and have given us the chance to prove and improve ourselves through all the footsteps of life"*

## Abstract

**Purpose of thesis:** This paper comprehensively explain the overview of RFID technology aiming to explain the understandings from implementation to future work by concentrating on challenges, risks, advantages and disadvantages along with precautions correspondence to implication. One the biggest challenge of RFID is the standardization, so a brief introduction of standardization is included in this paper to give clear view to the concerned people along with history of RFID. The possible solution of the problems is also part of the paper. This thesis paper discusses what RFID technology is and the history of the RFID technology and what kind of advantages and disadvantages it has over other technology such as bar code system.

**Design/Methodology/Approach:** this thesis is consisting of two major parts. First part is comprised of extensive literature study where as second part is empirical study with the help of Interviews. Interviews have conducted to authenticate the theories correspondence to risks, problems, benefits and implementation. For this purpose different kind of personnel were selected who are related with RFID technology with different aspects such as consultant, supplier and users.

**Findings:** RFID technology has given a vital space where the industries and organization from public sector to payment system can play and get lots of benefits by using RFID technology with a scope such as detection of products in supply chain, security increased for the theft of books in the library and anti-counterfeit of medicine. Although RFID technology has brought many opportunities for the companies but it has also forced the implementers to think about its important considerations which can lead the users toward some serious challenges and risks, for example privacy issues, cost, security considerations and technical issue such as integration of data.

**Practical implications:** This paper provides suggestions for the successful implementation of RFID technology to improve the likelihood of success for their tasks. For this purpose RFID technology is discussed in detail as for as implementation is concerned in different organization like logistics, supply chain, inventory control, medical technology and libraries. Through RFID detection of products items (in Supply chain, inventory system, logistics, library and luggage control in air ports) with exact placement without any physical movement can be operated in computer systems even though it can be integrated with the internet so that it can be monitored anywhere through internet are the areas. More over how the potential of RFID technology can be utilize with appropriate way are the part of this paper which gives a broader visions to the companies.

**Originality/value of thesis:** This paper also put light in detail on benefits, risks, problems and opportunities to by combining the theories and practical like interviews with the specialist of RFID which give comprehensive practical solution and awareness for the investors and users. RFID tags can be secure by making tags permanent coding which cannot be change. RFID technology can be affected by some metallic surrounding environment. Lack of knowledge to solve the problems of RFID is also a threat for the implementers. Another example, old data of bar code can be feed in the tags as a history in order to review the past information of the product used in previous system.

**Key Words:** RFID, Supply Chain, Logistics, Library, Inventory management, Cost, Privacy, Risk.

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# Terminology

## A.

**AIAG (Automotive Industry Action Group)**

## B.

**BRAF (British Royal Air Force)**

## C.

**CATSA (Canadian Air transport Authority)**

**CD (Compact Disk)**

**CEO (Chief Executive Officer)**

**CT (Computerized Axial Tomography)**

**CTO (Chief Technical Officer)**

## D.

**DHL (Dalsey, Hillblom and Lynn)**

**DoD (Department of Defense)**

**DVD (Digital Video Disk)**

## E.

**EAN (European Article Numbering)**

**ECB (The European Central Bank)**

**EPC (Electronic Product Codes)**

**EPCglobal (GSI's subsidiary which handles GSI's RFID standards)**

**ERP (Enterprise Resource Planning)**

**ESCS (Effective Shop Charge Systems)**

**ETSI (European Telecommunication Standards Institute)**

**F.**

**FDA (Food and Drug Administration)**

**FedEx (Federal Express)**

**G.**

**GHz (Gigahertz)**

**GPRS (General Packet Radio Service)**

**GPS (Global Positioning System)**

**GSI (Global Standard Organization)**

**GTAG (Global Tag Initiative)**

**H.**

**HF (High Frequency)**

**HIG (Högskolan i Gävle)**

**HP (Hewlett-Packard)**

**HUT (Hamburg University of Technology)**

**I.**

**IBM (International Business Machines)**

**IFF (Identify Friend or Foe)**

**ISO (International Standard Organization)**

**ISO/IEC (International Organization for Standardization/International Electrotechnical Commission)**

**J.**

**JCB (Japan Credit Bureau)**

**K.**

**KB (Kilobyte)**

**KHz (Kilohertz)**

**KTH (Kungliga Tekniska Högskolan)**

**L.**

**LCD (Liquid Crystal Display)**

**LF (Low Frequency)**

**M.**

**MD (Managing Director)**

**MHz (Megahertz)**

**N.**

**NFC (Near Field Communication)**

**NISC (No-instruction-Set-Computer)**

**O.**

**OCR (Optical Character Recognition)**

**ONS (Object Naming Services)**

**P.**

**P&G (Procter and Gamble)**

**Q.**

**R.**

**RFID (Radio Frequency IDentification)**

**S.**

**SBCLS (San Bernardino County Library System)**

**SCM (Supply Chain Management)**

**SDK (Software Development Kit)**

**T.**

**TB (Tuberculosis)**

**TFL (Transport of London)**

**U.**

**UCC (Uniform Code Council)**

**UCPNAVI (Ubiquitous Cartography for Pedestrian Navigation)**

**UHF (Ultra High Frequency)**

**UID (Unique ID)**

**USB (Universal Serial Bus)**

**V.**

**VCC (VeriChip Cooperation)**

**VCD (Venture Development Organization)**

**VCL (Vatican City Library)**

**VUT (Vienna University of Technology)**

**W.**

**WB (Wallet Mobile)**

**WHO (World Health Organization)**

**Wi-Fi (Wireless Fidelity)**

# 1. Introduction

In this thesis we tried to highlight the important aspects of RFID technology such as implementation, challenges and problems. To do so we go through from the history, how RFID works, its challenges, weaknesses and benefits. RFID has proved its importance to this new era of business where organizations are in the competition for example DHL; they have proved to their competitors with strong Logistics execution. Other different kind of companies and organizations are also now very active with strong planning and strategy such as armies, museums, libraries and security system (Pedroso, Zwicker and de Souza 2009). Especially in the last 5 years, RFID is a hot issue; from supply chain to brands outlets RFID becomes important. *“In recent months, no fewer than 100 RFID-related articles were cited in ABI-Inform. Although the exact date for compliance is still subject to debate, the US Department of Defense, Wal-Mart, and Target Corporation had all mandated that their key suppliers be RFID-enabled by the end of 2006”* (Spekman and Sweeney 2006). Demand has rapidly increased of RFID of food industries, drug organization, retailers, manufacturing, shipping and pharmaceutical industries (Jeppsson 2008). Almost all these industries including other different departments are taking keen interest along with implementation on RFID. A recent report estimated that in 2010 there will be almost 47 billion tags used in all over the world whereas 12 billion of tags are being fixed to consumer goods (Spekman and Sweeney 2006). If we go through to the history of RFID then it will be revealed that RFID is not a new technology. British Royal force used this technology in World War II. RFID was also used to trace out and identify the German forces by Allied ground forces (Dew 2006). After this, RFID technology disappeared and now it appears again with different new ideas and concepts especially in recent years as for as way and usage is concerned (Spekman and Sweeney 2006). RFID is very simple concept; there is no rocket science behind it like very simple software with a small chip and antenna, but there are some problems and legal requirement (such as privacy legislation for the customer) to implementation of RFID system (Alan, 2005; Kelly and Erickson 2005). RFID reader collision (occurs when the signals from two or more readers overlap) and RFID tag collision (occurs when many tags are present in a small area; but since the read time is very fast) are the part of problems while using RFID. We can realize the importance of RFID technology by this statement that RFID was considered in the top10 technology during 2004 and 2005 (Lai, Hutchinson and Zhang 2005).

## 2. Research questions

In current days different companies are focusing on less input to get maximum possible output with less effort. At the same time different organization need more security system and privacy as for as their structure and products are concerned. RFID is a possible solution in different areas of different department for all above mentioned issues. The purpose of this research is to highlight the challenges regarding RFID technology especially in supply chain, logistics and transportation and libraries. Our research questions are:

RQ1. What are the important applications of RFID technology? And how RFID technology has given the solution to improve the process in different organization such as supply chain, logistics, inventory management, library and medical technology?

RQ2. How RFID technology can leads the risks, disadvantages and scope of RFID technology after implementation and how to avoid with those these risks?

## 3. Theoretical Study

### 3.1. History/background of RFID

If we look around the history of RFID then we will be realized that RFID is not a new technology (Schmitt and Michahelles 2008). Michael Faraday, Guglielmo Marconi and James Clerk Maxwell are the inventors of RFID technology in 19<sup>th</sup> century which was based on electromagnetic waves and radiation. But the initial concepts of using reflecting wave for the information from the object came from the experiment of Frederick Hertz in 1886 whereas in 1922 radar invention was appeared later and was used in World War II (Wyld, 2006; Walczyk and Hesham 2009). RFID was also used by US musical inventor (Le'on Theremin) in Former Soviet Union in order to do spy work (Wyld, 2006).

RFID technology has been used by British Royal Air Force (BRAf) in the World War II. The function of RFID technology is to differentiate their own or friendly aircraft from the enemy's aircraft (Spekman and Sweeney 2006; Aguirre, 2007). Initially RFID was produced on the basis of radar, and its size was big with more power. RFID tags were also known as transponders which were used in the aircraft in World War II, where these transponders normally gave signal response in order to differentiate the friendly aircraft from enemy's aircraft. The term IFF "identify friend or foe" was a system which basically was based on the RFID (Dew, 2006).

RFID technology can be categorized into three generation as for as RFID tags are concerned. The tags used in first generation were big like a brick erect on the circuit boards. RFID readers normally read the information emit by radio waves from RFID in one of the range as 125–134 khz, 13.56 mhz, 870–930 mhz, 2.45 ghz, or 5.8 ghz but it varied normally depends upon the country to country and usage. US military force mostly sponsored the research and development on the different technology like high performance avionics, integrated circuits and computer softwares in order to track the railcars and transporting the nuclear waste in early time. From 1950 to 1970 the research and development were focused on RFID and in 1990 the government of America started research and development on RFID technology. In the second generation circuit board converted into microchip with a smaller size as compare to first generation. Configuration of RFID consisted of small tags like a thumb and microchip was made by silicon integrated circuit and an antenna was erected around it with copper coil. These are passive tags. The description of passive tags will be described in RFID 3.2 part. In 1984 USA and European countries started to use in huge of amount of microchip. Some of companies like Motorola, EM Microelectronics and Philips Semiconductors started to use these microchips in order to reduce their cost. During 1991 to 1993 the railways department installed 3 million tags which cost 200 million dollars to adopt the RFID system in their operation in USA, Canada and Mexico. RFID is being started to be very popular in office building and for cars without using key. Same as in European companies like Sokymat (Switzerland) and Rafsec (Finland) in the transportation system for re-useable tickets and entrance system without using any key like buses and metro. In the third generation of RFID's development, using of this technology in different new ways (such as implantation of tags into human body and key less buses) are the important

developments. RFID started to become the first choice for the technologist in order to do new research and get a huge competitive edge. This third generation is also involved in the standardization of RFID technology where International Standard Organization (ISO) was introduced in 1990s and that was the serious issue because implementation of ISO for RFID technology was a challenge as far as more working and money is concerned (Dew, 2006).

Srivastava (2005) describes the development of RFID technology through the decades which is shown in Table-1.

Table 1- Development of RFID in the decades (Srivastava, 2005)

<b>Time period</b>	<b>Event</b>
<b>1940-1950</b>	Radar defined and used Major World II development efforts RFID invented in about 1948
<b>1950-1960</b>	Early explorations of RFID technology, Laboratory experiments
<b>1960-1970</b>	Development of the theory of RFID. Early field trials
<b>1970-1980</b>	Explosion of RFID development Tests of RFID accelerate Early adopter implementation of RFID
<b>1980-1990</b>	Commercial RFID applications enter the mainstream
<b>1990-2000</b>	Emergence of standards RFID more widely deployed
<b>2000-2010</b>	Innovative applications emerge. Combination of RFID with personal mobile services Subcutaneous RFID emerges for animals, humans RFID becomes part of daily life

The research on RFID has taken decades with the development in a variety of different ways, ideas and fields: radar, computers, military, supply chain, logistics, hospitals, pharmaceutical industry, food industry, transportation, library and security system.

### 3.2. RFID (Radio Frequency Identification)

RFID (Radio Frequency Identification) is an electronic device which is made of small electronic chip (Tag) and reader along with a small antenna. RFID collects data automatically by using radio signals (Smart et al., 2010; Lisa et al., 2010). This electronic chip has a particular capacity (2000 bytes) to store the data depending on the nature of product. Storage data capacity is also more than bar code device (Sheffi 2004; Yu 2008). The function of RFID is the same as bar code but it is fast, more effective and efficient (Wyld et al., 2005). With the bar code every object have to be passed through the bar code detector separately while with RFID a large number of objects or products can be scanned at same time. RFID coding system and its use is different and more effective over bar code system like communication of reader with the tag gives a higher level of interface which cannot be seen in the bar code system (Kelly and Erickson, 2005).

RFID has capability of transferring data without any physical contact of object by means of radio waves. Software development kit (SDK) is necessary to keep in working of RFID technology. If we talk about the tags then we can categorize the tags into two types active and passive. Active tags are always better as for as capacity is concerned because it has more capability of storage of data. Active tags have their own power batteries so that data can be recited at more range. Whereas if passive tags use the power supply from electromagnetic field of reader, that is why their range of reading data is less comparatively (Fu and Retscher, 2009). In table 2 comparisons between passive and active tags has described.

Table 2- Comparison between passive and active tags (Wyld, 2006)

Passive tags	Active Tags
<ul style="list-style-type: none"> <li>• Operate without a battery</li> <li>• Less expensive</li> <li>• Unlimited life (because of no battery)</li> <li>• Less weight (because of no battery)</li> <li>• Lesser range (up to 3-5m, usually less)</li> <li>• Subject to noise</li> <li>• Derive power from the electromagnetic field generated by the reader</li> <li>• Require more powerful reader</li> <li>• Lower data transmission rates</li> <li>• Less tags can be read simultaneously</li> <li>• Greater orientation sensitivity</li> </ul>	<ul style="list-style-type: none"> <li>• Powered by an internal battery</li> <li>• More expensive</li> <li>• Finite lifetime (because of battery)</li> <li>• Greater weight (because of battery)</li> <li>• Greater range (up to 100 m)</li> <li>• Better noise immunity</li> <li>• Internal power to transmit signal to the reader</li> <li>• Can be effective with less powerful readers</li> <li>• Higher data transmission rates</li> <li>• More tags can be read simultaneously</li> <li>• Less orientation sensitivity</li> </ul>

With the capacity of 865.6~867.6 MHz the tags are being used in the new research project of UCPNAVI (Ubiquitous Cartography for Pedestrian Navigation) and these tags are licensed (Qing and Guenther, 2009). UCPNAVI is the project in Vienna University of Technology (VUT) to boost the direction of route in smart environment by using the statistics and steering (Retscher and Fu, 2007). There is another type of tags is also available, this is the combination of active and passive tags that is called semi-passive tags. These kinds of tags have their own battery to read the data but it transfers the data using the electromagnetic wave (Reid, 2005).

Ranges of bandwidth of RFID is different which depends on the country's policy regarding privacy, this system is highly licensed by the government of the country but for the industrial and scientific requirement the RFID using bandwidth does not require license (Yu, 2008). We can see the comparison of bandwidth of RFID having different frequencies on table 3 mentioned below:

Table 3- Frequency band of RFID usage and its benefit and drawbacks (Yu, 2008)

Frequency band	Benefits	Drawbacks
Low frequency (125-134 kHz)	Popular deployment, Lower interference by metal	Lower reaction range (under 1.5 m)
High frequency (13.56 MHz)	Popular deployment Lower interference by mist Popular deployment	Lower reaction range (under 1.5 m), Higher interference by metal.  Higher interference by mist
Ultrahigh frequency (UHF; 860-960 MHz)	Higher scope of signal communication	Tag and tag too close may be exerts detuning
Microwave (2.45 GHz)	Higher reaction range	Not popular implementation more complex and without completely standardization

In Table 3 it is clearly indicated that that with low frequency (125~134 kHz) is most matured but with the high frequency of 13.56 MHz has more versatile application as compare to low frequency. Bands of UHF and 2.45 GHz have almost alike characteristics but UHF has more range of orientation. 2.45 GHz is not popular and it is more complex because of the compulsion of complete standardization as for as its implementation is concerned (Yu, 2008).

### 3.2.1. Component of RFID

It is necessary to study the component of RFID technology in order to gain the knowledge about the RFID technology as for as its challenges, problems and solution are concern. Figure 1 shows components of RFID technology (Ahsan et al., 2010):

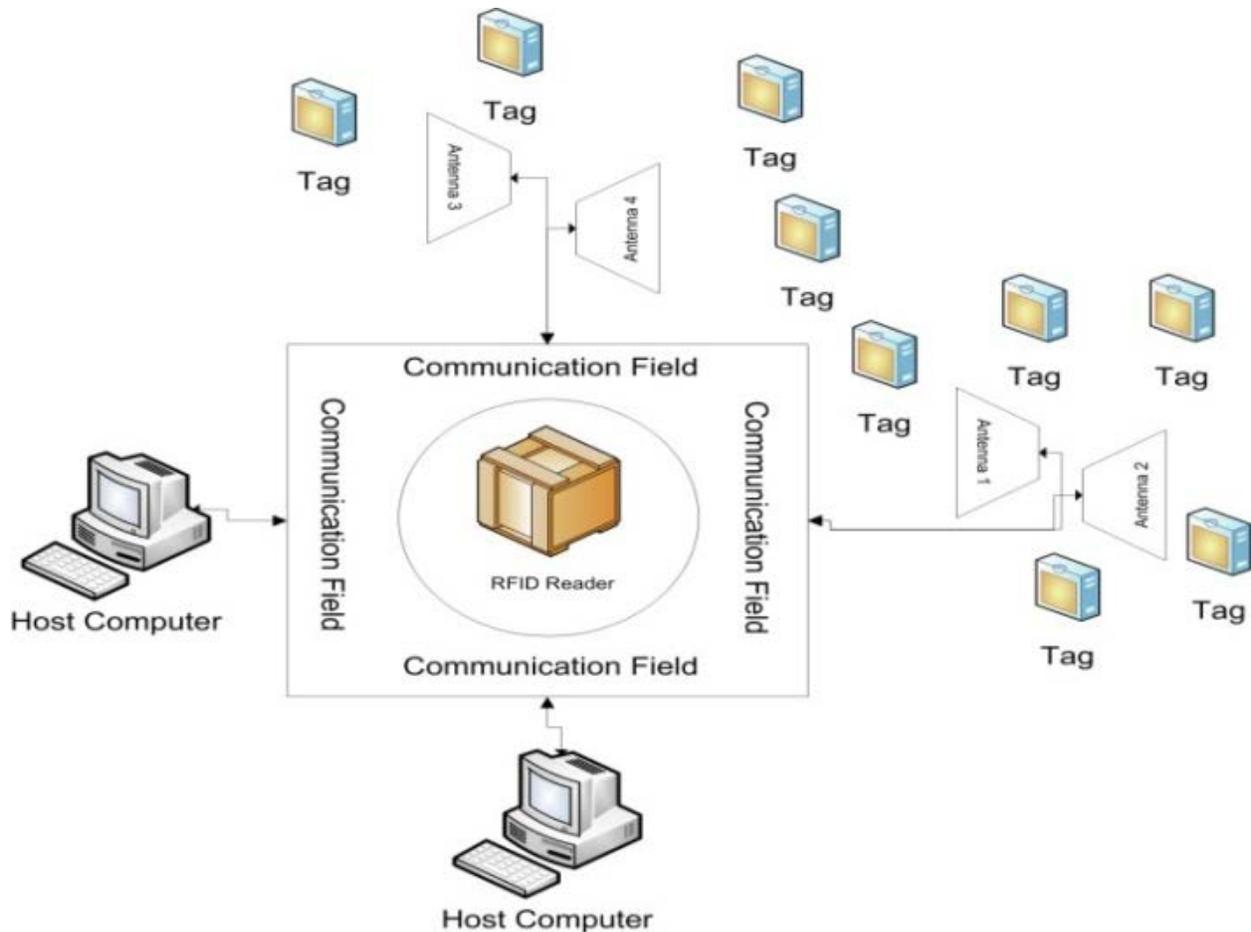


Figure 1- Components of RFID System (Ahsan et al., 2010)

#### 3.2.1.1. Tags

Tag is a form of chip which normally attached with the product or object. It includes unique ID numbers or codes. These codes or ID is different and unique for the different product. These chips are made of circuits. The data of these chips can be changeable or permanent which depends on the type of the chip. In rewriteable tags data can be changed without any limit while

in read only chip without any electronic programming data cannot be changed. Size and shape of RFID technology can be vary depending on the nature of usage and environment. Plastic tags are mostly stick with the object like credit cards because of size of object. Tags can be in a capsule shape or other. Below in Figure 2 & 3 you can see the different shapes and sizes of tags:

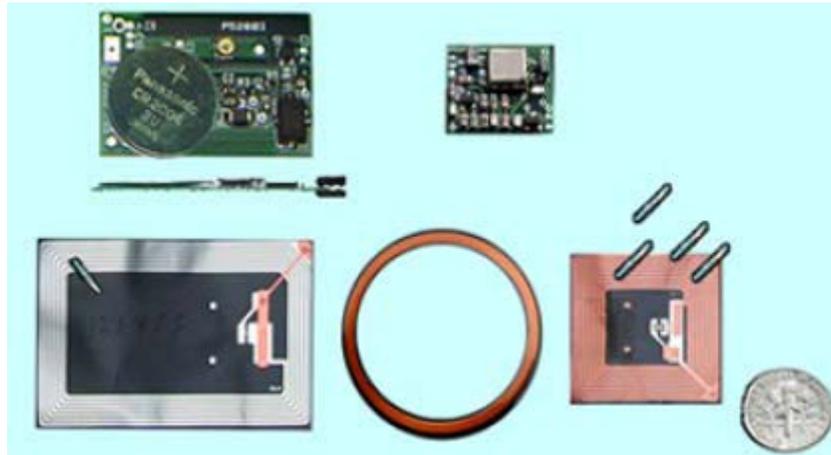


Figure 2- Different sizes and shapes of tags (Ahsan et al., 2010)



Figure 3- One type of passive tag (Binder and Domnitcheva, 2003)

Hitachi has made a very small tag which has size of a grain; its size is  $0.4\text{mm}^2$  (David, 2006). So it depends to company to company and type of function. As of as history of tags is concerned, the first patent tag was introduced in 1973 and these tags were active tags and rewrite able. This was the first US patent for the RFID technology. In year 1990 first time tags were used in the animal body in order to track them. September 11 is a biggest disaster of the world, after this research seriously think use of RFID technology into human body. VeriChip Cooperation (VCC) took advantage and developed tags to track the human (Xiao et al., 2007; Rosenberg, 2008).

### 3.2.1.2. Antenna

Antenna is a conductive device which gathers data and transfers it to the readers; antenna is responsible device for communication between tags and reader (Kumar et al., 2009). Basically it is bridge between readers and tags in order to transfer the data from tag to reader. More than one antenna can be placed for one reader to increase the efficiency of readers (Gardner, 2004). In Figure 4 there are some different types of antennas can be seen (Ahsan et al., 2010):



Figure 4- Different types of antenna (Ahsan et al., 2010)

### 3.2.1.3. Readers

Readers are more complicated and higher cost item as compare to the tags in the whole RFID system (Fine et al., 2006). Readers are connected with antenna, where reader gets information via antenna from tag. Data is transferred into form of signal then the reader converts it into digital form. Reader transfers this digital data to the nearest computer. Reader is a middle place of RFID system which receive signal with certain frequency and transmit to the computer, reader receive the info in the form of radio waves and transfer it in form of radio waves also but middleware (as software of RFID) transfer the data and translate it according to the computer system. Readers can collect data from tag or write the data onto the tag and manage it in the network or computer system. Reader can have anti-collision system in order to collect or transfer the radio waves from multiple areas with multiple frequencies. Readers can be connected with some specific USB wire or with Wi-Fi technology (Gardner 2004; Ahsan et al., 2010).

Reader can use two different type of methodology for transferring or collecting data from tags through the antenna. To give the response to reader, tag needs some energy in order to communicate with reader. For instance two type of method for the passive tag are used, near field and far field.

In Figure 5 you can see how data is transferred. Two circulating magnetic field around the reader antenna are created to transfer or collecting the data.

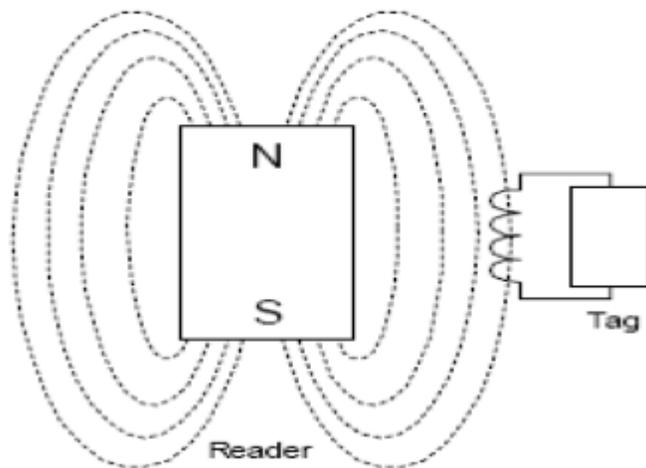


Figure 5- Near field methodology of RFID (Ahsan et al., 2010)

Whereas in far field method in Figure 6 you can see the form of magnetic field is dispersed. The transferring or collecting of electric field is scattered just like radar between tag and reader.

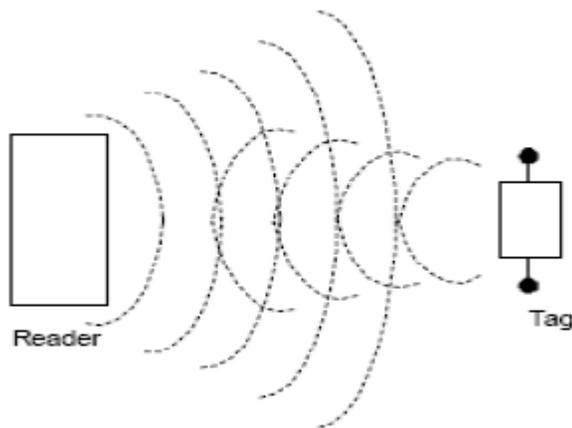


Figure 6- Far field methodology of RFID (Ahsan et al., 2010)

The only difference of these both method is that the near field method is used for the lower and high frequency bands where as far afield method is used UHF and microwave which are normally range of long read.

### 3.2.1.4. Middleware

Middleware is the platform of software which get the ID and information from RFID networks and sieve the data in order to make it eloquent information for the whole network (Yoo and Park, 2009; Gardner, 2004).

### 3.2.2. RFID and auto-ID technology

Auto ID technology is broad category of technology which is used to identify the different object such as human, animals or product. Auto ID technology is a device to identify the objects, collects data and transfer it into the required place without physical touch. RFID is types of auto ID technology, other example of auto ID technology are bar code system, biometric systems, smart cards and optical character recognition (OCR) etc (Wyld, 2006). Figure 7 represents the family of auto ID technology.

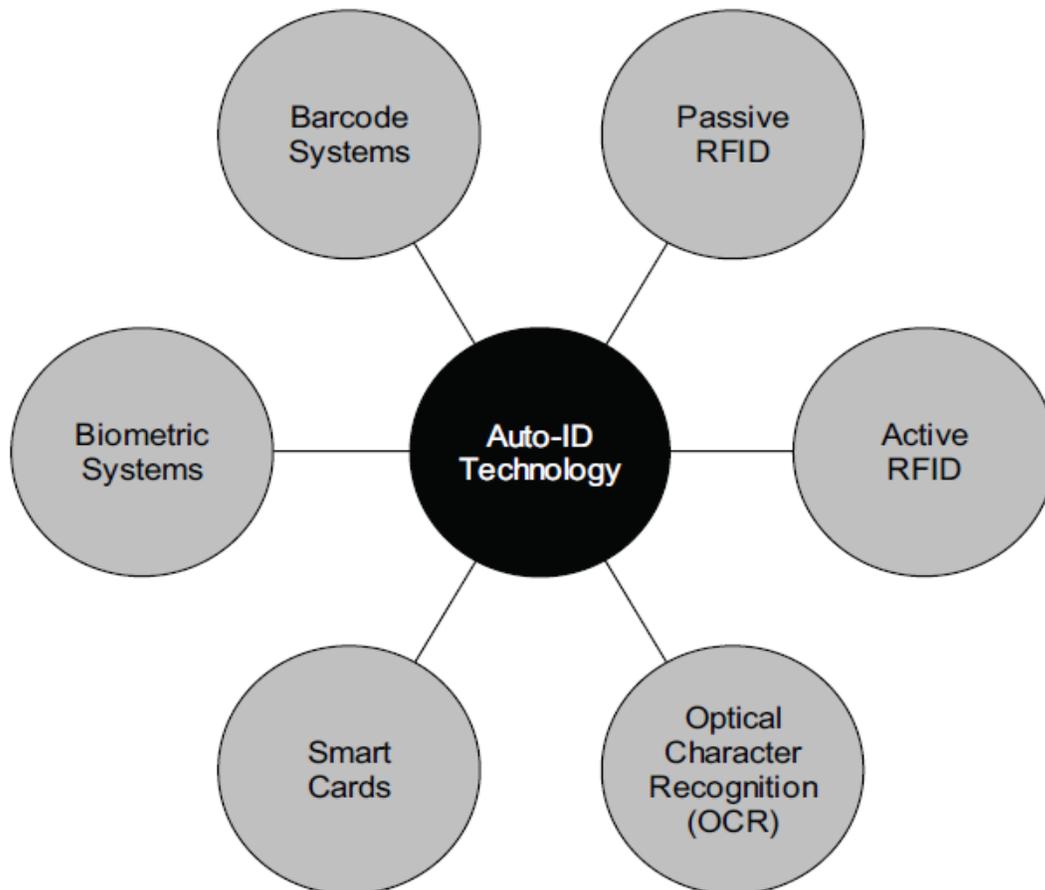


Figure 7- The family of auto-ID technology (Wyld, 2006)

We will not explain about the above mentioned types auto-ID technology because our purpose to show this Figure 7 to just mention the name of other technologies which are included in the auto-ID technology, otherwise we would be distracted from our core topic. The comparison of Bar code systems and RFID is necessary because RFID has same principle of working and RFID has also replaced the Bar code system. The detail is expressed in the next section.

### 3.2.3. Comparison of RFID technology and Bar code technology

Bar code technology was invented by two students (Bernard Silver and Norman Woodland) of University Drexel. Bar code become very famous as it was assumed that five billion bar codes scans are working; this was estimated by Uniform Code Council (UCC) (Wyld, 2006). Due to limitation (which is already mentioned) of Bar code the concept of RFID become very famous (Wyld, 2009). In Table 4 there is comparison of Bar code and RFID which clearly shows that RFID is more effective and efficient over Bar code.

Table 4- comparison of Bar code and RFID (Wyld, 2006)

Bar Code	RFID
Bar codes require line of sight to be read	RFID tags can be read or updated without line of sight
Bar codes can only be read individually	Multiple RFID tags can be read simultaneously
Bar codes cannot be read if they become dirty or damaged	RFID tags are able to cope with harsh and dirty environments
Bar codes must be visible to be logged	RFID tags are ultra-thin and can be printed on the label, and they can be read even when concealed within an item
Bar codes can only identify the type of item	RFID tags can identify a specific item
Bar code information cannot be updated	Electronic information can be over written repeatedly on RFID tags
Bar codes must be manually tracked for item identification, making human error an issue	RFID tags can be automatically tracked, elimination human error

Because of limitation of bar code system, Auto ID center has developed RFID system with the collaboration EPC (electronic product codes) and EPCglobal network. This collaboration was developed by 100 companies and five top research universities. These companies were included software companies, retailers and consumer product makers (Lai et al., 2005).

### 3.2.4. How RFID works

RFID technology is used mostly on products, vehicles, pallets, boxes, machineries or components of any product in order to communicate the identification data and this communication is done by using electromagnetic fields or waves (Pedroso et al., 2009).

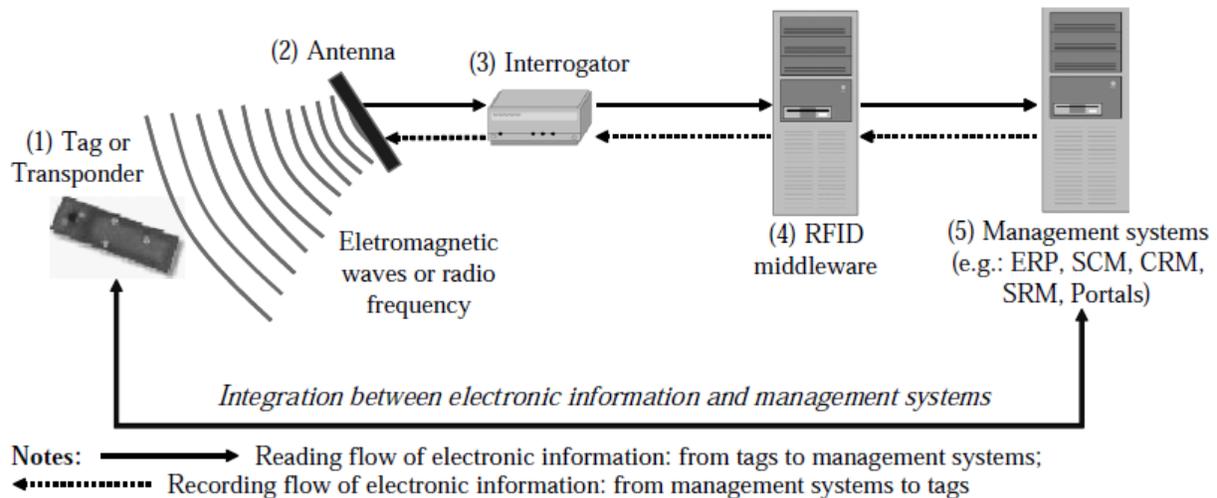


Figure 8- Function of common RFID system (Pedroso et al., 2009)

Information on tags are detected by the antenna, this information can be description of product along with additional information (for example if product was operated by barcode in previous system then this can be the code of that barcode system. As mentioned above that tags are attached with the items that moves one place to other place, these tags are detected by the sensors of antenna which transfer as radio frequency to interrogator. In order to detect the information from tags these sensors are distributed in different places or location like in the supply chain these are mounted on shipping docks, control point distribution centers and warehouse. These also can be mounted on weighing stations and receptions of the product in new place. To distribute the required information is dispersed and distributed by the RFID middleware which mentioned in the figure 8. This information flows in the system which is consisting of antenna, interrogated sensors and computer networks including RFID printers. When the product like pallet pass through the range of antenna, sensors detect the information and information flows between managerial system to tags and from tags to managerial system where integration of system occurs as well (Pedroso et al., 2009; Brito, 2004).

Gardner, (2004) has described the working of RFID process in seven steps. In first step the tags are mounted on the object which moves one place to another, in the second step EPC (electronic product code) are detected by the readers. These EPC are the unique number for the identification. In the third step middleware filter the data and distribute it. EPC information

system is the hub of distribution and keeps the data detected by the readers. In the fifth step data is authenticated to support the business process while information is kept as protected while information can be read without any password or with password. The sixth step shows linkages between EPC and multiple EPC information system. The last step Object Naming Services (ONS) give the yellow page which provides the information to EPCglobal network. This network contains data which can obtain by the participants in the RFID system (Gardner, 2004). EPCglobal are the standards for RFID technology which is mentioned in standardization of RFID (4.6.3).

### **3.3. Involvement of Key International organization for the Standardization and development of RFID technology**

Due to importance of RFID technology some of key international organization has taken keen interest for the development and standardization of RFID technology. The brief and precise detail is mentioned below:

#### **3.3.1. EAN/UCC**

In the march 2000 GTAG (global tag initiative) was introduced in America and Canada. Under this The European Article Numbering (EAN) and Uniform Code Council (UCC) govern and bring out the standards. These standards are also called EAN.UCC. These standards cover the Ultra high frequencies and data formats along with integration of air interface of GTAG with ISO 1800 Part 6 (Seidler, 2005; Srivastava, 2005).

#### **3.3.2. AIAG**

Automotive Industry Action Group (AIAG) has developed standards of RFID. Sixteen hundred members are involved in this association (AIAG) at the automotive and truck manufacturing supply chain as for developing of RFID standards. For example this association has developed standards of RFID in order to identify the tires and wheels. This standard is named as AIAG B-11 which was developed with the collaboration of EPC (electronic product code) (Ward and Kranenburg, 2006).

#### **3.3.3. EPCglobal**

The purpose of EPCglobal is to uphold the Electronic Product Code (EPC). EPCglobal came into a figure as a result of joint venture between the European Article Numbering and Uniform Code Council. EPC was introduced by Auto-ID Center, EPC is used to identify item. The EPCglobal aim is to make an international standard to RFID technology more effective (Ward and Kranenburg, 2006).

### 3.3.4. International Standard Organization (ISO)

ISO also has taken strong interest in order to standardize the RFID technology in different areas for instance in animal tracking. Smart Label standards were introduced by the ISO in the year 2000. ISO (international standard organization) introduce the working of RFID (tags and readers within the frequency of 13.5 MHz) according to the new ISO/IEC 15693-2. In 2005 ISO was working on high-frequency tags (ISO 18000-3) and ultra-high frequency tags (ISO 18000-6). These standards are based on the tracking of goods while working in supply chain. ISO (international standard organization) has also introduced ISO 11784 and 11785 standards specifically for the animal in order to track them (Srivastava, 2005; ISO/IEC, 2009).

ISO (international standard organization) has focused on following three main area of RFID technology:

- Identification cards and related devices
- Automatic identification and data capture techniques
- Conformance

In table 5 the detail is given of these three specific areas:

Table 5- Overview of ISO standards related to RFID (Srivastava, 2005)

#### **Identification cards and related devices**

Standard	Area	Details
ISO/IEC 10536	Identification Cards: Contactless Integrated Circuit(s) Cards	Typical range of 7-15 cm. RFID at 13.56 MHz
ISO/IEC 14443	Identification cards: Proximity Integrated Circuit(s) Cards	Typical range of 7-15 cm. RFID at 13.56 MHz
ISO/IEC 15693	Contactless Integrated Circuit(s) Cards: Vicinity Cards	Typical range of up to 1 metre. RFID at 13.56 MHz

## Automatic Identification and Data Capture Technology

Standard	Area	Details
ISO/IEC 15961	RFID for Item Management - Data Protocol: Application Interface	Defines Common functional commands and syntax features (RFID tag types, data storage formats, compression schemes), independent of transmission media and air interface protocols. Companion standard to ISO/IEC/15962
ISO/IEC 15962	RFID for Item Management - Protocol: Data encoding rules and logical memory functions	Specifies interface procedures used to exchange information in an RFID system for item management. Protocols ensure correct data formatting, structure of commands, and processing of errors in the system.
ISO/IEC 15963	RFID for Item Management – Unique Identification of RF Tag	Specifies numbering system, registration procedure and the use of uniquely identifiable RFID tags.
ISO/IEC 18000	RFID Air Interface Standards	This series of standards provides a framework to define common communications protocols for international use of RFID, and where possible, to determine use of same protocols for different frequencies. This series deals with only air interface protocol and not concerned with data content of physical implementation of tags or readers.
ISO/IEC 18001	RFID for Item Management – Application Requirements Profiles	

### Conformance

Standard	Area
ISO/IEC 18046	RF Tag and Interrogator Performance Test Methods
ISO/IEC 18047	RFID Device Conformance Test Methods

### 3.3.5. European Telecommunication Standards Institute

European Telecommunication Standards Institute (ETSI) is also taking interest actively as for as standardization of RFID is concerned. ETSI has developed standards with collaboration of different countries which are consisted of 55 member countries. European Telecommunication Standards Institute has developed the standards which are related to Ultra high frequency (UHF) bands which are outlined in ETSI EN 300-220 (Srivastava, 2005). The standard EN 302 208 are the standards which give compensation for the reader to use Ultra high frequency at more power with wider width (Seidler, 2005).

### 3.4. RFID Application

Before going to the application of RFID system let us have a look at the market of RFID technology for the past few years globally.

#### 3.4.1. Analysis of RFID market

Venture Development Organization (VCD) is consultancy firm which gives advises and consultancy on the basis of market research, VCD has revealed that market of RFID system included its software, hardware and services has been reached almost 965 million US dollars in 2002 as for as global shipment RFID technology is concerned. Venture Development Organization was expecting 2.7 billion US dollars in the year 2007 whereas the market sale of RFID system touched 1.3 billion US dollars. It was also predicted by Sullivan and Frost that market of RFID technology will be reached at 11.7 billion US dollars. It was also assumed that integration of RFID system will increase dramatically. Below is the Figure 9 which gives the comparison and growth of RFID product and Integration services for the RFID technology.

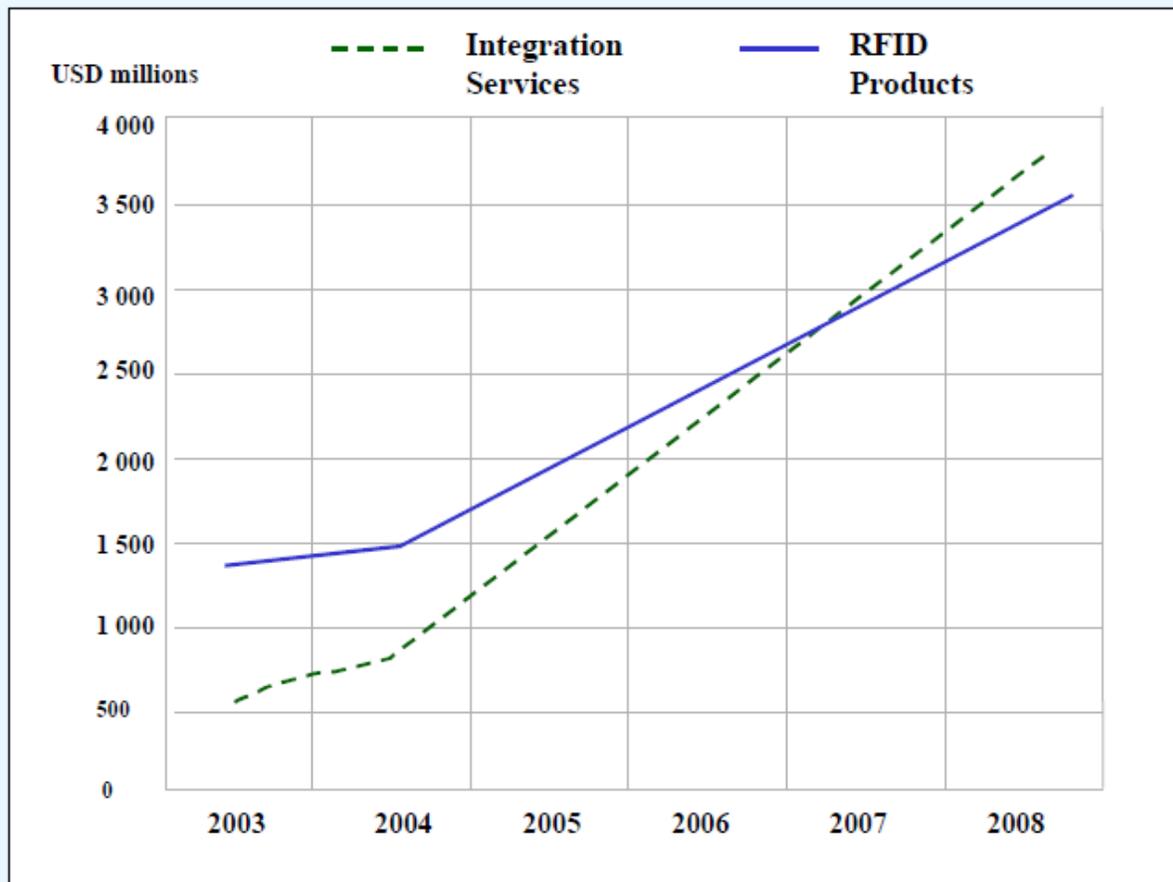


Figure 9- Sales of RFID product and Integration services from 2003 to 2008 worldwide (Srivastava, 2005)

As per prediction of most of analysts were agreed upon the growth of RFID technology mentioned in the figure 9. But most of development has been done from traditional and already established areas like animal tracking, security systems etc. RFID is more likely to be adapted to electronic industry where RFID also increased in supply chain industry but for the short span of time. In 2004 consumer goods manufacturer consumed 6.9 million US dollars on RFID according to prediction of Yankee group (Srivastava, 2005).

### 3.4.2. Application of RFID

Table 6 describes the emergent fields for the scope of RFID technology these days. RFID is not only used by the production or technological field but also it is even now have high scope of use the human body, VeriChip Corporation first introduced implanted chip to facilitate the human in order to identification of human.

Table 6- Traditional and Emerging RFID applications (Wyld, 2006)

Traditional RFID application	Emerging RFID application
Security/access control Electronic article surveillance Asset/fleet management Mass transit Library access Toll collection Animal identification	Warehouse management Supply chain management Reverse logistics Shipment tracking Asset tracking Retail management Document tracking Anti-counterfeit Advance access control Mass transit – monthly and single trip Airline baggage handling Aircraft parts and tools Health care applications Regulatory compliance Payments

It was estimated that almost 2000 people implanted the RFID chip into their body worldwide in 2007 (Rosenberg 2008). With the passage of time RFID technology is going more mature, now it's going to employ in variety of industries (Chae et al., 2010). According to survey of Computing Technology Industry Association, popularity of RFID technology is increasing day by day. Furthermore the survey of 155 IT companies has found that 46% of their customer has introduced the RFID technology to their systems (Thibodeaux, 2008). RFID technology usages are increasing in every field of daily life. Some of important implementations of RFID technology are as below:

### 3.4.2.1. Logistics and Transportation

RFID technology has proved its potential and importance in the public transportation. The implementation of RFID technology was done in the area of highway in order to get fares on toll. Losses were bear by transportation companies of public sector due to selling of tickets and passes because of the process was time consuming and expensive in the vehicles or dispensers. These problems have been solved since using of RFID technology especially with contactless cards. Electric management system enable to make a successful change in order to improve the system of transportation as well as reduction of cost by using RFID technology in their electronic management system. For this purpose transportation companies used contact less smart cards which are very stable against liquids, temperature or dust and their life is goes about 10 years. In USA contactless smart cards were used for the purpose to collect fares, these contactless smart cards were made by Philip company. 65.5 million US dollars were declared to consume in the year 2004 for the vehicles on new digital enforcement technology by TFL (transport of London). RFID tags were included in this budget in order to identify the plates. RFID has also been entered in the bus system for ticketing purpose since 1997 in Korea. This kind of development can also be seen in the city of “Thailand” Bangkok as for as RFID technology is concerned for their ticketing. They are using token both for individual trips or regular travelling. Even taxi drivers are facilitated by RFID technology in order to get payment for the travelling for this purpose, first experiment was done by using mobile phone included all necessary data at Tokyo in year 2004. JCB international, a credit card company which did this trial with some specific drivers having reader in order to identify the tags in mobile system for payment. These tags were passive tags. RFID has also been used in the courier system in order to sorting and right identification of parcels for the delivery purpose which allowed the improvement of the productivity and efficiency along with saving of time. Airline has already been using RFID technology in order to manage the baggage system. To give the facility for the baggage management Hong Kong International Airport has declared for using of RFID technology in order to get effective results where tags were mounted on the baggage of passenger which can be detected by the readers in reception area where passenger can get their luggage without any irritation and problem (Srivastava, 2005; Mecham, 2009 ). Box 1 shows some benefits of RFID technology in area of labor and cost. It also describes about benefits in manufacturing area of inventory management system.

#### **Box 1) Reduction of Labor and Cost**

RFID technology gives a complete automatic set of information without physical involvement which allows the organization to improve their customer services, reduce the operation cost in logistics and supply chain. Due to reduction of physical work, the labor requirement going be also less which reduce both labor and cost for the overall process (Park et al., 2010).

#### **Manufacturing Area**

RFID technology assists the manufacturing process by controlling the inventory system along with real time management. The management regarding process can track the product from the

initial flow from raw material to finished product. This thing can give high level of monitoring and checking of the product which increase the efficiency of the manufacturing process ultimately. This also results in reduction of manpower and cost (Kelly and Erickson, 2005).

Delta Airline is already using RFID technology for the tracking of the luggage of passengers in order to give better services (Li et al., 2006). In 2005 it was estimated that 2 billion bags are handled annually in the airlines worldwide where RFID has proved its effectiveness with wide precision (Wyld et al., 2005). This technology also proved a valuable role in application in toll road system. In the old system cars or vehicles cannot pass the toll station without paying the toll charges, where they have to stop their vehicles. Now application of toll system removed those barriers which have given the opportunities to save the time. RFID automatically detects the account holder and without any stoppage, the transaction can be done (Ahsan et al., 2010). Figure 10 shows a picture how RFID technology is integrated into the process.

### ➤ Warehouse systems with special holders

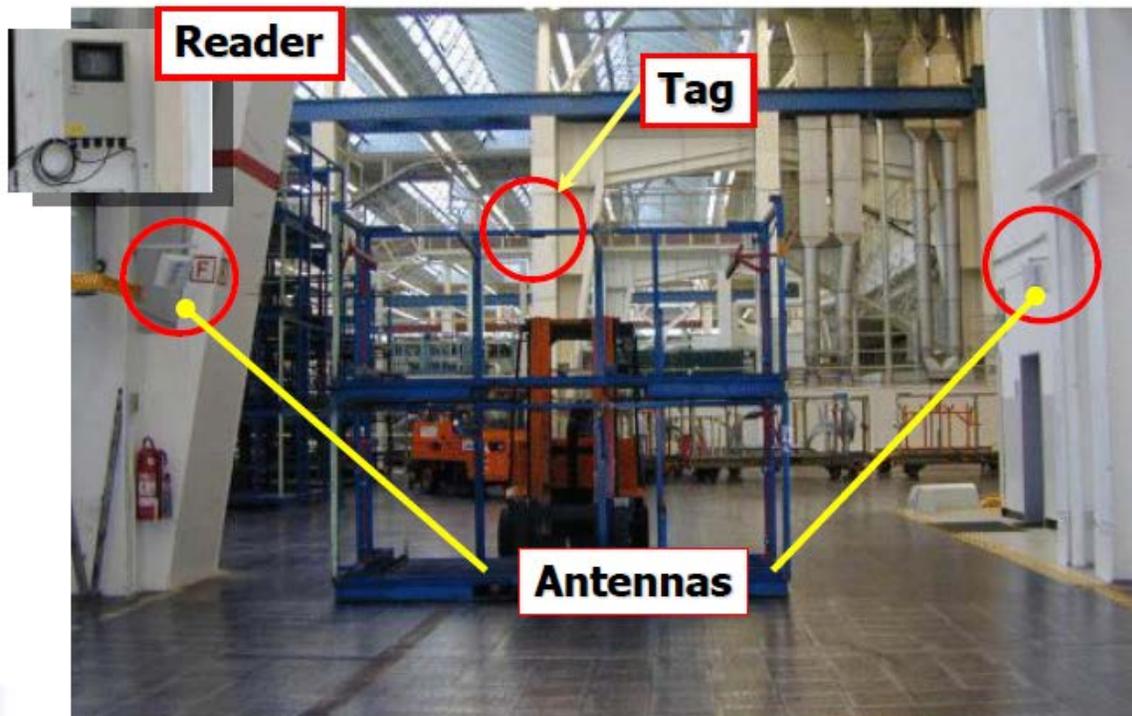


Figure 10- RFID system in warehouse (Provided by Mr. Lucas Åhlström)

RFID technology has given benefits as a result of good customer relationship due to on time, right and easy tracking product in the logistics system. For example implementation of RFID technology increased relationship between HP and Wal-Mart. RFID has changed the shipping operation method while the work with 3<sup>rd</sup> party logistics company which have their own management system for the warehouses (Lee et al., 2010; Spekman and Sweeney 2006).

Logistics and retailers are the areas in which right information at the right time in right place is very important, where RFID technology can play important role in order to reduce that gap of information. In case of internal process and between companies RFID technology can increase effective coordination in the areas like shipping, transportation and product receiving in order to controlling and managing the stock along with their traceability (Pedroso et al., 2009; Blanchard, 2009). In 2005 Wal-Mart has queried immensely for tagging their shipments which only not affect operations only in United States of America as well as it affected shipments all over the world including their warehouses (Mehrjerdi, 2008). RFID technology has now important role in the logistics system as it helped to improve the process efficiency as well as reduction of labor and human errors in logistics management (Palsson, 2007).

### **3.4.2.2. Supply Chain Management (SCM)**

Managing the warehouses considering the transportation of the boxes from one place to another, the arrangement of the product with in the boxes and the arrangement of the boxes according to product type where some products are sensitive or have fewer life cycles like meat, milk or drugs which also need specific temperature and humidity during the traveling. All these issues makes the supply chain management very important part as for as improvement and efficiency are concerned (Bergquist, 2008). It is note able that in the supply chain the shipments are done via different sources such as air, railways, trucks and ships and others while there can be a problem for these means as for as weather, traffic, legislation or other issues are concerned. There are other problems during the travelling of the products like broken part or some time parts are products can be stolen or mixed up with other product some time with other shipment. There are lots of chances of uncertainly during the shipment of products. RFID technology almost solved these problems in the supply chain to improve the productivity and efficiency. The manufacturing and the assembly industry of United States has focused on the 100 percent efficiency rate of reading the material while using RFID technology on the pallets (Ranky, 2006) (Wang et al., 2009). RFID technology is the rational development of cohesive supply chain system, the importance of RFID technology can be realized with this statement that in recent time we can see barely any magazine or research on supply chain without discussing RFID technology. Companies has specially advertised the importance of RFID technology to the supply chain point view explaining them about the benefits of RFID technology such as the flow of information with continuous and accurate tracking of the product in real time. Many firms have saved a lot of money by installing the RFID system to control their production process, for example Ford has deployed the RFID system for the purpose of part replenishment and for the locality of vehicles. According to a study revealed by University of Arkansas that 16% saving has done by managing out of stock product in the supply chain by using the RFID system in the supply chain (Spekman and Sweeney, 2006; Sheffi, 2004). Gillette is also the one of top most beginner users of RFID technology for their inventory system. In the year 2003 they bought five hundred million tags in order to achieve their required target for the improvement of the inventory system (Sheffi, 2004). More benefits regarding inventory control system can be seen in box 2.

## **Box 2) Inventory control**

Recent year logistics companies (especially in China) are showing a huge response to adopt the RFID technology into their logistics systems. RFID technology has allowed the logistics companies to give greater satisfaction with huge secure and safe services to the customers. This technology has reduces the logistics cost. In the year 2004 seventy percent of Chinese logistics companies got thirty percent increasing of business because of this technology (Lai et al., 2005).

RFID technology increase the performance of the inventory system by reducing stock out which can cause consumer purchases or customer can contact with the competitors of their transaction by leaving the order. In Hawaii the food traceability has been launched by using RFID technology to control the supply chain of their food throughout the Hawaiian island. By getting information in every stage they are now able to manage the stock by less expiry of food (Kumar et al., 2009; Hemmings, 2009).

RFID technology has also given benefit in the shape of better inventory control management. Staff members of library can monitor the books in the shelves and some other stack section without checking the books from every shelf physically. Portable reader or scanner allow staff member to accomplish this task without wasting extra time with precise manners where staff member also can monitor if some books are missing (Dawes, 2004).

Misplacement of items within inventory system is very expensive, which leads not only arrange the item only also waste of missing product. RFID technology keep eye on every product with clear information of location of the item. RFID technology has reduced the chances of missing items (Camdereli and Swaminathan, 2010).

RFID technology has saved billions of dollars for the supply chain of the companies because of hundred percent visibility of every product in every stage even from raw material to end product. Organization can monitor their inventory management system by having proper check and having proper degree of visibility on the product in the shelves. RFID enables the accurate tracking of the product in the shelves leads an efficient work flow in the inventory system. RFID technology allow the system with high level of services which reduce stock level, less time for the tracking of the product from different location and less labor will be required to maintain the warehouses. The other benefits are smooth streaming business process which permits accurate accounts and reduces the human errors (Aguirre, 2007).

RFID technology has been claimed to improve efficiency and effectiveness in order to control and managing the product and information follow in supply chain because of easy and complete tracking of the product (Vijayaraman and Barbara, 2006; Southall et al., 2010). This technology is capable to solve the information gap and allows giving more liberty to the different process and time management for the area of supply chain management. Moreover for the effective logistics system there is need of stock control and management along with tracking of the product on right time and RFID technology is the right product which can full fill these tasks.

Supply chain operations can be radically change in the presence of RFID technology in retails where using of RFID technology on recyclable containers enables to give benefits and pay off investments (Pedroso et al., 2009). The biggest companies of the world are now using the RFID technology to improve their productivity and efficiency, for instance Wal-Mart was the first organization which has used RFID technology to make their supply chain smooth on each product where tags were attached onto the items (Srivastava, 2007; Vlad and Iris, 2008). Not only Wal-Mart is taking interest in RFID technology, DoD (department of defense) is also taking a massive interest in this technology for their supply chain in order to improve their system (Reyes and Jaska, 2007). RFID has given a competitive edge to their company by improving the business process at fundamental level. Cost saving by RFID is separate thing while if we talk about other benefits which has proved extra edge for scope of RFID technology like Wal-Mart and Target Corporation have decided to share their data with their supplier, although sharing this kind of knowledge is not the new concepts between suppliers and the companies but this technology made it easy with in broader terms along with increasing of trust between them and there is no any excuse to exchange the data because organization do not want to share some information by making excuse for barrier of information flow (Spekman and Sweeney, 2006). RFID technology allows identifying the product location within the management system which enables the management to make collaboration between customer and supplier as for as planning, forecasting and replenishment is concerned in the supply chain of organization (Gardner, 2004). Wal-Mart is the biggest retailer in the world which was expecting to receive five billion boxes in 2005 with saving of 5 million US dollars by saving ten pennies from each box and same as about 8 million US dollars were saved. They believe that they can reduce the labor and inventory cost along with improvement in supply chain by getting more productivity and efficiency in the system (Mehrjerdi, 2008). Supply chain is the most important area for targeting of RFID technology which can revolutionize by the using software with intelligence and wireless technology. Pallets, boxes, plastic crates are now tagged by retailers or supermarkets in case of return ability of these objects which enables crystal clear and a clear unobstructed view of stock and inventory. RFID technology can hold additional information like in case of food inventory the tags can be filled with information of manufacturing, expiry date and even country of origin of that particular product. This can help in managing of shipments and delivery of product to target place efficiently. Procter and Gamble (P&G) is one of earliest companies which involved for using of RFID technology and allowed them to increased one billion US dollars in their working capital (Srivastava, 2005). According to a survey with fast consumer goods with their manufacturers, retailers and distributors which indicate that using of RFID technology on pallets and other means of carrying product has increase the productivity for the identification of products are concerned. Furthermore it is also revealed that shipping of automotive industry got benefit by the facility of RFID technology. Expenses of tires in the vehicles are the second highest in cargo transportation where RFID technology has reduced enormously by using tire management system. A LCD manufacturer used RFID technology to improve the portfolio system in the supply chain for the replenishment of stock (Nambiar, 2009). Stock taking is always problem in supply chain for the company and RFID technology has made it easy with removal of human errors, inventory systems become more efficient. The tracking of product life cycle become stress-free because of RFID tracking system the company now can trace the exact stock of product with its size, weight along with its delivery on time with proper record in any time and place. The products like milk, meat or vegetables which have very less

expiry date now can be identify in case of problem or delay in delivery, with the on time information provided by RFID system the appropriate corrective action can be taken easily on the basis of that particular information. This also has given benefits to product which are dangerous or faulty where recall measure can be done very without any difficulty (Reid, 2005). In the Brazil some companies are focusing for the implementation of RFID technology, Unilever has launched project for the implementation of RFID technology in the personal hygiene and household products to inspect and checking the flow of the product (Pedroso et al., 2009).

### **3.4.2.3. Security system**

The security of and access to restricted areas are very much concerned for the organizations these days. RFID technology has improved the security systems in different areas like schools, different kind of labs, technical areas and airports etc. Now the companies are using RFID technology based card for the entrance, exit or important changes of the systems. These cards have limited or some specific access for the particular task for the particular employees or authorities. In the year 2004 CATSA (Canadian air transport authority) has RFID technology in order to restrict or access to specific sensitive area in the cards. These cards are the contactless cards with contactless readers capable to restrict the person without authentication to the restricted areas. RFID systems are also successfully implemented in the area of education institute for the monitoring of students. In the year 2003 China RFID technology has used in the cards in order to avoid fraud. Chinese ministry of education and railways were confronting serious problems correspondence to genuine and valid cards for the purpose to identify the right authorized person for the discount on the basis of studentship. For this purpose Ministry of education of China has imported ten million smart cards to avoid such problems along with microchips which each has capacity of 2 kb data and distance range of these microchip was 1.5 meters. In these microchips the data of student can be stored and in the future all qualification like diploma's information can be saved. A primary school named Rikkyo Primary School in Japan has done a trial of RFID technology to monitor the students for checking of incoming and outgoing enabling the system to calculate the exact time of arrival or exit from the school along with restriction of ingoing to the school ground. Reader can detect the tags from the distance of almost 10 meters by scanner which has eliminated the effort to check one by one the students and they do not need to stop the students for checking. These tags were provided to the students and staff; tags can be pierced or fixed on the bags or on some personal belongings which can check the students with actual time. Active tags were used for this purpose which can detect the many students at same time on the distance of ten meters while passing through the scanners. This system also restricts or identifies the entry of illegal entry or unauthorized access of person into the campus. By using the RFID technology emails can be delivered to the parents for the information regarding their entrance and departing time from campus and due to absence personal information except only unique code of RFID tags the information cannot be read or displayed to the unauthorized person as for as privacy of personal information is concerned. In 2003 North American school (Enterprise Charter School) in New York installed the RFID system. This system enables to restrict the students or staff for over access to territory of school in order to avoid stealth of library books and computers. It also permits the staff and students for the certain buying of stuff from cafe or canteen. (RFID technology has made the payments very

easy and secure; box 3 shows the benefits of RFID technology for the secure and easy payments).

### **Box 3) Payments**

Payments are now easier by using RFID technology in lot different kind of area such as toll payment and some mobile application in order to pay money for the taxi or other charges. This mobile system is also being used for the speed pass. The payment system receives information from the reader and matches the ID and transaction concludes. This is the most secure and easy way for payment of charges (Aguirre, 2007).

In Japan the payment by utilizing RFID technology in the mobile has already been using since 2005. This revolution has decrease the irritations of payment by cash as well reduce the time of purchasing; these mobiles are called WB (wallet mobile). Moreover Japan government has also implemented the mobile with RFID technology aiming to do transaction for the purchasing and reservation of railways and airplanes tickets (Seidler, 2005).

In Sydney Star City Casino which includes gaming floor, guest rooms, health clubs etc have operations of eighty thousand uniforms which cost almost 1.8 million American dollars and according to the nature of area, the garments of employees has specific theme garment. RFID technology is used to detect the uniform for the employees throughout the laundry cart to laundry machine. This technology also supports to manage the inventory system of garment. RFID technology enables the timing of changing of uniform for the particular place or for the change in shift time where it identify which uniform will have to be used for the specific time and place as well (Srivastava, 2005). RFID tags can be attached on the vehicles of the particular companies which permit the administration to identify the usage of their vehicles as well as tracking can be done with the help of this technology (Ahsan et al., 2010). RFID technology has immense impact as for as homeland security is concerned. Agencies are now getting benefits by utilizing the RFID technology for the security purpose while checking and monitoring the people and the material which pass through the important areas like airports, railways, harbors or any kind of checkpoints (Spekman and Sweeney, 2006). The use of RFID can be seen in the security for the personal cars, watches or other expensive personal things (Srivastava, 2007; Langheinrich, 2008). Boats stealth is also a one of the biggest issue; Philips introduced the RFID based label in order to avoid the theft of boats in Germany. Before this, boats can be theft and thief normally can change the color of the boat with painting, but with the usage of RFID technology the chances of these issues has been reduced. RFID technology is also now using in the graveyard department to secure the dead bodies in grave or morgues (Srivastava, 2007). In 2006 St Luke's Health system decided to use RFID technology. They were already using the bar code system which reduced the human error but the problem with the bar code system they suffer was that; bar code could not work in the moisture condition whereas RFID technology is stable in this condition. In the year 2004 an American based company Purdue Pharma started to use RFID tags on the bottle of tablets (OxyContin) for the aiming to ship these medicines to Wal-Mart and other

wholesaler. These intentions were also done in order to meet the requirement of Wal-Mart for using RFID technology as well as to avoid the counterfeit and stolen drugs (Li et al., 2006).

#### **3.4.2.4. Medical and Pharmaceutical**

It was estimated that RFID technology has 297 million US dollar market in US healthcare center in the year 2007 (Lee et al., 2010). RFID technology is also penetrating into the area of medical and pharmaceutical field which enables to give authentic and easy delivery of information for the patient in the hospitals along with decrease of human errors as the medication of patient is very sensitive issue. RFID technology has also increased the efficiency as for as medication treatment of patient is concerned. This Radio frequency identification system with the help of wireless computer network and its attachment with the medicines or on the bracelet permits the concerned people to access the exact information and record of particular patient in order to manage the medication with the right quantity and time. RFID technology can be used on the badges of staff or with patient's bracelets or with the bed, the information is stored in the tags which enables the staff to care the patients while giving the medicines or other treatment in real-time instead of time consuming method like handwritten instructions. The chances of human error have been reduced by this method even though after medication or certain treatment the updated information can be also being done quickly. In 2004 FDA (Food and drug administration) has approved the implantation of RFID tags into the patient aiming to identify the location of patients in USA. Pharmaceutical manufacturing companies using RFID technology in the bottles or packets of the pills or other medications which help to identify the right pharmacies and also it give assistance to pharmacies or drug stores in order to avoid the piracy or counterfeit medicines. The biggest manufacturers of medicines in the world such as Abbott Laboratories, Procter & Gamble, Pfizer and Johnson & Johnson have started to use RFID technology for their medicines in 2004. RFID tagged medicines are not only prevent the pharmacies by counterfeiters but also indicate the expiry date of the medicines. Pharmacies can receive the medicines via distributors, if some abnormality occurs like incomplete or inaccurate transaction of medicine, RFID technology permit the concerned people to monitor or take corrective action accordingly by beeping alarm. In 2004 FDA has recommended to the medicines companies to use the RFID technology for their medicines products in order to avoid the distribution of fake medicines especially on those products where chances of piracy of medicines are more. RFID technology also has proved its potency in the dental industry. The Dentalax has introduced RFID technology for the engineering of crowns and bridges (Srivastava, 2005). RFID technology is now utilized in the treatment of bone fracture. Premo (magnetic specialist) and HUT (Hamburg University of Technology) introduced the implantation of RFID technology for treatment of bone fracture. Their purpose is to monitor the recovering process of fractured place. RFID technology gives all the information about healing which remove the process of X-rays and CT scans. RFID tags which can be implanted in the bone with steel rod for the bone is sensitive and radiation free. Removal of X-rays and CT scans gives reduce the chances of radiation risks which are not good for the human body (Dirjish, 2010). Engineers at Purdue University are working on project to make tags which can be implanted into the tumors (an abnormal new mass of tissues which can cause problem for the human body) so that doctors can control dosages for the tumor as well as identification location of tumors in the body. Organs and tumors move inside the body in the course of treatment, for this purpose doctors need rather new technology which can help them to

give the information about the exact amount of radiation received by tumors. These kinds of valuable information can help to cure the human body from the tumors more effectively (Ziaie, 2008). Tuberculosis (TB) is a very sensitive disease as it can affect other through air. Health care centers are now utilizing the RFID technology by isolating the affected patient from other and with RFID technology the patients are identified which help to track the specific patient and increase the efficiency of medical services (Lai et al., 2010). RFID technology not only helps in the case of counterfeit of medicines but also improves the patient and victim traceability and even this technology helps to avoid the chances of surgical instrument which can be left in the patient after operation (Reid, 2005).

Box 4 shows the benefit of RFID implementation in order to avoid the counterfeit of the products.

#### **Box 4) Anti-Counterfeit**

Counterfeit term is use for fake or copy of the product by unauthorized people. Counterfeit is very big issue these days especially in the medical field. Companies and pharmaceutical stores are using the RFID technology in order to avoid counterfeit chances. RFID tags are used on the bottle of the medicines which enables the concerned to identify the original and authentic product. As mentioned above the famous companies such as Abbott Laboratories and Procter & Gamble are now using this technology for the anti-counterfeit purpose. Another benefit of RFID on the medicines is that whenever medicine is going to be expiring, the RFID technology can indicates it to the concerned personnel. RFID technology also enables if some medicines or medical product are deliver to wrong place. The alarm beeps if the product deliver to wrong place or some inaccurate or incomplete transactions is done. Counterfeit of the medicines can also harm the patient which is the most sensitive area of concerns for the medical technology, by tracking and monitoring the right product the chances of this risk also been reduced (Dos Santos and Smith, 2008; Srivastava, 2005).

In 2001 Euro bank notes are tagged in order to prevent the system from counterfeit and fraud. The European Central Bank (ECB) was working on this issue to embed the RFID tags. For this purpose the discussion was under go with the famous technological companies such as Philips and Hitachi (Srivastava, 2005).

The Hong Kong authority and businesses were facing problem of counterfeit problem of garments. In order to identify the right product they have implemented the RFID technology into their process. They started to use the RFID tags in the internal side of the garment or attached with garment accessories. This implementation has helped them in order to identify the counterfeit product. According to them it has really helped them out of the counterfeit problem which is an effective method for the anti-counterfeit of the product (Mehrjerdi, 2008).

Counterfeit of drugs in the world is very serious issue as it can make the human life in danger, World Health Organization (WHO) has estimated that bear loss ten to thirty billion dollars every year as for as Viagra, Lipitor, Ambient and others medicines are concerned. Twenty five thousand patients who suffer from the disease of cancer has faced diluted and sub potent

treatment in the year 2004. This problem is a really big problem even though it is also difficult for the FDA do inspect this issue in order to get or stop them because there is no protection chain which could enable to identify the area from where these products are coming from or to catch the concerned person behind the crime. RFID technology has reduced the chances of occurring of these problems (Spekman and Sweeney, 2006). RFID technology implementation in the hospital has saved the imperative resources. This technology enables not only the staff to improve the services but it also makes the patients to be comfortable due to less chances of problems in case of emergencies (Ahsan et al., 2010; Lavine 2008). In US some agencies are focusing on the regulation to implement the RFID technology, like FDA has emphasized on the using of RFID technology for the medicines which is the one the hot issue in the supply chain of pharmaceutical companies (Pedroso et al., 2009). The governments from different countries are using RFID technology to monitor and track the medical records such as USA (Rosenberg, 2008).

### **3.4.2.5. RFID and Library**

Privacy of books is a very much important issue in the library and librarians have more concerned about the collection of library. In recent year a commercial was launched by IBM about the RFID potential in the library. In that commercial a person with trench coat is roaming in the library mysteriously, who takes books from the shelves and putting into his pocket and then he tried to go out. When he tried to cross the door an alarm beeps, the librarian say to him that; sir you have forgot the receipt. RFID technology has made the library more secure and efficient than before (Muir, 2007). Library department is very sensitive department due its precious collection, therefore library get benefits from the standards specifically for the library such ISO/IEC 15693 and ISO/IEC 18000-3 (Butters, 2008). RFID also has easy track ability without any physical movement (Radislav et al., 2009). Now one of the extensive usages of RFID technology can be seen in the library where implementation of RFID technology is aiming to assist system in an effective and efficient way for the loan and return of books, CDs or other material. Bar Code system has already occupied the library system for so many years, but the limitation of bar code system in as for as improvement in the productivity of operation of library has given the opportunity to show its potential. Bar code is only capable of reading books one by one whereas RFID technology made it in advance level as this technology can read so many books at the same time within second. RFID utilization in library has reduced the labor and human errors which enable the higher level of accuracy of inventory system of library (see more benefit of RFID in box 5). Due to potential of RFID system the famous library “Vatican City Library (VCL)” (which owns forty million pieces of material including books and others) has adopted the RFID technology for their library system in 2003.

#### **Box 5) Reduction of Time**

In the library reduction of time is great success of RFID technology which allow the user to do transaction of borrowing and returning of the books very easy and self-check. User can do the transaction of many books at the same time within second because RFID readers are capable to read the tagged books at the same time. There are lot options thus using RFID technology in the

library for example if a user want to return the book, so after return the books there is no need to sort the books to their original place by the employee. Sorter can sort the book according to the system with the help of RFID technology automatically. This thing can save the time as well increase the efficiency of the circulation of transaction (Dawes, 2004).

Alta Ski area has introduced RFID tags embedded ticketing services. Although bar code much cheaper than the RFID system but RFID technology has given more convenience to their operations and procedure. RFID system is more reliable and eliminates the tension of checking one by one for the entrance of people which also reduce the time and increased the efficiency of staff. These statements have been revealed by Michael Maughan, Alta's chief financial officer during the National Ski Area Associations 2008 National Convention and Tradeshow (Allan, 2008).

FedEx a courier company is now using RFID technology on the wrist band of the truck driver, which permits the drivers to open the truck door without inserting the key. This system can make the driver fast as for as delivery of parcels or other products are concerned. Moreover company is also working the project in which the truck will start automatically with wrist band embedded with RFID technology (Kelly and Erickson, 2005).

In 2004 almost thirty thousand books were tagged along with future plan of tagging more 2 million. The decision of adopting RFID technology behind the reason such as low cast and it does not have any chance of any damage of material as this library has oldest piece of complete version of Bible and some antique manuscripts. Companies from the Netherland are tagging its books with RFID technology like NBD Bilblion which deliver 2.7 million books to the Dutch libraries every year. Roppongi Hills Library (Tokyo) is also one of the famous libraries in the world which has been using the RFID technology since 2003 (Srivastava, 2005). SBCLS (San Bernardino County Library System) introduced the RFID technology and explained that the purpose of RFID technology is not to reduce the employees but to facilitate the staff members of library (Kieczykowski, 2009). UK has great interest of implementing the RFID technology into the library system; Glasgow University Library is one of those earliest libraries which have implemented the RFID system. After implementation of RFID technology the public library also announced to use the RFID to library system like Norwich, Haringey, and Essex. The library association has conducted conference in order to make checklist for the implementation of RFID system. Similarly Denmark is also focusing on the development of RFID technology for their library system (Ward and Kranenburg, 2006). RFID technology can recover the cost of library system because there are very less chances of missing items of library which removal of buying those things (Hadro, (2009).

### **3.5. Challenges, Risks and Scope of RFID**

A research has indicated that the level of risk of RFID implementation has a substantial impact on the performance of organization (Lim and Koh, 2009). It is necessary to discuss the different aspect of RFID as for as challenges, risks and the scope of RFID are concerned.

### 3.5.1. Market key drivers

Standardization of RFID technology is no more new topic, where concerned personnel know about different standard of RFID technology. There are lot of these standards are incompatible to each other. For example ISO standards for the tags from the range of 13.56 MHz (ISO 18000-3) and 860~960 MHz (ISO 18000-6) are accepted because both tags can be readable in America and Europe. 13.56 MHz ranged tags permits to read the information from the distance of some centimeters and its uses are personal identification, toll or travelling e-payments and ticketing. Whereas tags with the range of 860~960 MHz can be read more than 1.5 meters which are mostly used in the supply chain, warehouses, logistics and retailers. There are some countries where the legislation of more ranges of tags is not developed such as France, Italy and Turkey. This is really considerable driver which can create problem for the market development and initiative (Lieshout et al., 2007).

### 3.5.2. Cost

The major obstacle to implement the RFID system is its cost, this system entail tags, reader, antenna hardware and software cost along with maintenance cost after implementation of the system. Moreover for some companies both systems RFID and bar code have to be used at the same time as some companies are not using RFID. For these companies, they have to use both system which leads to the high cost (Li et al., 2006).

As mentioned before that Wal-Mart has already forced to their supplier to use RFID technology on their pallets or boxes. This can change the strategy of operations for the suppliers. RFID implementation in operations of manufacturing or in the other fields can make the management to reorganization of the process for which they need to hire some consultant with collaboration of RFID consultant. This reason can give the greater challenge as for as cost of managing of this whole process is concerned (Lieshout et al., 2007).

The cost is biggest barrier for the implementation of RFID system in the library. It was estimated in 2004 that for the library have the volume items of 250,000 may need almost 333500 US dollars. Although the cost of the RFID system has been reduced as compare to previous days but still it is under consideration. Tags are the most top cost factor, but its cost depends on the volume. The range of cost of RFID tags is about 0.60 to 0.90 US dollars in 2003 (Dawes, 2004).

Cost of RFID is much more as compare to bar code, which could force the companies to think about implementation of the RFID technology. As per year 2004 the cost of RFID tags was 0.25 to 0.30 US dollars whereas the cost of bar code was about 0.0024 US dollars which is very less if we compare with RFID technology. The cost is going to be less day by day, but there is still a big difference or for the comparatively less cost, long time is required in order to reduction of the RFID tag cost in the future (Kurt and David 2008; Lai et al., 2005).

### **3.5.3. Data Transfer related issues**

Data transferring and getting information by the reader is a very important area for the effectiveness and efficiency of RFID system. Sometime reader reads false information or multiple information from the tag can be obtained. The research on this issue revealed that dirty data is the core problem for this issue. Here middleware can play important role by filtering the right and require data with avoidance of unnecessary data and also guarantee to transfer the valid data to network. Another issue with the data transfer is the amount of data obtaining or transferring with high quantity or more than the capacity which can affect the efficiency of the system (Li et al., 2006).

Data management in retailers is very important and it is a considerable debate for the RFID technology. To complete utilization of RFID technology they need to manage the data transferring to right place with minimum effort. The data also need to be integrated with the accounts and customer relationship management. For this purpose there is a strong need of training of employees which also leads towards cost and extra work for the organization (Jones et al., 2005). The problem of integration is really trouble for the companies which are not using or planning to implement the RFID system. For example if a supplier of company is using RFID tags on the product, the retailers would have a different implementation need. These issues can make troubles as retailer management will think how to modify their warehouses and production process and how should they embedded the RFID tags to their pallets or boxes because they have more concerns about the information in the tags already embedded by the suppliers. The data generated from the tags should be integrated with the existing system (Goel, 2007).

### **3.5.4. Visibility of tags**

Tag visibility is a big issue in the library as for risks are concerned, RFID tags are visible like bar code. Although tags can be very small but it cannot be denied that these tags could be removed from the books (Dawes, 2004).

### **3.5.5. Tag and Reader selection**

Tag and reader selection is also a very important part when implementation of RFID technology is concerned because it can influence lot of factors such as tag frequencies, antenna shape and design and reader quality. Larger and strong antennas are required for the LHF tags which can result as a higher cost for the tags. But in other hand for the high frequency tags (tags can be smaller and cheaper) there is need of strong reader which is also in high cost. For the high frequencies in RFID system to improve the efficiency of reader can harm the workers because of high radiation but despite of fact these kinds of frequencies have not been introduced yet. There are other problems with high frequency which include the reflection problem and negative impact by metal or liquids. Antenna design can also affect the performance of RFID system. For example circular polarized antenna should be used in tag deployment is within the radio field is unknown. Tag separation is very important to enhance the quality performance of system. If distance of tags will very less, it can reduce the performance of system (Li et al., 2006).

### **3.5.6. Readability of exit sensors**

Tags readability on the exit gate or exit way of concerned department is a considerable issue. For example as for as libraries are concerned some experts suggest the distance of readability should be 3 feet and some suggests 4 feet. If the readability distance will be more then it could be the problem in order to avoid to theft or security of books. Although this problem can be avoid by taking right measures, but it should be kept in the mind when implementing the RFID system in the library (Dawes, 2004).

### **3.5.7. RFID Standards**

There are two types of main standards available for the RFID technology (Other than ISO), one is UID (Unique ID) and the second is EPC (Electronic product code). UID is Japanese based standards which are support by 352 companies such as Sony and Toyota. Whereas 2<sup>nd</sup> type of standards (EPC) is US based which represent US and European companies. There is still a question whether ISO will accept EPC standard as an international standards or not. In the China the companies which are selling DVD have to pay extra for the patents of the standards for each DVD, because they do not have intellectual property for the standards. The cost is really high as more than one fourth of total cost which is a big challenge for the Chinese companies (Lai et al., 2005).

If we look through the supply chain for the adoption of RFID technology then it will be revealed that compatibility of RFID technology with other RFID technology of different organization is necessary. They need to use common tags or frequencies for their RFID system. Uniformity problem of RFID system is the one of the reason for high cost of RFID system. The similarity of RFID system has reduced the cost of RFID technology to some extent. There are number of RFID standards are established recently. ISO has some particular standards for UHF and LHF which has already explained in ISO standards for RFID (4.6.4). Similarly the American National Standard introduced UHF for specifically for the passive tags, moreover Wal-Mart has also adopted UHF for the retailer systems. So different kind of standards are challenge for the companies (Li et al., 2006).

### **3.5.8. Tag reliability**

Normally tags have adequate life of its working almost 10 years or more than 5 years, but mostly tags are embedded on the outside of the pallets or on the containers in supply chain or warehouses. These pallets or boxes are lifted by the forklift or these products are transferred by other means which can damage the tags because of physical contact. Therefore, the damaged tags could not be read or some error can be generated while transmitting the information which can create the problem for the stock management or flow of the product to right place with right time. So here handling of the tags and its placement on the right place is very important (Gardner, 2004).

### 3.5.9. Privacy, risks and security

Despite of benefits there are some security problems with the RFID technology system. For example unprotected passive tags can access by unauthorized person who can lead them towards fraud or tracking and privacy of important information. Hackers can sell the RFID tags with low prices and behind it they can track information and give to the competitors or competitors as a hacker can monitor or track the information (Li et al., 2006).

Privacy of important data tags are biggest issue in the library. Information can be added in the tags depending on the management. This information can be read or misuse by unauthorized person. Normally libraries have very precious collection including ancient item, so privacy of important information is a very sensitive issue for the concerned (Dawes, 2004).

RFID tags can be read without beeping any alarm; if some want to read the tag then they can read the information without any notice of management if hackers are able to access the information. Another problem occurs when companies syndicate the unique serial number and the personal information. For example if a transaction is done with the credit by the customer then the shop will generate information with the serial number by making a link. The hackers can get the information which can be security threat for the consumer. Below in figure 11 a scenario of privacy aspect is illustrated (Juels, 2005).

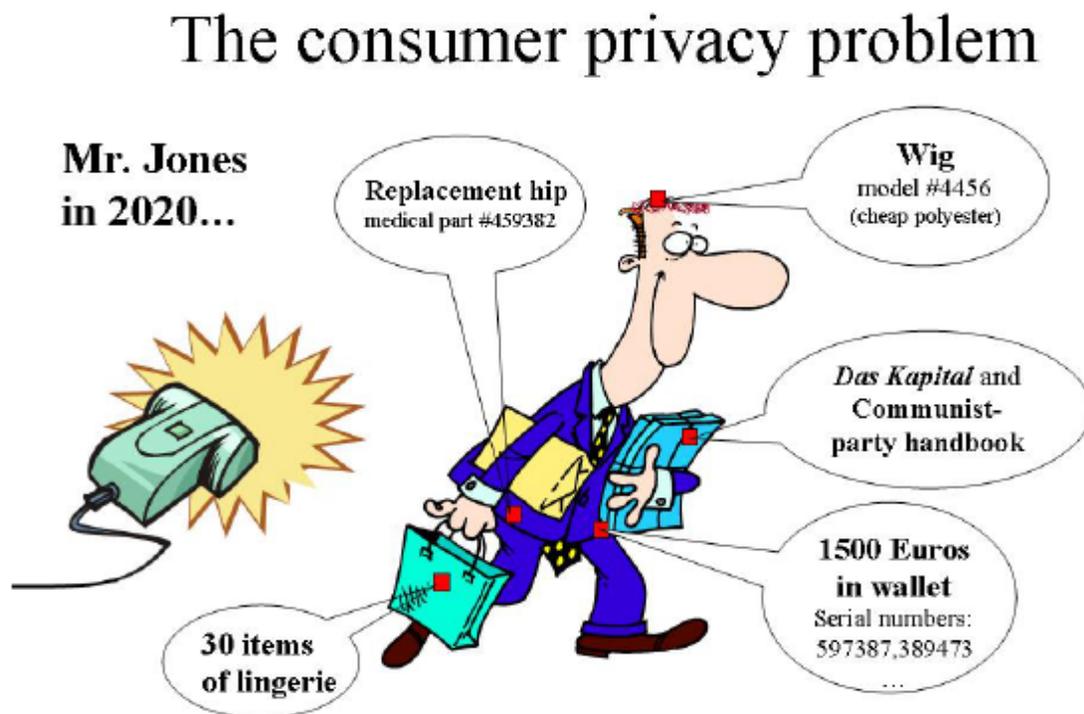


Figure 11- consumer privacy problem (Juels, 2005)

Information technology become a very complicated and advance which is capable to save and link the data, due to its advancement now people are very conscious about the their privacy threats. People do not want to give or use their information by other people or groups. There are some groups of people who think that RFID technology allows to other people use their personal information and they can track them easily without their permission. The using of RFID technology embedded on the products has increased the negative impression of people which can affect the companies by avoidance to use this technology in order to satisfy their customers. However some of application of RFID technology does not have too much serious privacy concerned such as RFID technology utilization on pallets. But some have very serious issues like in 2003 Benetton (A global fashion brand) decided to use RFID technology for the improvement of their supply chain and inventory system. This security and privacy concerns issue by the consumer; made the Benetton not to implement RFID technology into their clothing systems. Another example of such issue is Gillette razor which was suspected by the consumer that they are using spy chips fixed with products. Boycott has started by making a web site by the people aiming to boycott the Gillette products until they will not eliminate the RFID tags from their products. This is a bad luck for the RFID technology that people think that RFID technology is associated with the spy campaigns which can be a threat for the privacy. Figure 12 is taken by the website which was aiming to boycott the Gillette products.



Figure 12- Website page to boycott the Gillette products (Aguirre, 2007)

The facts also revealed that other wireless system are capable to detect the information from the tags. People think that by using RFID onto the product they can be tracked anywhere such as home and offices. Passive tags have a short range of readability which is normally used in the supply chain. However the advancement of the technology can be real threat for the people where particular laws and legislation should be made in order to avoid such privacy issues. But some of organization has some laws regarding frequencies which are already discussed in the ISO and EPCglobal part (Aguirre, 2007; Naone 2009; Langheinrich, 2008). RFID technology is facing dual challenges, like in USA some group of people related to people are against the RFID enables badges as they think that they are traced by the management of the company which cross their privacy limits. At same time IT specialist are making advancements in RFID technology and implementing in the systems to support the operations (Hamblen, 2007).

### **3.5.10. Readers related issues**

Passive tag has limited range to be detected by reader, but there is a serious debate of experts that tags can be read by readers within 18 inches. There are readers which have more range than 18 inches, here some legal requirement stop them to use in the specific areas. But the problem is that unauthorized person can use illegally that reader in purpose to get information which has some security concerns. These readers can be used in cars or other thing and can get the information from the particular person if they have some stuff embedded with the tags. For example a person borrows some books from the library and that person is walking towards his destination, car having reader crosses the person aiming to detect the information from the tag. By this activity that person can get the information as per his plan if the tags or not protected or if the person has already managed to get information from that particular tag. This issue generates really very serious privacy concerns of a person (Muir, 2007).

### **3.5.11. Interference and orientation issues**

Orientation issues of antennas and tags are extremely disputed as most of people think that orientations of tags have little effect on the performance of RFID system. RFID tags can be read in different orientation with high speed as there is no need of line of sight but the antenna design and its interference and position can affect the performance of readability of tags. But in some different kind of environment tags orientation really does matter for example if the tags and reader orientation is around the environment of transformer or electric wires (Clarke et al., 2006). Metal material can block the waves come from the RFID because radio frequency waves cannot penetrate into metal. Another problem of readability of tag is water or liquid which can absorb the wave. Here orientation of RFID system should be workout properly before implementing the RFID system (Singh et al., 2009).

### **3.5.12. RFID awareness and training issues**

RFID technology is facing lots of challenges in the shape of cost, privacy and standards etc, but there is another challenge for the implementation of RFID technology is the awareness, knowledge or the training of workers. A survey has done by the Computing Technology Industry

Association for RFID awareness purpose which exposed that eighty percent of the companies (who has responded on this particular survey) said there was lacking of skilled employees as for as RFID technology's skills are concerned. Training of the employees to make them skillful with high command on RFID technology was biggest challenges for the other companies. The amount of the companies on the surveys was two-third. This is a serious problem for the successful implementation and usage of RFID technology in companies. The skills and knowledge which is requirement of effective implementation of RFID technology such as awareness of physics of radio frequencies, knowledge of standards, installation, configuration and troubleshooting skills for every component of RFID such as tags, readers, antenna and software system etc. Lack of awareness and skills of anyone mentioned area can create the problems for effectiveness of system (Sommer, 2007; Mehrjerdi, 2008). In 2008, William Chamberlin M.D of University of Illinois Medical Center has clearly says no to RFID technology as it created some risk just because of incorrect installation of RFID technology. Its electromagnetic properties interferes the medical equipment which can be hazardous. Experiences and knowledge is very necessary to implement the RFID technology as it can be problematic along with very serious issues (Page, 2008; Gurahian, 2008).

### **3.6. Precautions for the effective implementation of RFID technology**

The research on the problems and precautions is ongoing these days. Some of the precautionary measures are as below:

There are some systems available to detect the unauthorized readers aiming to misuse the information of RFID tags. Unauthorized readers can be detected by read detectors which can help to avoid such incidents. These detectors can also jam the frequencies of tags in order to prevent from misuse of information.

Smart shelves are another solution to protect the tags from the illegal readers, or it can also protect from the killing of tags (Weis et al., 2004).

Passive tags are the good option as its read range is less, although it can be increase in the future but with specific legislation, it could be overcome. This solution is good choice but the increasing of range of passive tags have still a question mark as for as privacy or security is concerned (Reyes and Jaska, 2007).

Active tags are comparatively bigger in size and expensive, although its range is more than the pass tags because of the bigger size it can be visible very easy to the people. They can remove these tags very easily because of easy visibility of the tags. Active tags are sometime not suitable especially in the library.

Another disadvantage of the active tags is its less life as it has built in battery with it. Therefore active tags are not suitable as for as long term material usages are concerned. Active tags with higher range of readability can create confusion while reader could detect so many tags at the same time. So in the case of library or other where higher readability range of tags is not required, the passive tags can be beneficial comparatively.

The angle of antenna can also influence the performance of RFID management system. If the angle of antenna is not on the right direction then it can give poor signal to the devices which can affect the performance of receiving and transmitting of data information (Yu, 2008).

There are some other options also available in case of protecting the tags from hackers, for example tags can be deactivated permanently if someone wants to discard the tagged old product. These tags also can be temporally sleep or deactivated in case of closing of working process due to closing time or vocations. Another option of jamming the tags is also available in order to avoid the taking information by unauthorized person. This option is mainly use when hackers attack the tags already (Sitlia et al., 2009).

One of the common approaches to protect the tag information is applying the password. Password for the tags can prevent from the unauthorized person to approach the information in the tags (Lee and Kim, 2006).

RFID technology is the new emerging technology as for as potential challenges are concerned, the researchers are continuously working on it which would give more solutions or method to avoid the uncertainty of RFID implementation.

## **4. Methodology**

Methodology chapter will give the overview of research method which is used to give the answer of research questions. Methodology of any research paper is very important as for as strong research is concerned. Appropriate context of research along with right place to where data can be extracted is very necessary.

### **4.1. Literature study**

Scientific literature has been used to complete this research paper. Studying previous research is very good source to get radically apparent picture for context of the paper. It can give help to make the vision broader for the topic (Yin, 2003).

Our research questions consist of important implication of RFID technology along with its problems, risks, advantages and challenges. Literature study is done in order to give answers of our research questions. We cannot get information with small number of literature because our research questions are consisting of different aspects of RFID technology. An intensive literature study has been done in order to get help for the answers of our research questions.

According to our research question we started to search data about the application of RFID and its usages along with its benefits, drawbacks, risks and scope. First of all some literature are searched for the history and working procedure of RFID to get overview. Data of important application has been searched in detail. The most important part of literature study is advantages, disadvantages, risk and scope including solution for the problems of RFID. We have a huge amount of literature study. According to these points research is conducted by using scientific databases such as Emerald, ACS journals, ACM portal, EBSCO host, Wiley InterScience. Internet also been used to support the paper.

### **4.2. Case study**

The case study is the collection of empirical data which has surroundings logical and analytical approach. The case study not only gives the data but also wide ranging research stratagem. Case studies can be single or more than single (multiple case studies) (Yin, 2003).

Case study research do extremely well when we want to get the answer of research questions because case study make the complexity of issues more open and clear. It also broadens the experience and increase the strength of data by using case studies. We have selected different kind of experts related to RFID technology. These case studies appropriate for our studies as we are trying to get answer about RFID technology as for as its implementation, risks, advantages and challenges are concerned.

Our case studies highlight and comprehensive relative investigation of a limited number of proceedings or situation of different context RFID according to our research purpose and their associations.

These case studies look at current real-life situations and offer the root for the application of ideas and additional room of methods related RFID to which we trying to give the answers of research questions.

Selected case studies investigate the modern facts within contemporary framework because the boundaries between theories and real life framework are vague, so that case studies will make the situation open to identify the answers of research questions.

In the literature study there are lots of data of application, benefits and drawbacks of RFID. There are lots of data we can extract from different literature and things are repeated in most of scientific articles. To validate and addition of use full data, interviews and questionnaire are done.

#### **4.2.1. Interviews**

Research has been done by conducting interviews with the concerned people correspondence to RFID technology. For the extensive variety of research data for the cases, interviews are very useful means. Interviews can allow us to highlight the important issue for the case. In some case we conducted interview online. Internet based interviews can save the time of travelling and this process is more prompted than the site interview (Walliman, 2005).

Yin (2003) has mentioned six sources of evidence to collect the data in his book. These sources are documentation, archival records, interviews, direct observation, participant-observation and physical artifacts. In our thesis we used interviews with the concerned personnel.

For the interviews our questions were open ended including some of them were close ended. At interviews the discussion related to our topic were very informative as we asked extra questions according to answers and situations which enable us make our vision broad as for as our topic is concerned.

It was also important to select the people who are the best option for this research. So we targeted all kind of concerned people who has relation directly or indirectly to the RFID technology such as users, consultants, and suppliers of the RFID technology. Users can give the information about risks, problems as well as benefits of RFID technology. Manufacturer or suppliers can give information about the possible benefits and application of RFID technology in different kind of areas, whereas consultants are the best option to get information for all kind of aspects of RFID technology including future works.

#### **4.2.1.1. Interview with the Consultant and Agencies**

##### **Lucas Åhlström**

Lucas Åhlström is the CEO in Retorium AB a company with business in the European market and in the Gulf area. The company is dealing with RFID, GPS, GPRS and communication systems. He is consultant at the iPack centre, in the Royal Institute of Technology and also member of the board in a European/Chinese high technology company Abigua Medito AB based in Sweden with products in the Ambient Media and RFID system technology.

##### **Sten Lindgren**

Sten Lindgren is the MD (Managing director) of Odette Sweden AB. Odette Sweden is a member-funded cooperating agency with the Swedish vehicle manufacturers as key stakeholders. The company works in Odette Sweden AB, Sweden CAR wholly-owned company. Odette Sweden working on that, through international cooperation to develop common standards for vehicle manufacturers and their suppliers in different areas E-Business, Automatic Identification, Logistics Development and Product Data Communications.

#### **4.2.1.2. Interview with suppliers of RFID**

##### **Fredrik Martinsson**

Fredrik Martinsson is the CTO (Chief technical officer) of Areff Systems AB and is one of the owners and a part of the Management Group and the Company Board and responsible. He is responsible for the technical company strategies, system customers, production as well as the technical development. Areff System AB is making Plastic card printers, Photo ID system, RFID key fobs, ISO short, RFID tags, NFC accessories and reader system.

Due to too much distance from Gavle, we sent him the questionnaire; open questions were asked because we think that for this kind of research paper the open questions are better than closed questions.

##### **Lars Thuring**

Lars Thuring is the Managing Director of Logopak Systems AB. Logopak, one of Europe's major suppliers of print & apply labeling solutions has recently supplied four of its "Flag-tag-on-demand" 920 PF pallet labeling solutions to Kraft Foods / Power Logistics in Fallingbostel Germany.

### **4.2.1.3. Interviews with the Users**

#### **Egon Nilsson (IT department of University of Gävle)**

Library management of University of Gävle (HIG) is planning to implement the RFID technology into library management system.

#### **Christer Lagnell**

Christer Lagnell is the responsible person to run the ESCS (Effective Shop Charge Systems). ESCS is a family company which builds and sells automated shops and self-payment systems. They also run their own shops with sales of readymade food that are open 24 hours a day without the use of any personnel by using RFID technology system.

### **4.2.2. Questionnaire**

#### **Frida Egerlid (Process Leader MTS & Supply Chain Coordinator at Korsnäs)**

A questionnaire was sent to Frida Egerlid because she was not able to give interview due to her busy schedule. Korsnäs is making products for liquid packaging industries. Their main product is carton boards. They are producing liners for corrugated board and Sack & Kraft Paper.

Supply chain is the main area where they are using RFID technology for the product flow during production process.

## **4.3. Research Quality**

Yin (2003), has mentioned four steps to judge the quality of the research: construct validity, internal validity, external validity and reliability.

### **4.3.1. Construct validity**

Construct validity creates some criticism of others point of view. Three ways are used in order to construct the validity of case: Multiple source of evidence, establish chain of evidence and key informant review draft. Collecting data from different source and different method always give extra help in order to give instance confirmation and validation of the data to make research more potent.

Validating data can be done by measuring of different mean from the data has been extracted by analyzing the source of case study. Construct validity refers to establish correct operational measures for the studied phenomenon. This thesis has used multiple cases of evidence such as interviews with consultants of RFID, users of RFID and supplier & manufacturers of RFID. In this thesis we discussed with important issues of RFID technology on the same matters and mostly informant has confirmed the same.

### **4.3.2. Internal validity**

Internal validity refers to case study in which researcher confirms the event occurs to some specific events. For example if researcher concludes some results due to some factors for particular event but actually that particular event does not happened because of the reason mentioned by researcher then it means researcher design has unsuccessful to address with some menace to internal validity. Internal validity is process of establishing a causal relationship between certain events. Our thesis has made some descriptive conclusion for some causal relationship between the case studies issues and the difficulties occurred during the implementation of RFID technology along with its risks, challenges and advantages.

### **4.3.3. External validity**

External validity means the results of the case study can be generalized. For example if an interview is conducted to one person for the any social issue, the result of this interview can be applicable to other person in same manner or not? This problem happens most of single case study. But we have done multiple case studies which conforms the external validity in relation to literature study for RFID technology.

### **4.3.4. Reliability**

Reliability refers to repetition of conducting the same case for further investigator in the future. The objective is to generalize the result with other researcher. If other researcher does the same case and should conclude the same result. The purpose of reliability is to reduce the errors and personal favoritism from the study. Reliability refers to the results of research's consistency in future and confirmation of results in a same manner. For this thesis it is impossible to get the same answers due to some reasons such as technology always goes better and better with different change of process. Same study can be done for future researcher but the results cannot be exactly same as we concluded in our thesis. There is possibility for the new inventions or ways using of RFID technology because RFID technology is still in the developing process. There may be lot of chances to get information about new things.

## 5. Findings

### 5.1. Findings from the literature study

RFID technology has reduced the overall processing cost in different department such as supply chain, logistics and inventory control system, medical technology and libraries. The reason behind is less physical contact for the monitoring and controlling of products which also leads reduction of labor. It also helps to monitor the flow of product of supply chain and logistics quite in efficient way as compare to the labor monitoring systems. In medical technology two type of main advantages RFID technology has given. One anti-counterfeit of medicine and the second advantage includes patient identification and its medication during treatment in the health care centers. It also includes the delivery of medicines to the right pharmaceuticals for example if the some medicine being delivered to the wrong pharmaceutical by mistake then RFID chip could give signal to concerned people by an alarm so that corrective action can be taken accordingly.

RFID technology gives many advantages in library regarding security concerns as in the library there are some precious and old items. RFID technology has also given benefits in payments areas.

RFID technology has good scope in the medical technology; experts are working on the RFID usage for the movement of the patients. Injured patient's movement is a very serious issue while the patient need so move. Working of RFID technology on better movement with giving ease for patient has a greater scope in the future. This research and working can help the hospital management in terms of better services and health management with the quality parameters (Ahsan, Shah and Kingston 2010).

Security and privacy risks are very prominent issue as for as weakness of RFID technology is concerned. Although there are some precautionary measures available but still there is a need to work more on the security and privacy measures and technical researchers are working on it (Weis, Sarma, Rivest and Engels 2004).

Another issue is the disturbance of signal by noise or dirty environment, which affect the RFID performance. This issue needs to be work in the future. Integration of active and passive tags is also the part of future research for the technology specialist of RFID. Wal-Mart is planning to install the RFID tags on to every kind of product but the compatibility of tags with other or one type of tag may be able to be used for all type of product. This compatibility is very much necessary in future because competition and advancement along expectations are going to be higher (Ranky 2006).

FedEx a courier service company is using wrist band embedded with RFID tags which help the driver to open the door of truck without inserting key as mentioned before. They are now working on the wristband which can also be used in the starting of trucks without using key by automatically ignition using RFID technology (Kelly and Erickson 2005).

RFID reader are capable of reading lots of tags at the same time, but the problem is that the data transferring rate and quality can be affected by the excessive load. Research can be done in the area while have multi reader in the RFID system. These multi readers can detect thousands of tags at the same time with clear and quality transferring of data <sup>[48]</sup>. Heath care business is very sensitive as human life can be affected due to error while using RFID technology. There is a need of common and open standards for the healthcare or medical industry (Van Oranje, Schindler and Botterman 2009).

## **5.2. Empirical Findings**

In literature study we have come to know about the important application of RFID technology in supply chain, logistics, inventory systems, library, transportation, security system and medical technology. There are certain advantages, disadvantages and risk regarding RFID. To confirm and get clearer picture about these issues, we conducted interviews with the experts of related to the RFID technology. Interviews were conducted with RFID suppliers, manufacturers, users and consultants, so that we will be able to get required information regarding every aspect of RFID technology. We focused these issues especially in supply chain, logistics and transportation and libraries. We got lot of information which can add more knowledge about RFID technology. Let us have a look at findings.

### **5.2.1 Interviews with the Consultants and Agencies**

#### **5.2.1.1. Lucas Åhlström**

Lucas Åhlström is the CEO in Retorium AB a company with business in the European market and in the Gulf area. The company is dealing with RFID, GPS, GPRS and communication systems. He is consultant at the iPack centre, in the Royal Institute of Technology and also member of the board in a European/Chinese high technology company Abigua Medito AB based in Sweden with products in the Ambient Media and RFID system technology. We conducted interview in KTH (Royal institute of technology) with him along with recording. He expressed his views in favor of RFID technology mostly we are also agreed as he is involved in this business since last 25 years and he is involved in research center regarding RFID technology in KTH.

According to him supply chain and logistics and transportation are the areas where RFID has lot of scope. The most important thing to improve the efficiency of these areas is the detection and identification of the right product with exact positioning and it is not easy to manage. But RFID technology made it easy and efficient. With RFID networks in the connection with computer system enables the personnel to proper check on product can be done in the office even though it can be monitored anywhere via internet. This enables not only monitoring the system but also reduces the time and labor as there is no need to check the items physically. For the luggage control system in air ports, RFID is becoming more important. He said tags can be put on the each bag with specific information in the tag. Airport staff can easily detect the luggage with

exact positioning. This system not only reduced the chances of missing luggage but also has saved the time.

Companies mostly introduced RFID system into their business process for the improvement of process's efficiency. They need to maximum output with less effort aiming to save the labor and time. Competition between the organizations is too much high; they need more good service for the customers or business vendors. Online information with the help of RFID technology has reduced the gap between business parties such as suppliers and stakeholders.

As for as innovation correspondence of implementation of RFID technology, innovation does not mean to make something completely new but to improve the process or utilize the technology is different and effective way.

Decision for the installation of RFID technology to improve the system in the company depends on the nature of system. The usage of RFID technology is only to replace the old system like bar code then that is not viable. RFID can be used in different context such detection of the product, getting information from each product which can be visible to the other concerned stakeholder, monitoring and checking of the product with its exact status.

Getting competitive edge is very important because lots of companies are now using RFID technology in their supply chain, logistics, and security system. The antenna and middleware are the crucial part of RFID, that they can affect the performance of RFID system. For the tag and readers you can buy standardized tag and readers but if antenna has is not working properly or placement is not to the right direction then the whole system will perform poorly. Same as with the middleware, this translates the information into another readable form. If the middleware is not working properly then it can be also problematic for the system.

Compatibility of RFID data with the other system such as accounts or other computer network is a problem. There is a need to work with on this issue because it also leads to the cost because of its separate network.

Despite of risks, RFID technology can be secure if implementation of RFID technology should be properly by taking precautionary measure such as locked tags can be used and about the cost if we compare the output by using this technology with cost then cost is nothing. Cost is also depends upon the usage of RFID technology that how it can be utilize to improve the performance or productivity of processes. He also highlighted the problem of compatibility of RFID technology with other system in the organization.

If the proper use of RFID technology with right direction takes the company towards more profit. Most considerable equipment of RFID is tags as for as cost is concerned, cost is inversely proportional to the quantity.

As for as price is concerned Mr. Lucas Åhlström has explained it by giving another interesting example that if a person goes to the showroom to buy a car, the salesman will ask the question that "sir what kind of car you want" then it will be very weird that the person say that "can you

please tell me about the costs. Here user has need to ask the query about what kind of features it has, and then the as per budget limitation and scope of use the user need consider the options. People need to know about the feature of the RFID technology if it is suitable for their company then they should utilize although in some cases it's expensive (i.e. if you are only replacing the bar code with RFID) but there is really misconception about the cost that RFID is very expensive. People just see the price of tags but they do not consider the output that how much they can earn.

Problems during implementation of RFID technology he explained that one problem of RFID technology is to installation in the wrong place. Tags cannot be worked near metal area around. He shared his experience that once there was problem that readers were detecting some tags which were not required and also not intended. After examining the environment it was revealed that the area is near to transformers with lot of metal wires through which readers were detecting the tags from other areas. So it is very important to briefly examine the area as for as installation of RFID system is concerned.

### **5.2.1.2. Sten Lingren**

Sten Lindgren is the MD (Managing director) of Odette Sweden AB. Odette Sweden is a member-funded cooperating agency with the Swedish vehicle manufacturers as key stakeholders. The company works in Odette Sweden AB, Sweden CAR wholly-owned company. Odette Sweden working on that, through international cooperation to develop common standards for vehicle manufacturers and their suppliers in different areas E-Business, Automatic Identification, Logistics Development and Product Data Communications.

RFID technology in particularly in the supply chain of automobile industries has made a massive difference if we talk about the productivity and efficiency of the process such as returnable packaging management and part replenishment. Especially he talked about the returnable packaging that its big challenge for the supply chain of automobile industries for managing the returnable packaging. RFID supports the system to detect the packaging material along with exact positioning and specific packaging for specific product also can be identified by putting the data of packaging into tags. Packaging material in automobile industry is very expensive. By using this technology automobile industries can save lot of money and they can have much control over returnable packaging in the supply chain management.

The way of usage of RFID technology in effective manners is a key because different companies are now using this technology. Implementation of the RFID technology in different method can give maximum output for the organizations such as better handling of the information collected by RFID. Companies also can utilize the potential of RFID technology by collaboration with their trading partners such as suppliers, customers, transporters as for as better traceability of data and updated information. It can create more trust and coordination between them.

RFID technology can be used as an innovation in the company for example he said that in supply chain the products which have less expiry date, the company can follow the product during the transportation. In case of problem with transportation like refrigerator of truck and time has

exceeded for the product. Then there is no need to deliver that product to destination they need to come back and inform the concerned people which can take necessary action accordingly.

Cost of RFID technology is a big issue on the question of drawbacks of RFID technology. According to him the cost of the tag is not an issue, but the cost of IT system, software and the readers of RFID technology are the prime cost effective aspect while installing the RFID technology into the system. Readability of tags in difficult environment is another major problem of RFID technology such as in the environment of metal and liquid.

There is need of research on RFID's data infrastructure. There is an intense need of integration of common data base of RFID with other data base.

## **5.2.2. Interviews with Suppliers of RFID**

### **5.2.2. 1. Fredrik Martinsson**

MR. Fredrik Martinsson is the CTO (Chief technical officer) of Areff Systems AB. He is one of the owners and a part of the Management Group and the Company Board and responsible for the technical company strategies, system customers, production as well as the technical development. Their products are NISC Plastic Card Printers, PHOTO ID system, RFID key fobs, ISO short, RFID tags, NFC Accessories, Readers System.

In the interview with Fredrik Martinsson has described that what type of companies they providing the RFID related product to different kind of areas. They supply installers, gym, public administration, hotels etc with RFID equipment for access control. They sell printer solutions as well as large volumes of printed cards for companies, public transport, waste management and other specific industrial integrators. They also develop and sell industrial or part of industrial RFID solutions for tracking and measurements. It clearly shows the scope of RFID technology these days in different organization. The important thing is that what they have gained. In Access Control there is a very obvious gain, when the use of keys can be removed. It is a much cheaper system for the customer to maintain when using RFID. For other implementations there are also some great achievements when the customer needs a solution that is flexible or where data needs to be stored together with an item or person. If there is a need to read multiple identities, then an RFID solution is often a good solution. Now, compared to 3-4 years ago, there is often a business case that actually gains money when implementing RFID.

Company has received very good feedback after using the RFID technology by different organizations. These organizations are satisfied with the use to RFID technology as expected. Piracy of tags does not have immense impact of security risks but it can be problematic for the performance and accuracy of the product. On the question of about usage of RFID technology he described that within the organization RFID technology has vital range of scope. Integration and compatibility of RFID technology with other systems in the organization is one of the barriers for the implementation of RFID technology.

### **5.2.2.2. Lars Thuring**

Lars Thuring is the Managing Director of Logopak Systems AB. Logopak, one of Europe's major suppliers of print & apply labeling solutions has recently supplied four of its "Flag-tag-on-demand" 920 PF pallet labeling solutions to Kraft Foods / Power Logistics in Fallingbommel Germany.

RFID technology has a lot of space for the Inventory control system, supply chain and medical technology. RFID already proving its potency in these areas, but way of using RFID technology in an efficient manner is very important. RFID has helped a lot the management system to improve the productivity of the process especially in logistics, supply chain, medical technology, library, animal detections and anti-counterfeit of the products.

Inventory control system can utilize RFID technology in order to improve its system and it also utilizing already. For example one of the biggest problems is misplacement of the products or items. RFID technology monitors the product information along with its location. There are two vital benefits one is that it has reduced the chances of missing product with does not allow to buy or arrange new one. Secondly it also save the time which could be consume for searching the missing product.

Payment for the purchasing or bills such as electricity or home utilities is always hectic work. RFID technology reduced the chances of these issues. Although this kind of payment systems are in development process but it has given a vital ease to personnel along with secure transaction.

Customers are satisfied with the RFID technology, but the problem is the experience with RFID technology. Due to lack of experience users are facing some minor problems.

On the question about risks he replied that implementation of RFID technology without required experience is main risks for the organizations.

### **5.2.3. Interviews with Users**

#### **5.2.3.1. Frida Egerlid**

Frida Egerlid is the Process Leader MTS & Supply Chain Coordinator at Korsnäs. Korsnäs produce carton board for the world's leading manufacturers of liquid packaging.

A questionnaire was sent to Frida Egerlid because she was not able to give interview due to her busy schedule and she also did not give answers of all questions, some of questions she replied, because she does not have too much knowledge for some of questions. Their company produce carton board for the world's leading manufacturers of liquid packaging. They started to use RFID technology recently in supply chain management and they are very much satisfied with its working and RFID technology has reduced the lead time and removal of manual working along with potential errors.

RFID tags allow the system to detect the product with the positioning automatically without any physical involvement and there are more chances for the errors in physical work because of human errors. RFID technology has remove all these barriers with it's automatically detection quality with the help of radio waves.

The only problem they are facing is the data conversion to RFID system from old system. In the old system they were using bar code system. Cost of middleware is high from company's point of view. Cost of system also depends on your supply chain set-up, if it is in the supply chain you plan to gain advantages from RFID. For a more simple supply chain set-up, tags are most cost effective equipment of RFID system.

### **5.2.3.2. Christer Lagnell**

Christer Lagnell is the responsible person to run the ESCS (Effective Shop Charge Systems). ESCS is a family company which builds and sells automated shops and self-payment systems. They also run their own shops with sales of readymade food that are open 24 hours a day without the use of any personnel by using RFID technology system. The interview with Christer Lagnell was just short interview due to his tight schedule.

Their company is very much satisfied with the working of RFID technology as it is working as per expectation and it is possible to read multiple goods at the same time. In the general term there is a possibility to read more tags at the same time and possibility to change the content/behavior of the tag during the product cycle. The tags can also have an active functionality in the actual product. These factors can be used to improve productivity but also performance of the product and/or the process that is used to handle the products.

He further added that the only problem with the RFID technology is that the tags are expensive even though now as day by day tags are reducing.

### **5.2.3.3. Egon Nilsson**

We have conducted an interview with Egon Nilsson at HIG (University of Gävle) who is responsible for the IT related issues in library. University is planning to implement the RFID technology for the library and reason is that there is really irritation for the student when they borrow or return the book because of one by one entry and scanning of the book, which also cause the extra time both for the library staff and students. Another reason of managing the books one by one to shelves or sometime books could be placed to the wrong shelves by mistake. These problems are really irritating for the management of library.

RFID technology has the capability to remove all these problems with active and well-organized manner. Library staff can save their time and increase the performance of customer services. It also could reduce the process time for both students and the staff. It also can reduce the labor because for the managing the books in the shelves other activities there is no need to have more staff member as its assist the process automatically.

At same time they are also considering the problem that tags are normally visible so that if someone wants to steal books for this purpose that person can remove the tags from the books. Despite of this, it could be manageable by tagging the book into hidden part (round area of book). Well RFID technology has important role in the libraries because of some of libraries have ancient items and their security is really does matter.

## **6. Analysis and discussion (In the light of literature and interviews)**

After a literature study and interviews now we will go through for analysis and discussion in the correspondence to the literature and empirical study. We have divided this part according to the research questions.

### **6.1. RQ 1**

**RQ1. What are the important applications of RFID technology? And how RFID technology has given the solution to improve the process in different organization such as supply chain, logistics, inventory management, library and medical technology?**

RFID technology has substantiated its potential and has aptitudes to give a wide range of scope in order to improve the processes in different kind of organization such as supply chain, logistics and transportation. The target market of RFID mostly is supply chain, retailers, logistics, automobile industry and animal tracking but there are lots of different areas where RFID technology can play very important role as for as improvement and facilitation of processes is concerned. From the literature review interviews with the experts and users of RFID it is clear that RFID really helped the companies to boost their business. In the logistics and supply on the time delivery of the product to right place is very important. RFID technology is the only best option to fulfill these tasks. RFID technology permits to track the product anywhere within the range, without any physical movement the product can be tracked. Sometime products supply to the wrong place by mistake, but RFID have reduced these chances by avoid wrong delivery.

To gain a new technology that has much more potential than older ones, such as bar codes. Now, RFID is a proven technology with standard to support implementation and this makes it easier for companies to choose the technology.

Within a company the main areas are warehouse management in supply chain and logistics, deliveries between companies (tracking) and process control (producing the product). When the products are on the market, the main areas where the use of RFID can be improved are maintenance and keeping control of the distribution channels. The proof of origin for the product is also something that some companies can use.

RFID tags are superior for all types of inventory and maintenance, since they can be applied in many different ways on different types of material and they can also hold some data to support off-line systems. The security of the information is also high due to both encryption of the data and the possibility to actually hide the tag on the object.

## **6.2. RQ 2**

**How RFID technology can lead the risks, disadvantages and scope of RFID technology after implementation and how to avoid with those these risks?**

### **6.2.1. Cost**

In the literature study it undoubtedly clear that time, cost and labor are already reduced because of this technology which boosts the profit of company. Almost all interviewee pointed out these issues very strongly. RFID has lots of issues regarding security, privacy, cost and some hardware issues with RFID technology like readability and visibility of tags. But these issues can be resolved by working properly on it. For the proper use of RFID technology there is need of proper awareness, knowledge and experience as well. Training is a necessary part of usage of RFID technology.

Cost is really a big barrier for the implementation of RFID technology. Most of the experts including the personnel to whom I conducted interviews believe the same. Like, if the customer just wants to replace a bar code, then the use of RFID is often too expensive. If we look to overall gain by the use of this technology then it will be exposed that cost has no value in front of getting more business.

Buying of more quantity of tags will be resulted the less cost. Of course, companies have to buy more quantity if it would implement the RFID technology into their system. For example in airline tags for the baggage is matter of lot of quantity, even it could be less expensive than the bar code. According to us nobody will use bar code system in this scenario because RFID technology is more efficient and effective so why people will use bar code system.

Cost is always an important debate regarding RFID technology correspondence to implementation of its network. According to literature and interviews cost is big matter for the company which is a threat for installation of RFID system. Mostly were agreed with this issue but Lucas Åhlström said that the gain by installing the RFID technology is more than the cost. At this moment other experts are also agreed. Cost is going down as this technology is going common, but still its cost is high if we compare with old system like bar code.

### **6.2.2. Combination of RFID system and process system**

Another issue is that in most cases in the solution of RFID needs to be combined with a product that was not developed to be used with RFID. That will cause problems regarding placing, reading distance etc. In the future, most probably, products and process will be developed from the beginning to be supported by RFID, and then the design of products and processes will instead boost the use of RFID instead of complicating it. Although RFID technology is not a new technology but still there is need to fine tune or utilization of complete potential of this technology.

### **6.2.3. Pirated Chips**

In interviews we especially discussed about the piracy of chips. The problem "pirate-chip" which is a copy of a genuine chip RFID chip is one of biggest issue. The aim for this is not to break the security, but to sell a similar product to a lower price than the original one. In some cases this is really piracy, since patent and other restrictions are broken. As an end user it can often be hard to tell the difference. Often, you need to see the actual physical RFID module to be able to tell the difference. This duplication of the same design can cause duplicate unique IDs on the market, but there is still a low security risk. If the customer uses a high security enable chip and take precautionary measures (including passwords, encryption and more), then piracy of RFID chip will not affect that security. But there are chances to for security risk, for example a company is selling cheap product whose purpose is to get information for the competitors or other purposes. RFID tags can locked permanently as for as changes are concerned, there are tags available which can be lock permanently after entering the information.

So, the pirate chip does not directly affect the security for the RFID industry, but they cause that a lot of low-performance products are spread on the market. That is not good in the long run. The security issues for the RFID industry lies in that the wrong RFID technology is used when there is a need of very high security. There are low-security solutions as well as very high-security solutions within RFID.

### **6.2.4. RFID and Bar code**

Literature study shows the domination of RFID technology over bar code technology. But after interview with Lucas Åhlström it is revealed that it is very important to understand and analyze the situation before taking decision for the implementation of RFID technology. For example RFID technology is replacing the bar code system, if the implementation of RFID technology is only replace the bar code system then it is just a waste of time and money as mentioned before, so RFID technology has much potential and scope to improve the processes. It should be utilized with different ideas and context of processes not only removal of bar code, otherwise it would be really expensive as compare to bar code.

### **6.2.5. Integration of RFID with other systems**

Integration of RFID technology/information with the current system of organization such as ERP (Enterprise resource planning) system in the automobile industry is biggest issue which is considered as a barrier to implementation the RFID technology. An ERP system is the computer based data network which integrate the data of whole organization including financial, material and human resources. Most of companies need to integrate all the systems, and RFID technology has no option for the integration. Even there is a problem in replacing of bar code with RFID to convert the old information in bar code into new RFID computer networks. But as mentioned before that there is a space for the research and development in the future for this particular issue.

### **6.2.6. Standardization of RFID**

Standardization of RFID technology can be an obstacle as cost of extra working on standardization than the normal working routines but in other hand the standardization of RFID technology could be beneficial if there is compatibility of standards with others or all users and manufacturer of RFID should work under one standardization organization. For example all tags manufacturing companies are going to work under the ISO, in case of the situation that some companies are dying or some products are going to get out of the market so these tags can be re-useable for other companies or product respectively.

### **6.2.7. Readability of Tags**

Readability of tags in the noisy and some kind of other environment such as areas which are covered by lot electricity wires or transformers is drawback of RFID technology. These kinds of environment really affect the performance of RFID technology system. Organizations which are going to implement this technology have to consider and should have to do proper working before implementing the technology. With proper and right measures they can avoid these problems by changing the position of RFID equipment.

### **6.2.8. Lack of knowledge and experience**

Lack of knowledge of RFID's potential is big barrier for the implementation of this system, without complete knowledge RFID technology cannot be used in effective way. Proper awareness will give broader vision to companies so that they can utilize full potential of RFID technology as well as they will be able to take precautionary measure in order to avoid risks and mistakes. There is a need to educate the people for awareness of RFID technology. For example if a car has lot of nice feature but if you will not show them to the people for these feature then why people would buy that car, if they do not know about those feature. Similarly the scenario of RFID case can be applied that there is a solid need be shown to the people for the awareness of RFID technology and its potential.

## **7. Conclusion**

### **7.1. Conclusion from literature study**

Supply chain, Logistics and libraries are the main targets are of RFID technology where this technology penetrated very fast. RFID technology has given a vital space where these industries can play and get lots of benefits by using RFID technology with a scope. RFID has increased the efficiency and productivity of the processes of supply chain, logistics, library and medical technology. Reduction of labor and process cost, better inventory control system, easy monitoring and checking of product, automatic security system, anti-counterfeit and proper delivery of product and reduction of process time are the main advantages of RFID.

Although RFID technology has brought so many opportunities for the companies but it has also forced the implementers to think about its important considerations which can lead the users toward some serious challenges and risks. The problems and risks of RFID technology make some confusion for the investors to introduce RFID technology into their organization whether these are real or some misconceptions. We have concluded that cost, privacy, security are the main barriers which can force the user to think or stop the usage of RFID technology. There are lots of risks and problems but those are not so serious such as tag readability, visibility of tags and RFID standardization.

### **7.2. Conclusion from empirical study**

Our empirical study shows that RFID most impact the supply chain industry more than other industries such as medical technology and libraries. Supply chain industry can include logistics, inventory control system and transportation. So many industries getting benefits from this technology in order to compete their competitors. There are very less options to get more benefits over competitors. The way of use of RFID technology does matter really. For example using of RFID technology in returnable package in the supply chain of automobile has given a new idea to the automobile industry for the efficiency, reduction of process time and cost.

Luggage control system is also having big scope for the RFID technology because it can give lot of benefits such as traceability of luggage without physical effort.

RFID technology has the potential which can be dangerous for the human or other privacy. But in the other side there are also precautionary measure to which these problems can be avoided to some extent.

This study has given us mix review about cost of RFID technology. Tags are not main cost effective but other component such as IT system or middleware are the cost effective items including antennas. Cost of RFID technology is already an issue which is not deny able but most of cases this is just the misconception nothing else. The company with early adoption of RFID

technology will give more and more businesses but other will wait and will be lacked the competitive edge by not utilizing this technology.

If a company is going to implement the RFID technology just to replace the bar code system only then it is really a high cost technology and not feasible for them. RFID technology has so many other scopes to give competitive edge for the companies if it will be used in the right direction.

To implement RFID technology in the field, it is very important to study the complete area where RFID technology needs to be installed. RFID technology can be interrupted in the presence of metallic and dirty environment.

Security issues are not big problem for the implementation of RFID technology. Tags information can be permanently locked which cannot be read by unauthorized personnel without proper permission and code.

### **7.3. Conclusion from Literature and Empirical study**

We have founded that RFID technology is growing technology to support the system especially in the supply chain, libraries, inventory control and medical technology in order reduce the cost of process, labor cost, reduction of time, traceability of product without physical effort and quick. In medical technology anti-counterfeit big issue and RFID has reduce the chances of fake medicines.

The problems with the RFID technology are very simple and easy to cure. In some case some problems are the genuine problems which need proper attention by the concerned people. Proper workouts are necessary to utilize the potential of this technology with which RFID technology has, well there are some problems which needs to considered and which are also under working by the researchers and technologist as for as improvement is concerned.

Most of the problems of RFID technology are found due to lack of knowledge about this technology. People need to be educated before using this technology or before take a decision for saying to no to this technology. RFID technology is rational positive technology which has proved its strength in different organization. Many of the organization are still waiting for more experiences from other organization or companies to remove their fear about this technology while during this time other companies are already getting benefits such as Wal-Mart.

### **7.4. Future research**

- There is need of depth analysis of study of standardization of RFID technology and make them compatible to each other. It also raises the cost and limitation usage of RFID due to different standards.

- Cost is most significant factor for the adoption of RFID technology, some thinks it does not matter and some thinks it matter. There is need more study of proper cost and benefit analysis.
- RFID technology has proved as an evolutionary technology in the supply chain, logistics and inventory management system already. But there are some more working is required, because RFID technology is newly adopted technology for the most of the companies where they need to convert RFID data into usable form or compatibility of data with the old system.
- The problems of implementation of RFID such as metal environment or dirty environment around the system and should be addressed in detail with reach in broader term and these problems should be highlight in order to reduce the chances of mistakes.

## **7.5. Limitations**

Our empirical cannot be generalized completely as data extracted during interviews with the suppliers can be in favor of RFID technology because in their mind they normally have positive aspects. Interviews are very less; from these limited interviews it cannot give the 100% surety of validation of data.

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# Appendix

## Questionnaire

1. Can you please introduce yourself and you responsibilities in the company?
2. How much do you know about the RFID at basic level or advance level?
3. When did you planned to implement RFID in your company and did you have idea of RFID at that time? (This question was removed while sending questionnaire to consultant and suppliers)
4. How did you manage your activities before implementing the RFID? (or How did your customer manage activities before implementing the RFID)
5. What were the good and bad things of previous system?
6. Why did your company introduce RFID into the system?
7. Do you think RFID is step of company as for as innovation is concerned?
8. After implementing the RFID what are the achievements in order to improve the productivity or performance.
9. Describe the common usages of RFID technology in your company?
10. What is the range of band of RFID in your company? (or you are providing in case of suppliers)
11. What do you thing that RFID should be used in order to improve the company's processes?
12. Do you think that applying RFID tags on network elements could be useful to track network maintenance?
13. In which area RFID manage to reduce the cost?
14. What are the main advantages of RFID technology according to you?
15. What are the disadvantages of RFID?
16. What do you think in which aspects RFID should be improved in its function?
17. What are the problems you have faced during implementation?
18. In which area RFID has made an ease as for as your working is concerned?
19. What are the risks involved with RFID according to you?
20. Are you using the RFID according to ISO standards?
21. Is RFID proved as a solution to reduce the working time and labor?
22. What are the most compelling reasons to adopt RFID in the company?

**23.** Which of the following represents the largest cost item in your company's RFID plan or adoption?

- a) Tags
- b) Readers
- c) Middleware
- d) Applications
- e) Services