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Scrutinizing Working and Proposing Solutions to Security Issues Involved in Retail RFID

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***Abstract*—** Radio frequency identification is an addition to already existing wireless technologies based on communication via waves. The RFID (Radio Frequency Identification) market is in a hyper growth phase. RFID technology has found its application in several fields which ranges from retail industry to government projects and medical sector. Via RFID, objects can be connected to Internet or databases in such a way that they can be easily tracked and companies can share and utilize data about them. RFID involves three primary components: RFID tags, RFID readers and central database which is placed in any computer system depending upon the amount of data it is supposed to handle. The benefits of RFID technology in the supply chain are fairly convincing. RFID technology has the potential to increase the profit of companies by improving the efficiency, accuracy and security of the supply chain. Because of positive and appealing prospective of RFID, many companies are busy in implementing this technology. It is for sure that in the coming future the market for RFID products and services is set for a huge leap. But if we view the other side of the coin, there are certain hurdles that are faced during effective implementation of RFID technology. RFID systems now have been in existence since many years but the technology for supply chain management is still emerging. The two major problems faced by RFID is collision between multiple readers and collision between multiple tags. In this research paper, the concentration is laid on major issues which poses obstacle for effective implementation of this technology. The paper illustrates removal of these hurdles with appropriate implementation. Moreover, paper focuses on in-depth look at cost, technology, standards, privacy and security and business process reengineering related issues surrounding RFID technology in supply chains.

***Keywords*—** RFID, retail industry, reader, tags, wireless communication.

I. INTRODUCTION

The term RFID [1, 2, 5] refers to Radio Frequency Identification, a technology which uses radio waves to automatically identify items or people. RFID is being used for identification of variety of items, consumer goods, vehicles, animals and much more. Like other automatic identification technologies like bar codes, voice recognition, face recognition, retina scan etc., RFID is also used to identify the objects. The major difference between RFID and other identification techniques is that RFID operation is not bounded by line of sight. Data is involuntarily captured and transferred to the system responsible for maintain database transactions without any need of performing data entry.

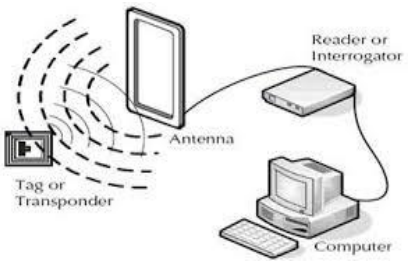

Fig. 1. Working of RFID.

Fig. 1 shows a typical system that uses RFID technology. The host system utilizes multiple RFID readers to capture digitized information related to product, stored in RFID tags placed on that particular product. RFID tag comprises of different data fields related to the product and most unique field being unique identification (UID). RFID based object locator is always in search of UID. Tag can be easily read independent of its orientation. RFID now have been successfully used in water and metals.

II. COMPONENTS OF RFID

Important components [3, 4, 7] of an RFID system are:

1. An RFID reader (also called transceiver) with an antenna and a transceiver.
2. A transponder (also called a tag) that includes an antenna and a chip.

It is a common term for technologies that use radio waves to automatically identify people or objects

- An interrogator or reader consists of a transceiver, decoder, and antenna. The transceiver is used to receive radio signals and thereafter decoder decodes it to byte stream. The antenna is used to emit/receive radio signals.
- A transponder or tag consisting of a microchip and a small antenna. Information to be processed is written in microchip. The antenna is used to emit/receive radio signals.

The entire RFID picture combines the technology of the tags and readers with access to global standardized databases. With this one can have real time access to up-to-date information about relevant products at any point in the supply chain. A key component to this RFID vision is the EPC Global Network. The unique identification number contained on the tag is called an Electronic Product Code (EPC). It also includes additional information which is of interest to manufacturers and different organizations. As items travel through the supply chain, the RFID tags placed on them helps to track the location of items. This concept can be well

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illustrated by a simple example - RFID is a technology that allows things to be identified via radio waves. An RFID reader sends an interrogating question to an RFID tag (e.g. "who are you?"). The tag can then respond with an answer to the reader (e.g. I am product XYZ from company ABC). All this process is carried out by electromagnetic waves. Radio waves can be transmitted directly through objects. More importantly, the radio waves carry with them a minute electrical current that can be used to power the tags, effectively turning them into very small, special purpose, computers. It's this power that the RFID tag uses to send the response to the RFID reader [6].

III. RFID IN RETAIL INDUSTRY

It can be argued that businesses today have been quick to understand the possible benefits of RFID to their bottom lines. Businesses can be made more competent by enhancing its information and technology infrastructure with the capability to sense what is actually happening in the real world. To support this statement let's take an example of pharmaceutical companies. With the help of RFID technology, companies can track the locations of expensive medicine very closely. This would reduce the loss of goods due to theft, and retailers can make sure that drugs are actually coming from the manufacturer. Some key players making use of RFID are Wal-Mart, US Department of Defense, Procter and Gamble and European Retailer Metro Group.

In fact, not only are business processes being improved on by RFID, but some processes will actually require RFID in the future. In future, the pharmaceutical industry is sure to make use of RFID as pedigree information that proves the identity of the manufacturer of a drug and the route it has taken through the supply chain is now being synchronized ever more strictly, and RFID is currently seen as the best way to solve this problem.

RFID applications can be of short range or long range. Long range applications deal with track and trace applications. It has been usually noticed that companies apply maximum effort in just knowing that what is present in their warehouse. RFID helps companies to track each unit easily and effectively even long after it has left the factory. RFID allows all this data to be transferred securely. With the use of RFID, the company can have an adequate control on the product's life cycle. The creation of successes and failures can be better understood. There have been several instances when companies had to recall the entire product due to a fault in a minor component. For example, a car manufacturing company has to recall its whole car for a minor defect in the air conditioning system of the car. By making use of RFIDs, such recalls can be made much more focused. Company can have a healthier data about post production performance of the car. There could have individually tagged components in the car. Data could be collected from anywhere like accident sites, repair shops and even the garage. Even inside the factory, tags could enable faster and focused fault tracing. Many companies follow Just in Time (JIT) practice. It means that components are used when they are delivered and delivered just before being needed. Such situations often lead to out of stock situations. This solution to this problem is use of RFID [3, 7, 8].

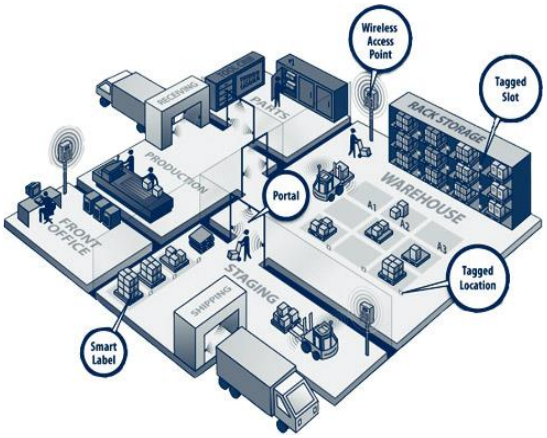

Fig. 2. Working of retail supply chain

Goals of RFID in Retail industry

- Decrease in lost stock
- Faster locating stock
- Lower labour requirement
- Reduction of out-of-stock
- Low safety stock level
- Faster Checkouts
- Better information
- Faster payment
- Reduced inventory requirements
- Shipping errors

IV. CHALLENGES RELATED TO RFID

There is no second thought in the fact that RFID has gone through a sizeable growth, but still there are certain serious concerns that are related to this technology and needs to be addressed. Enhanced sensitivity of the tags and readers has allowed RFID to overcome some of the initial challenges but at the same time it has led to some unexpected consequences. The sensitivity of devices like chip, tags and reader is much greater today. The new chips are highly sensitive that readers are picking up one too many aisles now in stores. There has been need to tune down some readers. It is obvious that almost every new technology goes through up and downs and RFID is no exception. From maturity of standards to interoperability between vendors to pure speed and range of tags, RFID vendors have made enormous strides during the last decade. The leading retailers and brands around the world like Marks & Spencer, Adidas, Macy's have successfully deployed RFID in apparel sector. Through each of these programs, RFID has provided a range of efficiencies for retailers, including: increased sales as a result of reduced out of stocks; improved margins based on lower level markdowns; and reduced losses due to improved visibility. One of the greatest challenges facing RFID is the price point of the tag itself. Today, the biggest challenge for passive RFID adoption isn't technology but business process changes to take advantage of what RFID can deliver. As an example, many retailers only do a full

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physical inventory once a year because it takes an enormous effort to manually count items. With the assistance of RFID, the same process can be done in few hours and in some cases, even in minutes. The retailers have to adopt themselves to the functioning of RFID to use it to full potential. In coming future, the emphasis will be laid on the factors like developing and getting more out of smarter electronics and enhance customer experience. RFID will also find its healthy application in management of perishable foods and healthcare applications.

The four major challenges [3, 9, 10] that industry needs to deal with in regard with RFID adoption are discussed as under.

A. Cost of Tags

Cost of Tags has been the biggest hurdle in adoption of passive Ultra High Frequency RFID adoption. Cost of tags is really an issue in open-loop applications. Tag is paid and is affixed to an object by the user and then the item is shipped to another user which is outside his or her system and thus loses the ability to obtain additional value from the tag. To support this fact, we can consider an example of supplier tagging a pallet before it goes to a distributor or end customer. The chances to benefit from an RFID tag are limited in open-loop applications. But in closed-loop applications the things are different as it offers hundreds, thousands of benefits as a tag is used over and over again. RFID tags may be used for years as compared to bar codes which are meant for single use.

B. Industry Fragmentation and Segmentation

RFID is not limited to tags and readers. A complete RFID solution comprises design, readers, tags, antennas, enclosures, application software, RFID middleware, cabling, and training and installation services. It is similar to asking someone to buy pieces of a vehicle separately and then build it. The time required for the completion of the project increases with the involvement of multiple suppliers. Although industry is trying its best to assure interoperability by employing certain standards, but the problem will persist until the load of system design, installation and support is eliminated from the end customer and consolidated with a single vendor.

C. Cost of Infrastructure Replacement

RFID made many semiconductor companies active. These companies were responsible for bringing expertise in physics, technology and chip-level design but however they were short of system-level experience and knowledge of current practices in auto-ID industry. Software engineers with adequate experience in high-level application and database software attempted to bridge the gap within RFID middleware. But the software developed was expensive and had poor real-time performance.

D. Environmental Dependence

One another big hurdle faced in efficient implementation of RFID technology is its environmental dependence. The earlier problem of the tag not working in moisture or liquid or in the presence of metal has been resolved by the companies. Services have improved to such an extent that now customers can send their items to the tag suppliers and choose their appropriate tag as per item and also the place where to place in the tag. However, when we consider infrastructure side, it is not possible for customers to send their shipping dock to decide the proper power settings, shielding requirements, selecting antenna and angling them.

It refers to the fact that an experienced RFID technician should visit the site personally. Preferably customers procure this level of support at earlier design stage in order to balance business processes and technological capabilities. It also allows selection of correct reader, antennas and solution form factor. Because these site-specific impacts have not been dealt properly, it has resulted in failure of many projects and left many customers who showed faith on RFID technology unhappy. This factor alone has created much of negative publicity as far as RFID technology is concerned. So, there is a need of better, experienced systems integrators and customer awareness of the importance of proper upfront design and installation support must be increased.

E. Enabling Wider Adoption

The rate of adoption of RFID has always been a disappointment. The industry should focus on fixation of the underlying problems with infrastructure and deployment rather than concentrating on RFID tag price reduction.

F. Forecasting demand

Retailers are very much interested in understanding of what products people will be buying and where the demand will be. To do this, there is need to collect demographic data and also the economic indicators to know about the spending habits of the public across the targeted market. For example, it has been found that in south India the demand for books exponentially as the weather gets colder. So, the retailers increase the amount of book recommendations which appear in the customer's feeds.

G. Identifying customers

The best way to increase the sale is to put the particular product in front of customers in best way. For this retailer depend on recommendation engine technology online and also the data gathered via transactional records and loyalty programs off and online. Concentration should be laid on the fact that how individual customers interact and make contact with retailers and decide the best way to interact with them for promotion of the product, be it via email, SMS or any kind of mobile alert.

V. SECURITY ISSUES IN RFID

Likewise, other security devices and mechanism, RFID too is not flawless. Before deploying RFID one needs to address all the threats and challenges involved in implementing RFID efficiently.

Counterfeiting in Basic tags - Counterfeiting in basic tags can be done very easily as they do not use any encryption technique. Attackers can easily modify the information stored on basic tags and modify them to gain access or validate products authenticity.

RFID Sniffing - Not all RFID tags are smart enough to identify how to discriminate between a genuine request send by valid RFID reader and a fake RFID reader. Attacker can use his/her

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own RFID reader to read information on tags and use it for their own selfish interests.

Tracking - An attacker can easily track the location or movement of the object bearing RFID tag. So, it should be accepted that an attacker can track an object even if one is using encrypted messages to communicate between the tags and the RFID readers.

Denial of Service - It is a mentionable fact that both RFID reader and backend server are susceptible to DoS attack. In such an attack, the RFID tag fails to verify its identity with the reader and as a result the service gets interrupted. So, it is important to take care of this DoS attack.

Spoofing - In this type of attack, an attacker masquerade himself/herself as authentic user of the system and poses to be an authorized database user. If an attacker succeeds in doing so, he/she can do whatever he/she wants to do with the RFID data like responding to invalid requests, denying normal service, making change in RFID id and much more.

Repudiation - Repudiation refers to officially denial by a person of having perform a particular action. Repudiation can happen in two ways: one is the sender or receiver may deny doing an action such as sending RFID request and we have no evidence to proof that. The second one is the EPC number owner or the database owner denies that it has any data about the tags attached to an object or a person.

VI. Approaches and Proposed Solutions for Tackling Security and Privacy Issues

There are a variety of solutions for tackling the security and privacy issues surrounding RFID. They can be categorized into the following areas [3]:

1. Tag Data Protection
2. Reader Integrity

Solutions for Tag Data Protection

A. Password Protection on Tag Memory

The most convenient method for tag protection is via use of passwords. The passwords will not allow any unauthorized user to read tags data without the owner's permission. But it should be kept in mind that same password should not be applied on all tags as their always persists chances of becoming virtually public. But on the other hand, if each tag is provided with unique passwords, there will be millions of passwords that need to be maintained in database.

B. Physical Locking of Tag Memory

The information related to the product is locked into the tag before it is released in open environment. The chip having the product details is read-only and is embedded during manufacturing process itself.

The other side of this concept is that no rewriting can be performed on such tag chips because of its read only factor. There's a need for additional memory to store modifiable or extra information. This will result in increase in cost and memory.

C. Authentication of the "Author" in Tag Memory

The author or owner of the tag encrypts the tag data with his own private key (i.e. digitally signs the tag) and writes the encrypted data into tag memory along with the author's name, a reference to his public key and the algorithm used in non-encrypted form. When the reader wants to verify the authenticity of information, it retrieves the author's name and other non-encrypted information from the tag to verify that the data has been actually written by the original author as claimed. However, if the RFID reader needs to update the tag with new data, a key management system is required in order to manage the private key.

Solutions for RFID Reader Integrity

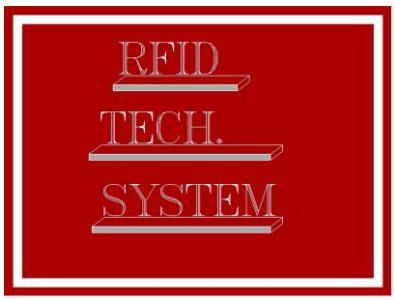
A. Reader Protection

Tag replies with errors in response time can be rejected by the readers. Also, the replies that don't match with the signal power levels are rejected by the readers. Readers can make use of random frequencies with tags constructed to shadow a frequency dictated by the reader. Readers are capable of changing frequencies randomly to prevent unauthorized users from eavesdropping on traffic. Further the data exchanged between the reader and RFID server may require verification of the reader's identity. An additional authentication process can be implemented between reader and backend application to confirm that information is passed to a valid processor.

B. Read Detectors

RFID surroundings can be furnished with exceptional devices to detect unauthorized read attempts on tag frequencies.

We have developed the solution for the above-mentioned problem via programming in C language. This concept has been implemented in such a manner that when a reader comes under the range of another already activated reader, the reader which was priory activated deactivates itself and newly activated reader takes its place. The following screenshots depicts the working of the concept.



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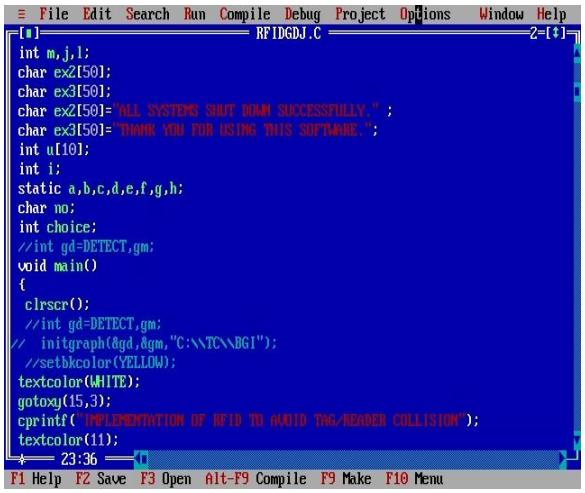

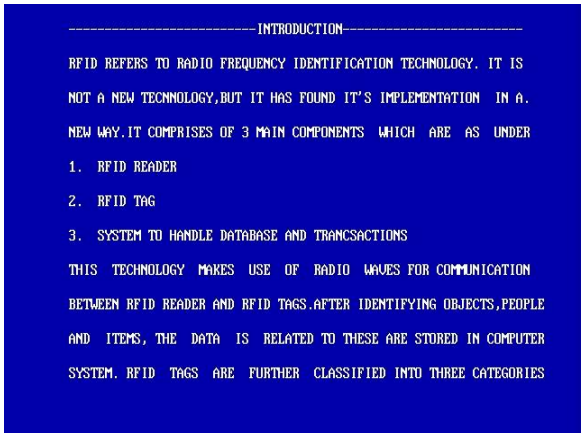

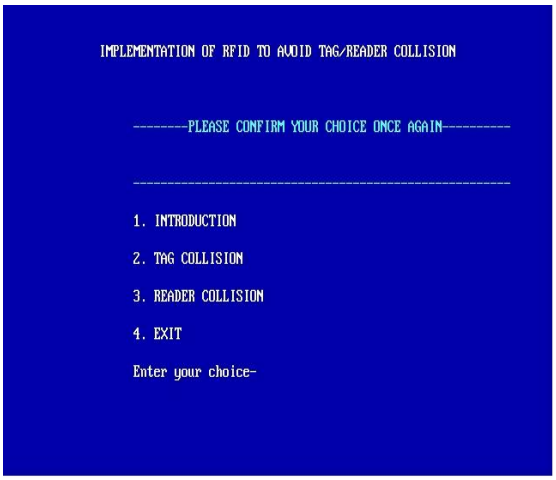

Fig. 3. Screenshots of implemented work in C++.

VII. CONCLUSION

Four major benefits of using RFID in retail supply chain is: (a) improved inventory management, (b) velocity of retail cycle, (c) integrated business model for inventory and supply chain management, and (d) improved store operation. Additionally, three critical risk factors for implementing RFID in the retail industry are (a) lack of expertise, (b) complexity of technology, and (c) uncertainty of technology [3].

Pros: (a) Real-time data on assets and goods, (b)Increased data and knowledge for decision making, (c)Reduced theft and loss, (d)Improved inventory efficiency and management, (e)Reduced labor costs, (f) Increased efficiency and product flow, (g) Goods authentication,

Cons: (a)High implementation cost, (b) Lack of globally accepted use standards, (c) Lack of better middleware (d) Privacy intrusion, (e) Strain in the IT infrastructure by overwhelming information systems as real-time scans move between multiple applications.

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