

Framework of Smart Mobile RFID Networks

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Abstract

Basically RFID (radio-frequency identification) is a wireless communication technology within the L1 (Layer 1, the physical layer of the OSI 7-layer Reference Model) and L2 scopes between RFID tag and reader. The RFID reader reads the code in the RFID tag and interprets it by communicating with the IS(information services) server via a proper communication network. This is the typical architecture defined by EPC (electronic product Code)global. RFID networks need to provide value added services in order to give better visibility to inventory movement across supply chain or closed loop applications like Asset tracking or Work In Progress tracking. The RFID reader can be stationary or mobile. A mobile RFID reader affords more applications than the stationary one. Mobile RFID is a newly emerging technology which uses the mobile phone as an RFID reader with a wireless technology and provides new valuable services to the user by integrating RFID and ubiquitous sensor network infrastructure with mobile communication and wireless internet. The mobile RFID enables business to provide new services to mobile customers by securing services and transactions from the end-user to a company's existing e-commerce and IT systems. In this paper, I describe about the core components of mobile RFID, advantages and its applications in scenario of smart networks. Although there are several types of mobile RFID readers in the market, I focused on mobile RFID technology that has several positive features including security, network architecture, operation scenario, and code resolution mechanism.

Keywords: EPC network, RFID, Mobile RFID, Smart RFID network

1. Introduction

RFID (Radio Frequency IDentification) has been recognized as a key technology for ubiquitous networks, which in turn is defined as an environment in which information can be acquired anytime and anywhere through network access service . Currently, RFID technologies consider the environment in which RFID tags are mobile and RFID readers are stationary. However, in the future, RFID technologies could consider an environment in which RFID tags are stationary and readers are mobile. RFID based on mobile telecommunications services could be the best example of this kind of usage. RFID-based mobile telecommunications services could be defined as services which provide information access through the telecommunication network by reading RFID tags on certain objects using an RFID reader in mobile terminals such as cell phones. RFID tags play an important role as a bridge between offline objects and online information. The RFID enabled cell phone was introduced by Nokia in 2004.

In these domains, RFID technology holds the promise to eliminate many existing business problems by bridging the economically costly gap between the virtual world of IT systems and the real world of products and logistical units. Common benefits include more efficient material handling processes, elimination of manual inventory counts, and the automatic detection of empty shelves and expired products in retail stores. RFID technology has a number of advantages over other identification technologies. It does not require line-of-sight alignment, multiple tags can be identified almost simultaneously, and the tags do not destroy the integrity or aesthetics of the original object. The location of tagged objects can thus be monitored automatically and continuously. The EPC Network, originally proposed by the Auto-ID Center and further developed by the members of EPC global, is currently one of the predominant standardization effort of the RFID community. RFID networks need to provide value added services in order to give better visibility to inventory movement across supply chain or closed loop applications like Asset tracking or Work In Progress tracking.

In traditional RFID applications, such as access control, there was little need for RFID middleware because the RFID readers were not networked and the RFID data were only consumed by a single application. In novel application domains, such as supply chain management and logistics, there is no longer a 1-to-1 relationship between reader and application instance, however. In these domains, many readers distributed across factories, warehouses, and distribution centers capture RFID data that need to be disseminated to a variety of applications. This introduces the need for an RFID infrastructure that hides proprietary reader device interfaces, provides configuration and system management of reader devices, and filters and aggregates the captured RFID data. This frees applications from the need of maintaining connections to individual reader devices.

The rest of this paper is structured as follows. In Section 2,I give detail about the EPC networks. Section 3 provides a brief overview of RFID technology and outlines the constraints imposed by the characteristics of RFID. In Section 4, I describe about smart RFID networks. I continue by presenting some sample applications and advantages of Mobile RFID in Section 5 and in section 6 conclusions are given.

2. EPC Network

A typical RFID network model may refer to the network architecture of EPC global as shown in figure 1 where the network entities are RFID tags, readers, ALE host, event management server called EPC-IS, EPC-IS service location server called EPC-DS, and code resolution server called ONS. Business application servers such as ERP, CRM, SCM, etc. are out of scope because they stay at back-end and are associated indirectly with an RFID network. Such a network model is for B2B applications.

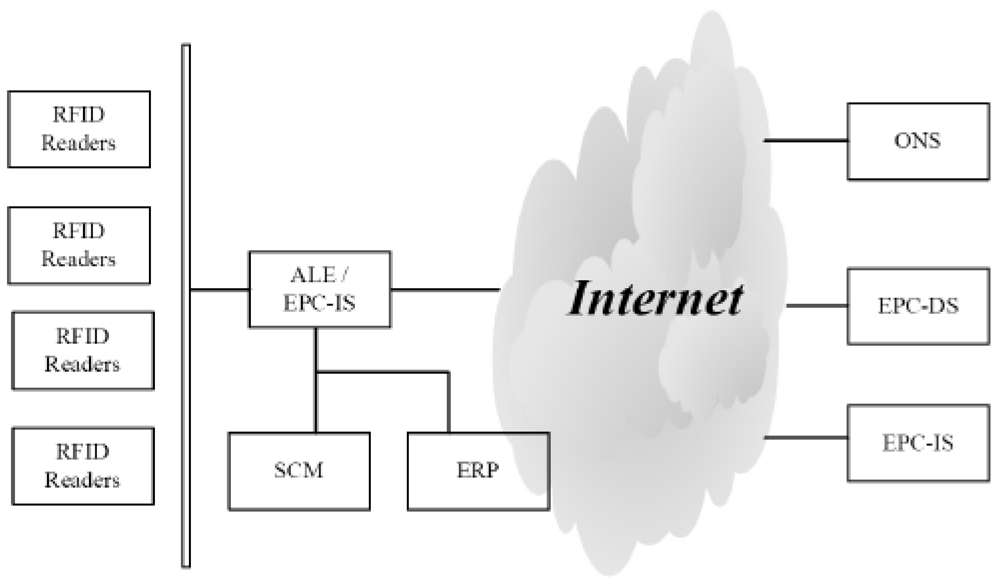

Fig. 1. EPC Network's Configuration.

3.RFID

Radio Frequency Identification (RFID) is an automatic identification technology which allows
remote interrogation of ID data on RFID tags using radio frequency as a means of wireless communication between tagged objects and RFID readers.

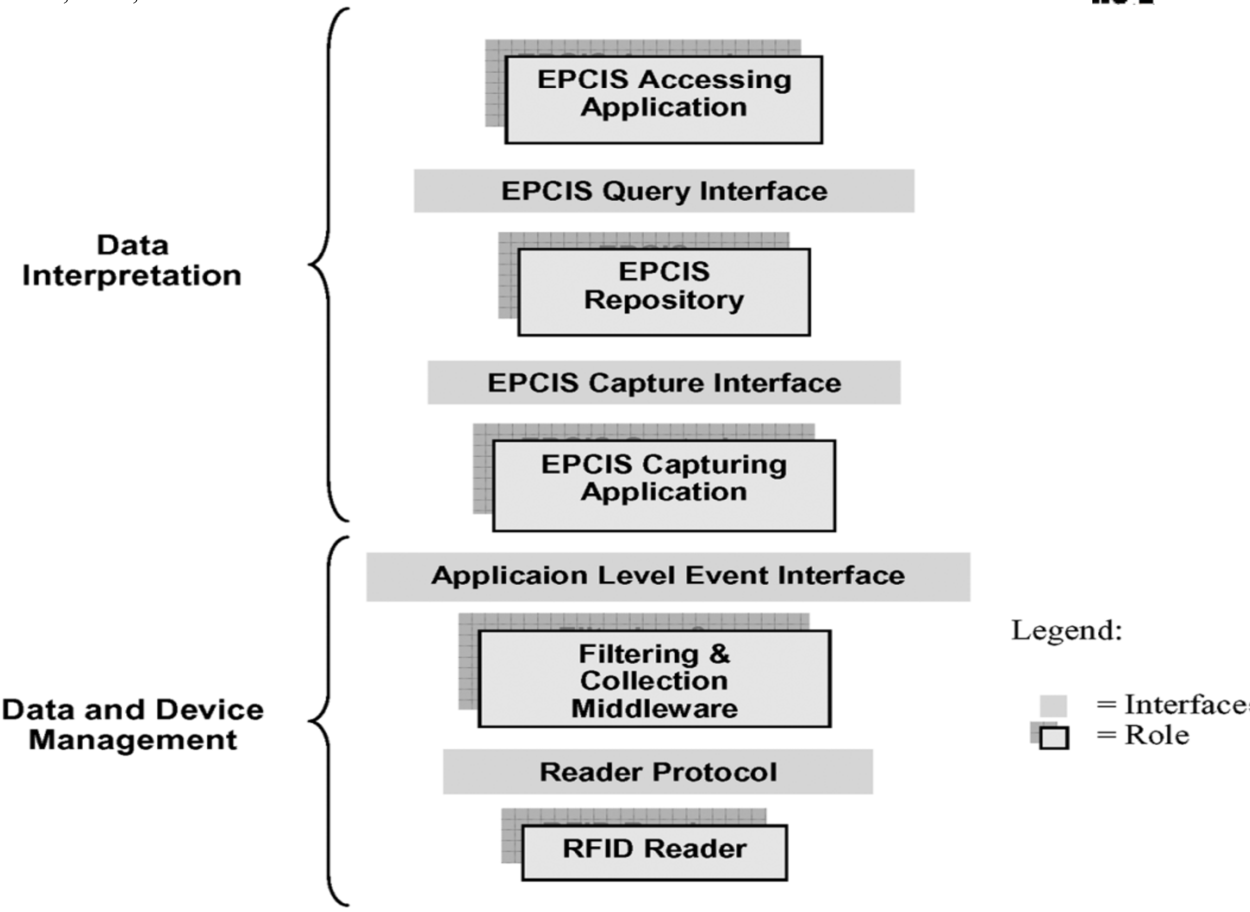

Fig. 2. EPC Network roles and interfaces

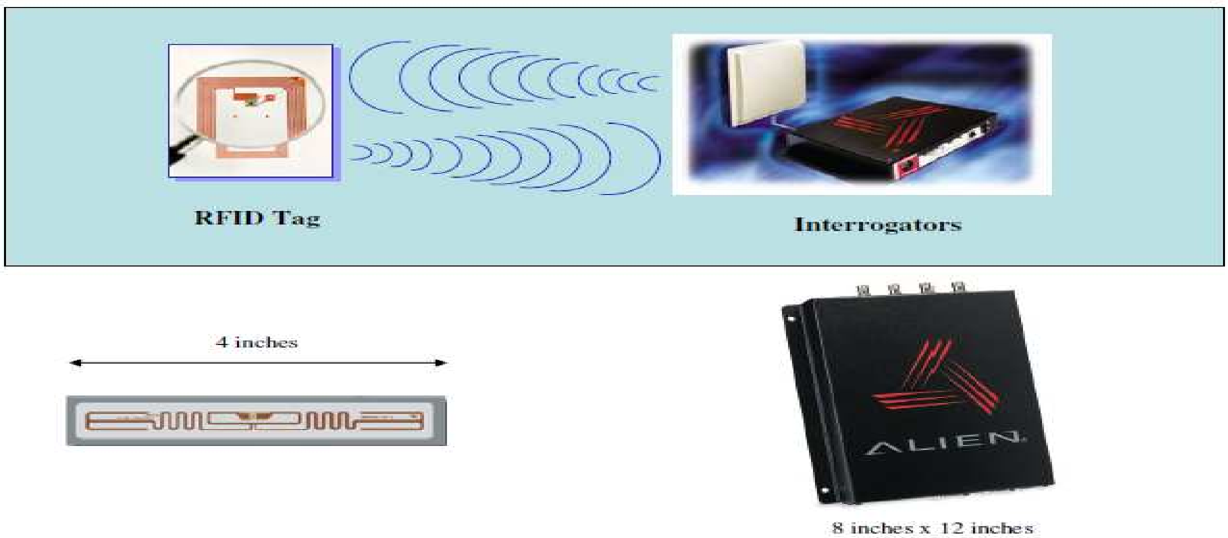

Fig.3.A simple RFID system

4. Smart RFID Networks

RFID technology leads us to the world of connected objects. It enables the inventory to speak for its presence and drives the processes as opposed to processes driving the inventory. This paradigm shift opens up new avenues and new approach to achieve process efficiency, better inventory management and improved business intelligence.

RFID Networks enable businesses to build Event Driven Applications and react to real time information. If business processes start working with the real time events the enterprises can become more efficient and lean.

To have a successful RFID implementation and reap true benefits, businesses have to

- Identify the business goals
- Build RFID networks that give them the visibility to "assets" and "inventory" and achieve business goals
- Collect and convert the RFID data into "actions" and perhaps in real time.

An RFID network generates a continuous stream of data and because of its sheer volume it needs to be handled very carefully. In the world of connected objects, the goal is to have efficient RFID Networks that give the right information to the right application at the right time (3R's) and make Enterprise Management Systems Event Driven.

- Data becomes valuable information if it is relevant to the recipient. In the application-driven RFID Network, applications define the rules for processing RFID reads. The network layer executes those rules for organizing the RFID data, and then delivers quality information to its subscribers. The most common example would be a RFID Network providing a location service. Anytime if an application wants to know the last location of an EPC, it can query the RFID network to get one. This service could help in recall management or just in time replenishment if one knows how far the inventory is reached in its supply chain.

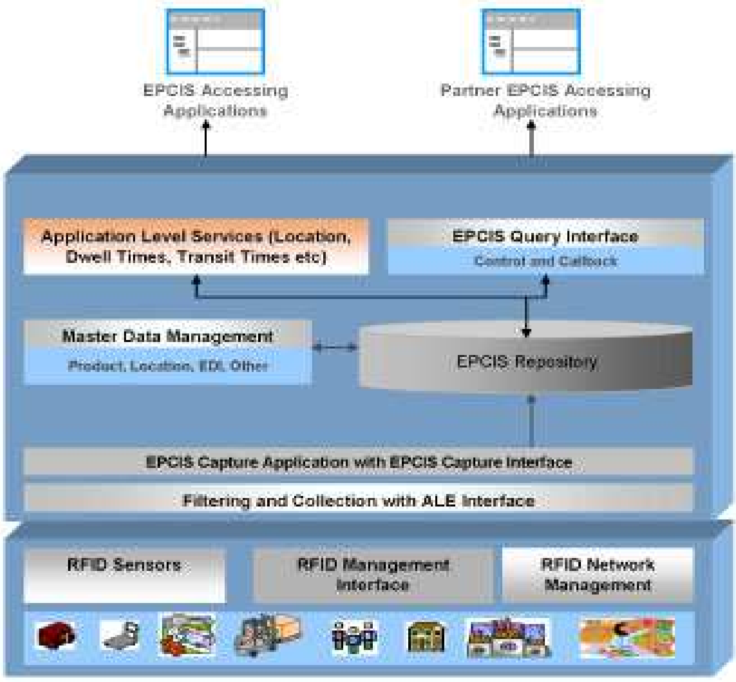

Fig.4. General Topology of RFID Network

- Similarly "Smart" RFID Network can provide other services such as dwelling times at a particular location or transit times between two locations. RFID networks can also provide complex services for instance "no product received (at a location)" or "no product stocked". This service can help in monitoring promotion execution in the retail supply chain or ensure customer satisfaction in any Supply Chain. Another example of complex service would be to push alerts out to subscribers when the inventory is aging or is already reached to the stale status.

5. Mobile RFID

5.1. Mobile RFID Technology

RFID is expected to be the base technology for the ubiquitous network or computing, and is likely to be associated with other technologies such as MEMS (Micro Electro Mechanical Systems), Telematics, and Sensors. Meanwhile, it is widely accepted that Korea is one of the countries that has established a robust mobile telecommunication networks in the world. In particular, about 78% of the population uses mobile phones and more than 95% of those phones have Internet-enabled functions. Currently, Korea has recognized the potential of RFID technology and has tried to converge it with mobile phone. Mobile phones integrated with RFID can be expected to create new markets and provide new services to end-users, and as such will be considered as an exemplary technology fusion. Furthermore, it may evolve its particular functions as an end user terminal device, or a u-device (Ubiquitous device), in the world of ubiquitous information technology. Actually, the mobile RFID phone may represent two types of mobile phone device; one is the RFID-reader-equipped mobile phone, and the other is the RFID-tag-attached mobile phone. Each type of mobile phone has different application domains: On the one hand, for example, the RFID-tag-attached type can be used as a device for payment, entry control, and identity authentication, and the main feature of this application stems from the fact that RFID readers exist in the fixed position and recognize each phone, giving the user specific services like door opening; on the other hand, the RFID reader equipped mobile phone, to which Korea is currently paying considerable attention, can be utilized to provide end-users with detailed information about the tagged object through accessing the mobile wireless network.

The basic communication scenario for mobile RFID service is as follows: First, a mobile RFID phone reads the RFID tags on an object and fetches the code stored in it . Second, a mobile RFID phone should execute the code resolution with which the mobile RFID phone obtains the location of the remote server that provides information on the product or an adequate mobile service. The code resolution protocol is identical with the DNS protocol. The ODS server in figure 5 as a DNS server and is similar to EPCglobal's ONS (Object Name Service) server. The mobile RFID phone directs queries on the location of the server with a code to the ODS server, then the ODS server replies by giving the location of the server. Finally, the mobile RFID phone requests contents or a service from the designated server whose location has been acquired from the ODS server.

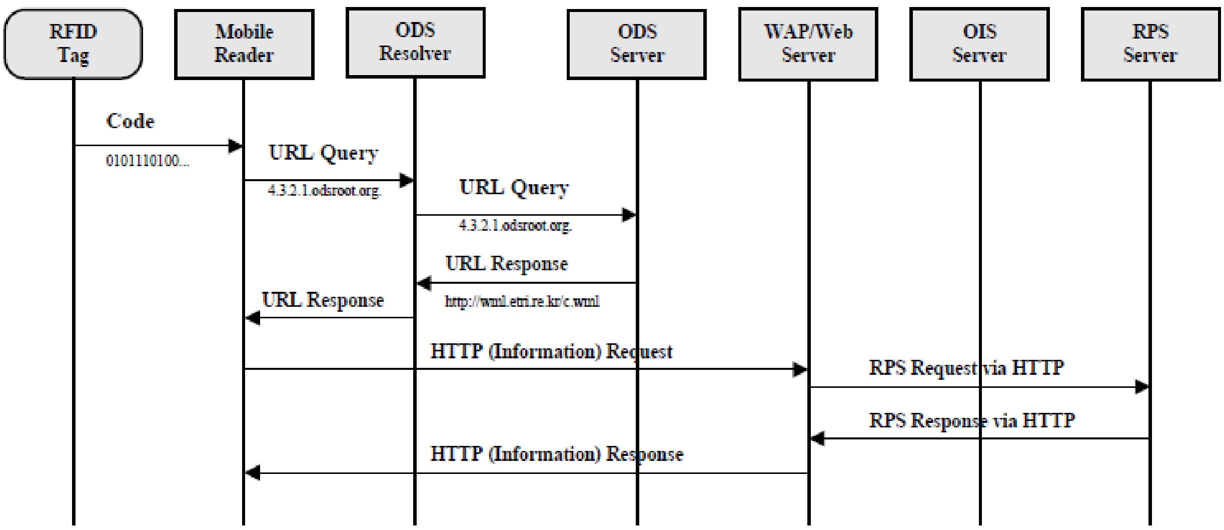

Fig. 5. Detailed Mobile RFID's Code Resolution Process.

Figure 5 illustrates the detailed code resolution process. The code store in the RFID tag is formed of a bit string such as '01001101110…' and this bit string should be translated into a meaningful form such as EPC, mCode (Mobile RFID Code), uCode, ISO Code, or something else . Given that '1.2.3.4' is obtained from a bit string translation and that '1.2.3.4' should be converted into a URN (Uniform Resource Name) form as 'urn:mcode:cb:1.2.3.4' , the remaining code resolution process is the same as the DNS reverse lookup process. The mobile RFID reader requests contents retrieval after code resolution. The RFID application in the mobile RFID phone requests contents from the WAP or web server returned by the code resolution.

5.2 Mobile RFID services

For a long time, RFID has stayed in B2B business fields such as transport and logistics, supply chain management, manufacturing and processing, and inventory control due to various problems such as still expensive RFID tag price, lack of 100% reading accuracy, limited operation conditions, etc.

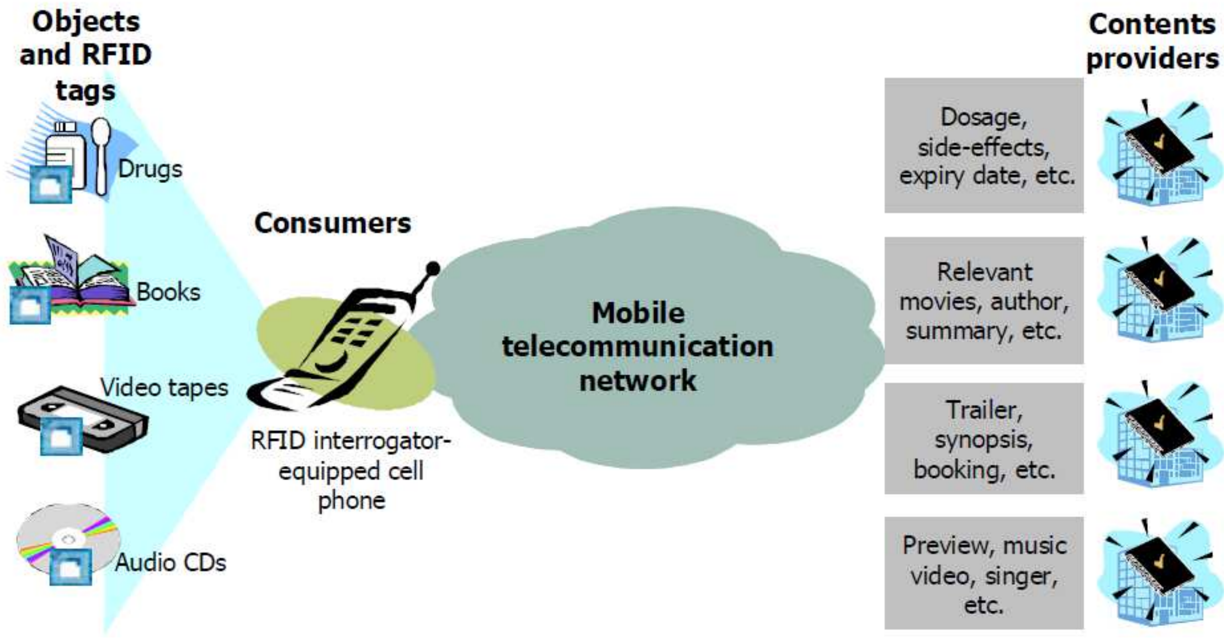

Fig.6. Use cases of mobile RFID applications and services

The model of the mobile RFID service as shown in figure 2 defines three additional entities and two relationships compared to those defined in the RFID tag, the RFID access network, RFID reader, the relationship between the RFID tag and RFID reader, and the relationship between the RFID reader and the application server.

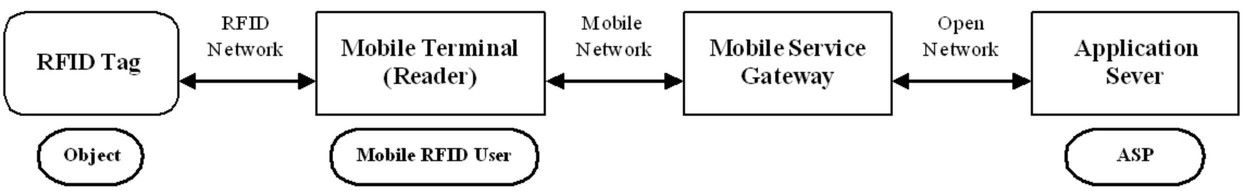

Fig. 7. Model of Mobile RFID Data Communication.

5.3 Advantages

Today we spend significant time stopping to scan bar codes. Collectively, over time, we introduce latency in the speed and efficiency with which we are able to move products through the supply chain. If you can remove bar code scanning from an operator's activities and collect the data through RFID, operators become more efficient at moving material and a wealth of efficiencies can be achieved. What this ultimately means is that if you are going to implement RFID, which represents some incremental costs in terms of product tagging, you'll need to modify your processes to optimize the benefits of RFID. This is not a new concept. We changed processes in warehousing and distribution centers when we moved from paper pick lists to real-time RF based data collection using bar code technology. We will change the way we do things again, because RFID allows us to automate data collection and get better utilization of our facilities, our labor, and achieve better velocity through our warehousing operations. And again the benefits of data collection automation are maximized by moving the tagging and implementation of RFID upstream. This moves the costs of tagging products to points upstream where greater efficiencies of tag programming and application can be realized. It also reduces costs associated with segregating tagged versus non-tagged products. Over the past several years we've done a deep investigation into the current practices within warehousing and distribution to look at how these practices would benefit from the combination of a mobile RFID solution and tagging "upstream". See below in fig.8.

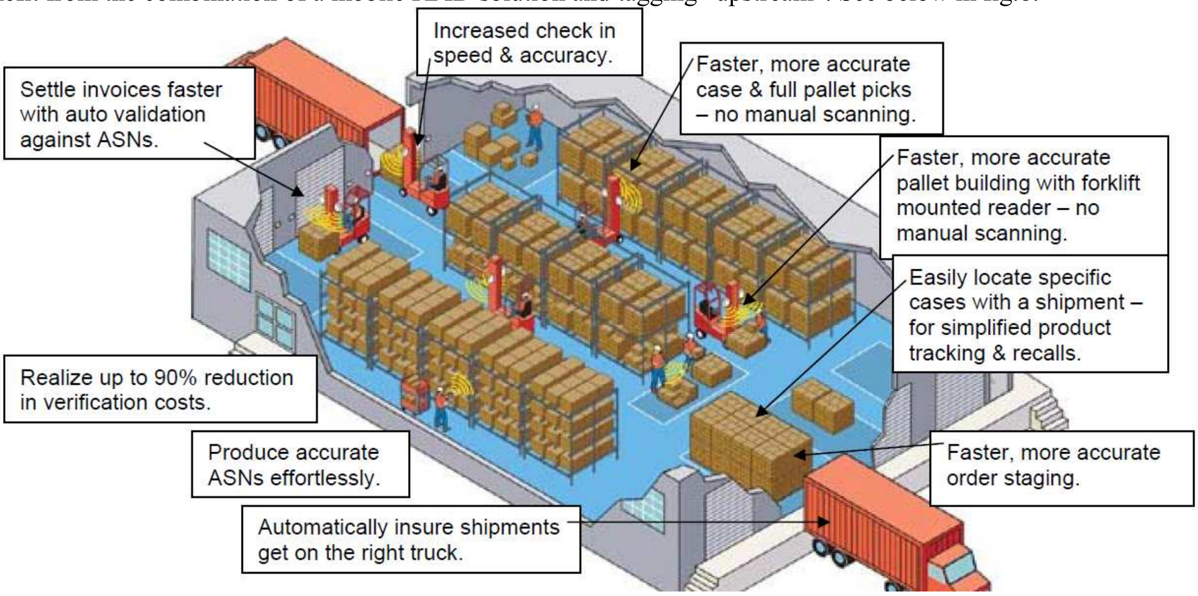

Fig.8. Combination of a mobile RFID solution and tagging "upstream".

5.4 Mobile RFID – Shipping & Receiving

If you look specifically at shipping and receiving, these are really just specialized instances of a warehouse move. You still have the same basic data content that you need to capture - "what have I got" and "where is it going/where is it coming from"? Today that is generally done by scanning a bar code on the pallet load that represents the load itself. The location is captured by scanning a bar code over the dock door as you go in or out. The earliest RFID implementations have all focused on a fixed reader placed at the dock door. You capture the "what is it" by reading the content of the pallet for as many tags as you can capture via the RFID reader as the forklift takes the load through the portal. The location element is implied by the network address of the fixed reader itself. If we look at an alternative solution based on a forklift mounted RFID reader you can still capture the same two data elements; the "what is it" by reading the pallet via the forklift mounted RFID reader and the location by use of a location tag placed in the dock door vicinity. A major advantage of the mobile solution is economical. In a typical warehouse you'd have around 100 dock doors, and those dock doors would be serviced by as few as 10 to 20 different forklifts. In the fixed RFID portal world you'd need 100 fixed RFID readers. In the mobile RFID world you'd only need 10 to 20 mobile RFID readers – a much more economical solution. Furthermore, the mobile RFID readers can be leveraged in other internal warehouse moves where it can generate further improvements in visibility, efficiency and velocity.

5.5 Mobile RFID – Case Picking

Case picking is another instance where a mobile RFID solution is beneficial. Today, the bar code for the pallet is available to the forklift operator on a spool. The operator scans the bar code for the pallet and is given his first pick location. The operator goes to it and scans a location or a pallet tag that he is picking from. That validates to the system that he is picking the right product. He is told to pick six cases and put them on the pallet. We hope he has picked six and not five. He hops in the forklift and is assigned the next location and repeats the process until done. At that point the pallet is taken to a shrink wrap machine and in many cases to an audit station where they check the correct count and SKU for that particular pallet load. At best, if the operator got the count and SKU's correct for that pallet load, you now have a redundant activity at an incremental expense. If he did not get it right, you have to break down the pallet and correct it. The cost of recovery is very high.

Tag readers interrogate tags for their data through an RF interface. To provide additional functionality, readers may contain internal storage, processing power connections to back-end databases. Computations, such as cryptographic calculations, may be carried out by the reader on behalf of a tag. The channel from reader-to-tag may be referred to as the forward channel. Similarly, the tagto- reader channel may be referred to as the backward channel. In practice, readers might be handheld devices or incorporated into a fixed location. One application of a fixed reader is a 'smart shelf'. Smart shelves could detect when items are added or removed, and would play a key role in a real-time inventory control system. Fundamentally, readers are quite simple devices and could be incorporated into mobile devices like cellular phones or PDAs. A standalone, hand-held reader with a wireless connection to a back-end database may cost around US $100-200. If RFID tags become ubiquitous in consumer items, tag reading may become a desirable feature on consumer electronics .

Fig. 9. The mobile RFID Reader.

6. Conclusions

As mentioned above, mobile RFID is an emergent and promising application that uses RFID technology. However, the mobility of reader and its service model – which differs from the RFID service in the retail and supply chain – will give rise to additional security threats. To address these issues, while both are important tools, neither killing nor recoding is the final answer in RFID privacy. The killing alone is not enough, and new mechanisms are needed for building privacy-preserving RFID architectures. In this chapter, we have tried to introduce the concept of mobile RFID and expose some of the additional security threats caused by it. The frequency band to support the air protocol is allocated from 908.5MHz to 914MHz in Korea in order to comply with ISO 18000-6 for air interface communications at 860MHz to 960MHz. We also describe a way of incorporating the new technology to work with cell phones in particular, both as an external security reading device (replacing 900MHz) and as an added security service to manage all RFID mobile device mediums. With this purpose in mind, the application areas of this service platform are also briefly presented. By doing so, customized security and privacy protection can be achieved. In this regard, the suggested technique is an effective solution for security and privacy protection in a networked mobile RFID service system.

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