Value Chain Dynamics in the RFID Technology

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Submitted to the MIT Sloan School of Management in partial

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Abstract:

RFID (Radio Frequency Identification) technology has been one of the oldest renewed technologies with a promise of becoming a foundation of "The Internet of Things" in future. MIT's Auto-ID labs and EPCGlobal have been instrumental in advocating standards, making mass scale adoption a reality. The early adopters were found to be in the retail supply chain industry followed by many interesting applications in areas ranging from Fish Tracking to authentication of currency notes. Projects implemented till 2006 were mainly pilot in nature with a desire to understand the technology, given its limitations and challenges and conclude with value propositions or return on investment analysis for corporations.

This work has attempted to study such phenomenon in greater detail, bring together the dimensions of technology and business as related to the current state of RFID. We found a very different set of value dynamics applicable to each individual component in the RFID business landscape. Analysis on presented in more detail for manufacturers (Suppliers) of goods as well as Sellers (Retailers) of goods. Further work may be in the form of analyzing the remaining components like logistics players and end customers in a similar fashion.

Case studies and interview were done to collect data. Secondary sources of information in the forms of published reports and articles are also used and referenced. Management science techniques like Systems Dynamics are used to model some of the value parameters for each component in the retail supply chain.

In conclusion, we think although each component of the studied landscape has shown value enhancement and erosion (primarily to cost factors), the overall system shows net gains. As all other technologies, RFID will become cheaper with increased adoption and has a very high probability to be prevalent and ubiquitous in near future.

Acknowledgement

This Thesis work was possible due to the help of many advisors, faculty, colleagues, friends and associates. I would like to sincerely acknowledge Professor Charles Fine for allowing me to explore the realm of RFID during my stay at MIT. His timely advice, patient guidance and the valuable contacts were a critical component of the whole process.

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Program office at the MIT Sloan Fellows program in encouraging me to take this opportunity, choose a topic of my interest and develop that deep bond with faculty and the institute via writing this Thesis.

MIT Libraries, Harvard Business School Libraries , IDTechEx, Gartner Research, Frost and Sullivan, RFID Journal, for allowing access to their infrastructure and published materials in their respective areas.

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And finally, my family for being very supportive over the past 2 most rigorous, interesting, challenging years of my life.

Milind Tavshikar
Boston, MA
May 2006.

Background

RFID technology uses wireless communication in radio frequency bands to transmit data from tags to readers. A tag can be attached to or embedded in an object to be identified, such as a product, case, or pallet. A reader scans the tag for data and sends the information to a database, which stores the data contained on the tag. For example, tags can be placed on car windshields so that toll systems can quickly identify and collect toll payments on roadways. Interest in RFID technology began during World War II and has increased in the past few years. During the war, radio waves were used to determine whether approaching planes belonged to allies or enemies. Since then, exploration in radio technology research and development in commercial activities continued through the 1960s and evolved into marked advancements in the 1970s by companies, academic institutions, and the U.S. government.[1]

MIT Auto-ID Labs

The MIT Auto-ID Laboratory is dedicated to creating the Internet of Things using RFID and Wireless Sensor Networks. The Labs aim from the start was to create a global system for tracking goods using a single numbering system called the Electronic Product Code. The MIT AutoID Lab is now one of a federation of six Auto-ID Laboratories around the world partnered with EPCGlobal Inc. the standards organization responsible for developing the products, systems and standards necessary to drive this vision. The Auto-ID Laboratories have evolved from the Auto-ID Center, initially founded in 1999 to develop an open standard architecture for creating a seamless global network of physical objects. Funded in part by EPCglobal, government and industry, Auto-ID Laboratories are based around the world at: MIT, University of Cambridge, University of Adelaide, Keio University, Fudan University and University of St. Gallen. Each with distinct interests and capabilities, but linked by the common vision of an "Internet of Things," The Lab continues to research and develop new technologies and applications for revolutionizing global commerce and providing previously unrealizable consumer benefits.[2] All of the technical experimentation required for this thesis was performed at the MIT Auto-ID labs.

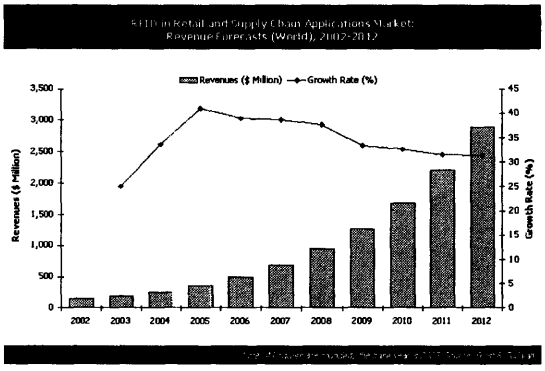
[1] GAO Report on RFID May 2005
[2] MIT Auto-ID labs on iesl.mit.edu

Review of the RFID Value Chain

The RFID Market

The world radio frequency identification (RFID) market in retail and supply chain applications generated revenues of $357.8 million during 2005. Frost & Sullivan expects the market to generate revenues of $2893.8 million in 2012. The world RFID market for retail and supply chain applications is expected to grow at a compound annual growth rate (CAGR) of 25.8 percent over the period of 2005 to 2012.

Chart below presents the revenue forecasts for World RFID market in retail and supply chain applications for the period 2002 to 2012.[3]



The market is expected to be driven by the North American region in the short term until the end of 2007. The RFID requirement of large retailers within this region is likely to encompass a large number of suppliers who would have to comply with the existing mandates. Europe is expected to witness a steady increase in market revenues and is expected to account for significant percent of the total market revenues after the North American region. The expected roll - outs of large retailers in West Europe along with increasing retail expansion efforts in East European countries is likely to have a significant impact for the RFID market in the region. Asia Pacific and the Rest-of-World regions are expected to represent the highest growth rates for the market in future on account of the presence of a large supplier base within these regions. The Asia Pacific and Rest-of-World segment is expected to grow at a compound annual growth rate (CAGR) of 36.0 percent.

Radio frequency identification (RFID) market has in general witnessed higher interest levels as compared to similar technologies such as bar - codes and wireless networks. While the heightened interest and awareness has driven a large section of the market towards trial, it has also resulted in unrealistic expectations that are hindering final deployment efforts. The initial hype surrounding the technology is on the decrease since 2005 with industry participants adopting a more realistic

[3] Frost and Sullivan Market Analysis of RFID world markets

perspective on the potential benefits of RFID. There is an increased focus on integrating RFID technology to work with existing business process and applications.

RFID in Supply Chain Logistics

Radio Frequency Identification (RFID) is a powerful form of auto-identification technology that can be used to uniquely identify, locate, track and analyze inventory within the traditional supply chain by using electronic tags and wireless interrogation capabilities. The tag is typically a transponder that can store pertinent digital information, which can then be read by an interrogator or reader when positioned within the read field of that device. There are many types of tags and readers with a multiplicity of different features and capabilities, affording a variety of possibilities for deployment. Suffice it to say that the most appropriate tag and reader combination for a particular product category, packaging and environmental scenario is highly variable, and involves a fairly deep understanding of physics to fully appreciate.

When effectively applied to supply chain processes, RFID can provide near real-time visibility that can be leveraged to deliver a number of important benefits, including reduced out of stocks, reduced safety stock levels, increased inventory turns, increased labor efficiencies and productivity, lower theft and shrinkage, as well as many other benefits.

The RFID-enabled supply chain refers to a collaborative scenario in which product is uniquely tagged at the point of manufacture and then automatically tracked as it moves through the supply chain, from the supplier to the manufacturer, transportation provider, distributor, retailer and customer. Tagging can occur at the item level or the trade unit level (pallet, case, tote, container, etc.). Item level tagging provides much more granular information, but the degree of difficulty for industry-wide adoption is significantly high that this is viewed as something that may take some number of years to be broadly implemented. Item level tagging, however, is being actively pursued by many organizations and industries today, as a near-term solution to many of the problems that plague supply chain operations and processes.

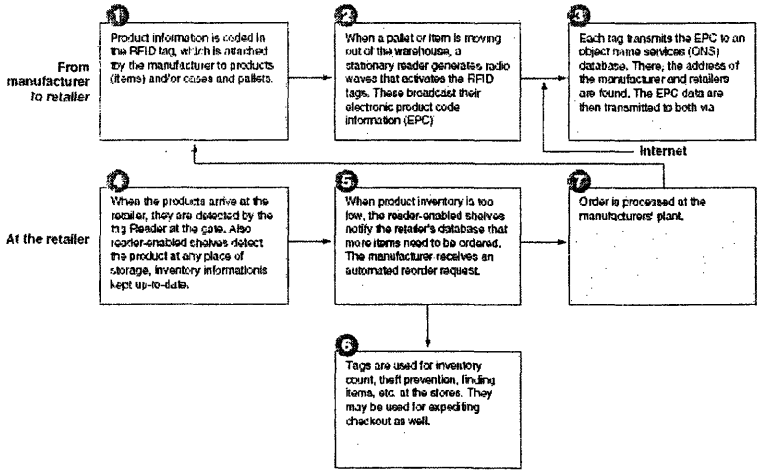
The traditional supply chain includes many different participants, some of which can be identified in the following illustration. It is important to note that the manufacturer is located "upstream," and the retailer or customer is located "downstream" in the supply chain, so that any such directional reference can be readily translated to the relevant participants. Since there may also be several forms of transportation (plane, train, truck, ship, etc.) involved in the movement of materials and product

from producer to consumer, the traditional supply chain can quickly become challenging from a planning view. This typically leads to a bloated, inefficient and sub-optimal situation overall.

RFID can provide near real-time visibility into the movement of materials, WIP, and finished product across the supply chain, in order to optimize performance for the supply chain as a whole. It is important that the introduction of RFID as an enabling technology not be viewed as a zero-sum initiative for the various participants, and that return is garnered by all participants in order to maximize the collaboration and total overall return [4]

Our study of various cases described later in the paper shows that problems along the supply chain can occur between business units within a single enterprise; they also can occur between (and among) enterprises. A major symptom of ineffective supply chains is poor customer service, which hinders people or businesses from getting products or services when and where needed or gives them poor-quality products. Other symptoms are high inventory costs, loss of revenues, extra cost of expediting shipments, and more. Let's look at an example of how an RFID enabled supply chain might conceptually look like:

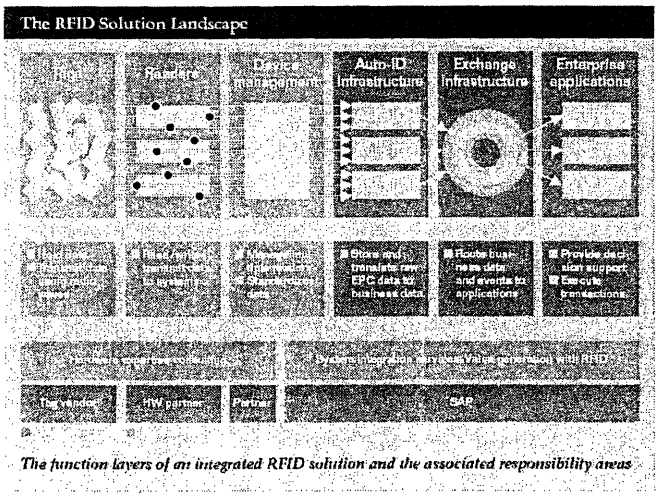
In general the RFID process in supply chain management can be represented by the following flowchart:



[4] Noblestar – RFID Introduction

RFID as a enabling technology[5]

Tags and Readers – enable capturing of data on the edge of the network



The function layers of an integrated RFID solution and the associated responsibility areas

An RFID system consists of tags and readers. RFID tags are small devices containing a chip and an antenna that store the information for object identification. Tags can be applied to containers, pallets, cases, or individual items. With no line-of-sight requirement, the tag transmits information to the reader, and the reader converts the incoming radio waves into a form that can be read by a computer system. An RFID tag can be active (with a battery) or passive (powered by the signal strength emitted by the reader).

Active Tags

- Can be read from a long-range distance of more than 100 feet.
- Are ideal for tracking high-value items over long ranges, such as tracking shipping containers in transit.
- Have high power and battery requirements, so they are heavier and can be costly.

Passive Tags

- Can only be read from a short-range distance of approximately 5–10 feet.
- Can be applied in high quantities to individual items and reused.
- Are smaller, lighter, and less expensive (and therefore more prevalent) than active tags.

Middleware to massage / route data appropriately[6]

Many early RFID middleware solutions focus on features like reader integration and coordination, EPC track-and-trace tools, and baseline filtering capabilities. But these are just a subset of the many features that complete RFID middleware platforms must provide. To stand the test of time, RFID

[5] SAP Info RFID Supplement
[6] Forester Report on RFID Middleware

middleware must include a balanced combination of seven core capabilities. These capabilities — starting from connectivity and moving up the stack — include:

Reader and device management. RFID middleware should allow users to configure, monitor, deploy, and issue commands directly to readers through a common interface. For example, users should be able to tell a reader when to "turn off " if needed. In some instances, middleware vendors offer plug-and-play-like capabilities that let users dynamically sense a reader's presence and link to it without having to write any code. Integration with other auto-ID or X-Internet technologies, like sensors and biometrics, is also important.

Data management. Once RFID middleware captures EPC data from readers, it must be able to intelligently filter and route it to the appropriate destinations. This capability should include both low-level logic like filtering out duplicate reads and more complex algorithms like content-based routing. Comprehensive solutions will also offer tools for aggregating and managing EPC data in either a federated or central data source.

Application integration. RFID middleware solutions should provide the messaging, routing, and connectivity features required to reliably integrate RFID data into existing SCM, ERP, WMS, or CRM systems — ideally through a services-oriented architecture. It should also provide a library of adapters to popular Warehouse Management Systems and Supply Chain Management applications like SAP or Manhattan Associates, as well as APIs and adapters for using standard technologies like JMS, XML, and SOAP to integrate with other third-party apps.

Partner integration. Some of the most promising benefits of RFID will come from sharing RFID data with partners to improve collaborative processes like demand forecasting and vendor-managed inventory. This means that RFID middleware must provide B2B integration features like partner profile management, support for B2B transport protocols, and integration with the EPCglobal Network, much of which is operated by VeriSign.

Process management and application development. Instead of just routing RFID data to business applications, sophisticated RFID middleware platforms will actually orchestrate RFID-related end-to-end processes that touch multiple applications and/or enterprises, like inventory replenishment. Key process management and composite RFID Adoption Pattern application development features include workflow, role management, process automation, and UI development tools.

Packaged RFID content. RFID middleware platforms that include packaged routing logic, product data schemas, and integration with typical RFID-related applications and processes like shipping, receiving, and asset tracking are major assets. Why? No one wants to start from a blank sheet of paper, and this content gives firms a headstart on their RFID projects.

Architecture scalability and administration. There's no question that RFID adoption is going to produce a lot of data, and RFID middleware is the first line of defense for reliably processing that data. This means that RFID middleware platforms must include features for dynamically balancing processing loads across multiple servers and automatically rerouting data upon server failure. These features should span all tiers of the architecture — even the edge devices.

Two types of RFID Middleware are generally in use:

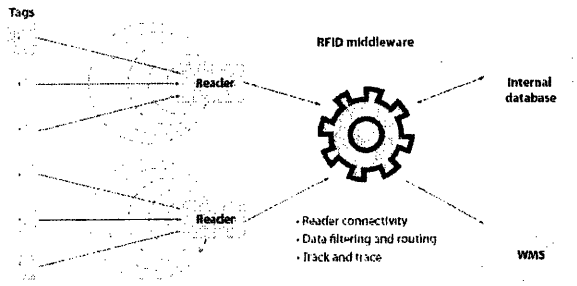


Fig: Single tier middleware:

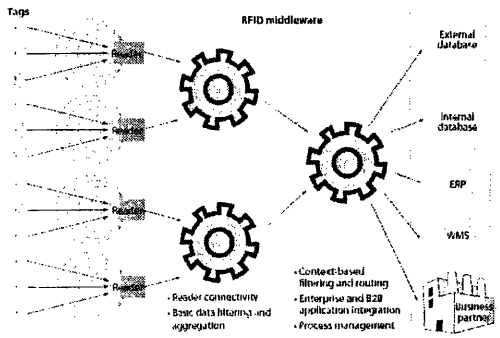


Fig: Multitier RFID Middleware:

Databases to support collection and aggregation of RFID streams

While it is difficult to predict exactly the total amount of data generated by RFID in a given year, it is clear that there will be an exponential rise in the volume of data created. RFID systems allow minutiae of data to be generated from the simple act of passing a tagged product, case or pallet of goods through a reader's range. Data such as the exact time the good entered the reader's range may be important for time-critical goods but for many applications, this type of data, although generated may not be useful and may be discarded. However, a substantial amount of it will need to find its way to the back office, while some of the data will need to find its way onto devices in the field. In our calculations of possible RFID traffic we have assumed that a proportion of the data created by an RFID system will be discarded because it is of little commercial value and that transporting it to the back office would be more costly than its worth to the organization.

RFID tags will inevitably create a lot more data than current solutions for item tracking such as bar coding because they not only enable an item, case of items or pallet of cases to be tracked but also allow that data to be altered as it goes through the supply chain. Thus an RFID tag can tell a reader station that the goods have reached a specific point in the supply chain, and the information on the tag can be changed to state the time when the goods reached that point and the length of time they were in transit from that point until the next in the supply chain. In this way RFID allows more accurate information to account for damaged/lost items, for example, from shrinkage or re-routing of the products to another destination. Combine with this all of the advantages RFID systems have over 'line of sight' systems such as barcoding means that there can be any number of points along the supply chain where tags can be read and altered without adding to overall shipment times. Whilst this makes real-time inventory tracking a reality, it has the potential to vastly increase the amount of data generated as an item goes through the supply chain.

If we take into consideration the millions of goods shipped by a retailer the size of Wal-Mart between its stores and distribution centers, it is clear that a vast amount of data will be generated. However, that this amount of data will be problematic even for an IT-savvy end user as Wal-Mart and some level of filtering will need to take place before the information is sent to the back office. Thus the real challenge is to limit the amount of mission-critical data that gets moved from the field to the back office. In this case, the vast majority of the 7 terabytes of data collected by Wal-Mart every day will serve it no purpose and will be discarded. Indeed there are a number of prominent middleware vendors that have identified this issue and are structuring their sales strategies around being able to filter RFID-generated data. However, that data will still need to reach the middleware database before it can be interrogated and filtered. It is clear then that some basic filtering needs to happen at the RFID reader level in order to avoid clogging data networks.

Backend ERP systems to perform business processes at the core of the network

ERP vendors like SAP and Oracle have developed interfaces and procedures to sense and collect RFID data at the edge of the network and process the same for decisions at the core of the network. For example in the case of SAP[7]:

Based on the SAP NetWeaver™ platform, SAP RFID technology can easily be integrated into a customers existing IT landscape, enabling use RFID data with both SAP and non-SAP enterprise

[7] As described in SAP published marketing material on RFID

applications. SAP Auto-ID Infrastructure enables handling of massive amounts of auto-ID data through:

- Connectivity with readers, tags, and other devices
- RFID data aggregation, filtering, and management
- Encoding and rewriting of RFID tags
- Integration of high-volume RFID data with back-end business processes

SAP RFID technology supports:

- Goods issue and receipt via automatic shipping/receiving processing based on bar-code and RFID reads
- Automatic advanced shipping notice (ASN) generation with associated EPC information
- Writing and encoding of tag identifications according to the EPC standard
- Handling of packing and loading of units, cases and pallets via RFID
- Handling of unit-level tracking and tracing, enabling you to see inventory at the item level and communicate the status of assets with trading partners
- Exception tracking, using alerts to flag situations such as out-of-stock or incorrect shipment quantities
- Pallet- and case-level tagging as well as item-level tagging
- Analysis of key supply chain and inventory metrics

Choice of Radio Frequency in RFID:

Choice of radio frequency is a key operating characteristic of RFID systems. The frequency largely determines the speed of communication and the distance from which the tag can be read. Generally, higher frequencies indicate a longer read range. Certain applications are more suitable for one type of frequency than other types, because radio waves behave differently at each of the frequencies. For instance, low-frequency waves can penetrate walls better than higher frequencies, but higher frequencies have faster data rates. In the United States, the Federal Communications Commission (FCC) administers the allocation of frequency bands for commercial use and the National Telecommunications and Information Administration (NTIA) manages the federal spectrum. RFID systems use an unlicensed frequency range, classified as industrial, scientific-medical or short-range devices, which is authorized by the FCC. Devices operating in this unlicensed bandwidth may not cause harmful interference and must accept any interference received. The FCC also regulates the specific power limit associated with each frequency. The combination of frequency and allowable power levels determine the functional range of a particular application, such as the power output of readers. There are four main frequencies used for RFID systems: low, high, ultrahigh, and microwave.

Low-frequency bands range from 125 kilohertz (KHz) to 134 KHz. This band is most suitable for short-range use such as antitheft systems, animal identification, and automobile key-and-lock systems. High-frequency bands operate at 13.56 megahertz (MHz). High frequency allows for greater accuracy within a 3-foot range, and thus, reduces the risk of incorrectly reading a tag. Consequently, it is more suitable for item-level reading. Passive 13.56 MHz tags can be read at a rate of 10 to 100 tags per second and at a range of 3 feet or less. High-frequency RFID tags are used for material tracking in libraries and bookstores, pallet tracking, building access control, airline baggage tracking, and apparel item tracking.

Ultrahigh-frequency tags operate around 900 MHz and can be read at longer distances than high-frequency tags, ranging from 3 to 15 feet. These tags, however, are more sensitive to environmental factors than tags that operate in other frequencies. The 900 MHz band is emerging as the preferred band for supply-chain applications due to its read rate and range. Passive ultrahigh-frequency tags can be read at about 100 to 1,000 tags per second, with efforts under way to increase this read rate. These tags are commonly used in pallet and container tracking, truck and trailer tracking in shipping yards, and have been adopted by major retailers and DOD.

Additionally, in the United States, the 433 MHz band is used to identify the contents of shipping containers in commercial and industrial areas to allow timelier and more accurate data transmission. According to the FCC, such use could benefit commercial shippers and have significant homeland security benefits by enabling the entire contents of shipping containers to be easily and immediately identified, and by allowing a determination of whether the contents were tampered with during shipping.

Tags operating in the microwave frequencies, typically 2.45 and 5.8 gigahertz (GHz), experience more reflected radio waves from nearby objects, which can impede the reader's ability to communicate with the tag. Microwave RFID tags are typically used for supply chain management.

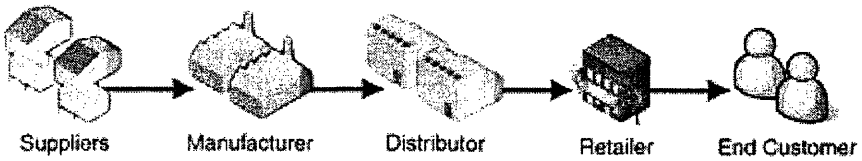
Table below provides a summary of the operating frequencies for passive tags[8].

Frequency	*Read Range and Rate*	*Typical Applications*
Low frequency: 125KHz	~1.5 feet; low reading speed	Access control, animal tracking, point of sale applications
High frequency: 13.5MHz	~3 feet; medium reading speed	Access control, smart cards, item-level tracking
Ultrahigh Frequency: 860 – 930MHz	up to 15 feet; high reading speed	Pallet tracking, supply chain management
Microwave Frequency: 2.45/5.8 GHz	~3 feet; high reading speed	Supply chain management

[8] Table adopted from AIM – The global trade association for automatic identification

Research Question or Problem Statement

What are the Value chain dynamics in RFID for supply chain industry?



Objective:

- Understand the RFID technology in general
- Analyze the Value Chain Dynamics (RFID) in the Retail Supply Chain
- Make observations on Needs, Solution Scenarios, Challenges and ROI for each component
- Attempt to model the above using System Dynamics Modeling

In a pursuit to find an answer to the problem posed above, we will research the supply chain from the manufacturer to the Customer with respect to RFID technology and analyze the benefits/costs for each major component of the supply chain. In particular we would like to analyze sample cases from the Pharmaceutical, Department of Defense and Retail industries. Advantages and Disadvantages of implementing RFID throughout the supply chain versus the practicality of doing the same will be studied. It is believed that every component in the supply chain has its own set of challenges in implementing RFID. We will attempt to research such challenges and comment on a strategy of overcoming the same.

The research will also analyze the standards being proposed by EPC Global and compare / contrast them with the standards emerging globally. Competing standards could potentially cause a disruption in the EPC prescribed method of RFID implementation and I would like to make observations and analyze such a disruption if any.

Most of the data collection will be done via analyzing secondary information as well as via questionnaires, interviews and case studies of the players in the RFID value chain. I would also like to use the data collected from the research to understand the past and current trends in RFID technologies and provide insights or predictions for the direction this technology may take in near future. As an extension of this research, we may also make an attempt to define a business model in which RFID will provide maximum benefits to users of the technology.

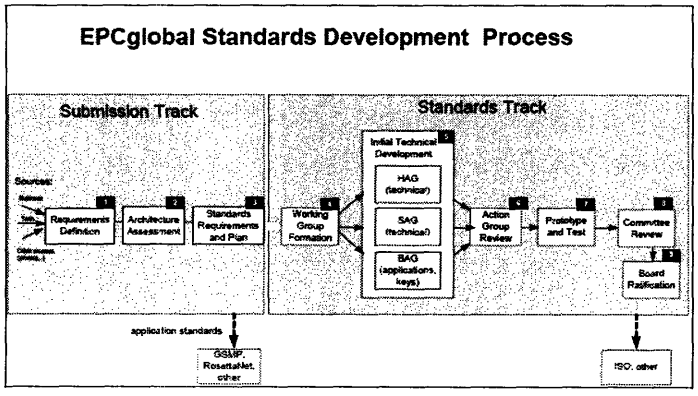
EPCGlobal Perspective[9]

EPCglobal is leading the development of industry-driven standards for the Electronic Product Code™ (EPC) to support the use of Radio Frequency Identification (RFID) in today's fast-moving, information rich, trading networks. EPCGlobal is a subscriber-driven organization comprised of industry leaders and organizations focused on creating global standards for the EPCglobal Network™. EPC's goal is increased visibility and efficiency throughout the supply chain and higher quality information flow between companies and their key trading partners.

EPCglobal is a joint venture between EAN International and the Uniform Code Council (UCC). EPCGlobal is a not-for-profit organization entrusted by industry to establish and support the Electronic Product Code (EPC) Network as the global standard for immediate, automatic, and accurate identification of any item in the supply chain of any company, in any industry, anywhere in the world. EPCGlobal's objective is to drive global adoption of the EPCglobal Network. The EPCglobal Network was developed by the Auto-ID Center, an academic research project headquartered at the Massachusetts Institute of Technology (M.I.T.) with labs at five leading research universities around the globe.

EPCGlobal Standards Development Process:

The EPCglobal Standards Development Process is a user driven standards process for the development of technical standards. Although many elements will be very familiar, this standards organization and process is a necessary hybrid and will not look exactly like any other standards organization. The EPCglobal Standards Development Process is an evolving process and continues to be updated as user needs warrant. The latest version (March 8, 2006) of the process is as below, details about which can be found on the EPCGlobal website.



Standards and specifications provide the common definitions, functionality and language for the hardware and software components of the EPCglobal Network. They help advance the EPCglobal

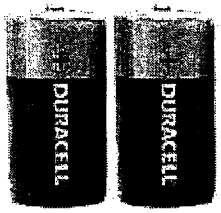
[9] Source: epcglobal.org website and related material published by EPCGlobal

community toward a common objective, namely, implementing the EPCglobal Network™ to improve visibility and efficiency in today's global, multi-industry supply chain. EPCglobal specifications result from much of the work that was begun under the auspices of the Auto-ID Center at MIT and form the foundation for the EPC/RFID technology that the EPCglobal community has begun implementing worldwide.

Data Analysis and Literature Review

Supply Chain Case Studies[10] (Suppliers / Manufacturers)

Company: Duracell:



Application: Retail, Consumer Goods

Level of RFID usage: Pallet Level

Benefits sought: Cost Reduction, Meeting Mandates

Project Status: Initial Pilot completed, ROI analysis in progress

Tags: UHF Gen2 tags

System: Unknown

Duracell is the world's leading manufacturer and marketer of high-performance alkaline batteries. Duracell also markets primary lithium, silver oxide and zinc air batteries. The company operates 10 battery-manufacturing facilities worldwide. With headquarters in Bethel, Connecticut, USA. Duracell sells its batteries throughout the world, primarily under the DURACELL® trademark. In 2000, Duracell net sales were $2.577 billion, and DURACELL batteries were the most popular brand of alkaline batteries in the world. This company is in the top 200 Wal-Mart suppliers. The top 100 have to tag pallets and cases by end 2004 and the rest by end 2005.

A minority of the cases will contain single items and be put on display in the supermarkets ie item level tagging. Wooden pallets last 1-2 years, plastic pallets last 5-10 years and in both cases the tags will be intended to survive for the life of the pallet. Most cases are disposable however. This company is probably also mandated by Albertsons, Target, Carrefour, Metro, Tesco and the US Military or some of these.

Company: Beaver Street Fisheries

Application: Animal and Farming, Retail

Level of RFID usage: Pallet and Case Level

[10] Source: IDTechEx

Benefits sought: Cost Reduction, Meeting mandates

Project Status: Initial Pilot completed in 2003, Payback in 2 years.

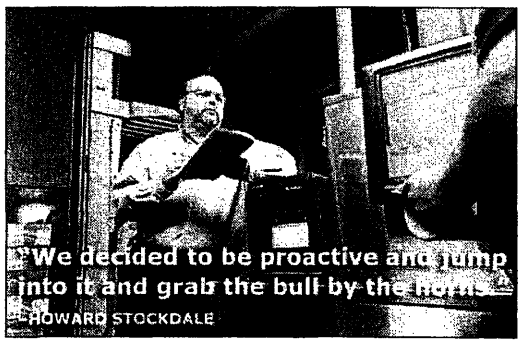
Tags: Passive UHF Gen1 tags

System: The Danby Group (inhouse development team)

Beaver Street Fisheries, one of the largest distributors of frozen seafood and meat in USA, was implementing an RFID compliance solution. The project was carried out by GlobeRanger and Franwell, an established RFID systems developer, have teamed with The Danby Group, a supply chain systems integrator. Beaver Street Fisheries planned to utilize RFID technologies to track cases and pallets of frozen fish at the company's seafood processing and packing plants for improved inventory management.

The first implementation phase includes setting up compliance stations where RFID labels are encoded with a Zebra R110 smart label printer/encoder and applied to cases of tilapia, crab, lobster and other frozen fish products and then validated through a RFID portal. Beaver Street Fisheries' long-term RFID vision is to involve its network of suppliers to apply RFID labels at the source and leverage information on the RFID tags to meet legal data requirements such as method of catch, catch weight, country of origin and date codes.

"We're on a quest to grow our business and we believe success lies in efficiency," said Howard Stockdale, chief information officer at the company which is based in Jacksonville Florida. "We believe RFID offers an opportunity to fine tune our processes and we've made a decision to aggressively pursue this technology. Participating in Wal-Mart's initiative is part of this strategy."



Beaver Street Fisheries first investigated RFID in late 2003, put together an RFID team, built a small laboratory then executed a three stage plan to introduce RFID at pallet and case level.

There have been challenges, not least because Beaver Street imports from over 50 countries says Stockdale, but embracing the technology led to a re-engineering process that will make the company more competitive. A very common benefit of RFID is that it leads companies to alter the way they do business. He says they are looking at the future and making appropriate investments. "We're going to become an even bigger player in the market and RFID is going to help us achieve that. That's part of our ROI that we know is coming."

Beaver Street began shipping RFID tagged cases and pallets to Wal-Mart in the week of November 1 2004. Labels were applied in an on-line conveyor system in successful completion of Phase 2 of the three phase program.

Company: Bradshaw International

Application: Retail, Consumer Goods
Level of RFID usage: Pallet and Case Level
Benefits sought: Meeting Mandates
Project Status: Trial Completed
Tags: UHF Gen2 tags
System: SAMSys, MobileXe

Bradshaw is the market leader in kitchen accessories sold through the grocery, drugstore and mass merchandise channels with its Good Cook brand. It is among the 137 suppliers involved in the rollout phase of Wal-Mart's RFID project.
Kitchenware supplier Bradshaw International had deployed an enhanced warehouse location tracking system, in purpose to comply with Wal-Mart's RFID mandates. The system was implemented in Bradshaw's 100,000-square-meter distribution center in Rancho Cucamonga, CA, USA.

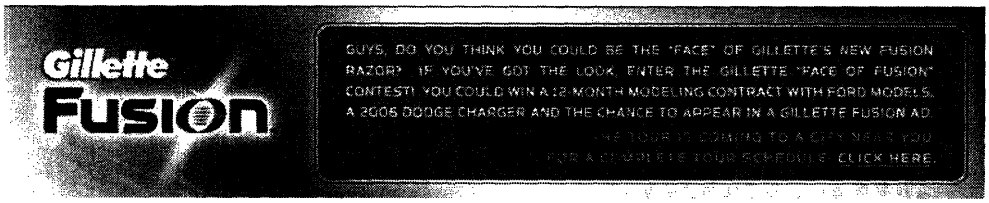
The RFID system is designed and implemented by MobileXe, a supply chain consultant and system integrator. The system utilised SAMSys' MP9320 UHF Long-Range Reader to perform verification functions ensuring the readability of RFID tags applied to Bradshaw pallets and cases destined for Wal-Mart's pilot RFID distribution centers in Texas. According to SAMSys, their hardware features a proprietary open architecture that provides a wide choice of tags as well as the ability to change tag protocols now or in the future without the need to change readers.

The RFID system incorporates EPC tags in a standard "pick to label" process. This approach enables Bradshaw to eliminate the cost of a standalone "slap and ship" or middleware solution. EPC labels are printed and applied only to EPC-flagged items, then given to an order puller or checker. Once a pallet is full or the order is complete, the EPC items are delivered to a special verification conveyor where the SAMSys reader is installed. A photo eye triggers the reader and determines a good or bad read. A bad read stops the conveyor, triggers a light tree, and requires a manual push-button reset. This pilot

system, or a similar one, is expected to expand to other areas of the Bradshaw facility as RFID adoption spreads, potentially creating a need for RFID equipments at the many doors in the company's warehouse.

The SAMSys MP9320 UHF Long-Range Reader deployed at Bradshaw supports all EPC tag protocols including EPC Class 0, Q+, Class 1. 1SO18000-6A, 68, 68 "fast", Philips U-code 1.19, 1.19 fast", Intermec Intellitag, and EM Marin 4022, 4222, 4223, and is upgradeable to EPC Class Gen 2. It also offers multi-regional support via configurability for North America FCC (902-928 MHz) and European ETSI (865-669 MHz) regulatory environments.

Company: P&G / Gillette, USA



Application: Retail, Consumer Goods, Razors

Level of RFID usage: Item Level

Benefits sought: Anti Counterfeiting

Project Status: Trials Completed. Implemented with Fusion Product Line in 2006.

Tags: UHF Gen2 tags

System: Alien Technologies, OAT systems, SAP, Sun Microsystems

In November 2002 Gillette announced it was buying 500 million RFID smart labels, a number comparable to all the smart labels sold in the world to date at that time. Its intended use for these tags seemed to span both pallet and case tagging and item level tagging in the sense of razor packs etc not the razors themselves. However, by the end of 2004 only a few million had been delivered and other, much later entrants had taken much larger deliveries. Part of the reason seems to be the need for Gillette and its customers - the retailers - to install infrastructure to read the tags. All along Alien Technology, the tag supplier, has denied that it has any output constraints.

Prices

Prices have never been confirmed publicly, but at about ten cents per tag the cost to Gillette will be $50 million for tags alone, with services, readers, software and so on probably being as much again.

When this project started in 2002 Gillette's profit for 2002 year to 30 September was $870 million, therefore to spend what could be over $100 million, including systems, for this technology is a bold move, but will accelerate the adoption and maturity of this technology. The tags are intended to be compliant with the EPC code of EPCglobal.

Wal-Mart item level trials

They are being used in a number of trial programs, including one with Wal-Mart. Since January 2003, Gillette has attached RFID tags to its Fusion line and its Mach 3 Turbo razor blades that ship to two Wal-Mart stores equipped with smart shelves that read signals from the chips and track the location of merchandise. When supplies on store shelves run low, stock clerks are alerted to refill them; when stockroom shelves run low, the system orders more. The trial ran throughout 2003. In the UK, the Tesco Store in Cambridge also trialled Alien-tagged Mach 3 razors in 2003. "RFID is one of Gillette's highest priorities. In ten years, RFID will be as ubiquitous as barcodes," says Dick Cantwell.

In another test, Gillette is planning to equip two of its packaging and distribution centers to track Venus women's razor blades as they move from packaging to inventory, are assembled on pallets and verified, and then trucked away. Gillette planned to connect these warehouses and goods to all its retail partners. Gillette is trying to convince them to install readers at their own docks and distribution centers. .

Problem: Razors and Duracell batteries experience large theft rates at retail stores:

Gillette has one particular problem to address more urgently than any other FMCG company: two of their most popular brands - Gillette razor blades and Duracell batteries - are typically both in the top five highest shrinkage products in the world. Both are small, have globally recognized brands and often retail at more than other versions, making them a target for theft at retail stores and within the supply chain. The retail stores bear the cost of external theft and it doesn't take long for them to get frustrated - some stores then sell them behind counters, crippling sales. As these two products are among Gillette's highest grossing items, the paybacks could be tremendous with the adoption of RFID.

Possible solution - Smart shelves

The trials are testing smart shelving in order to monitor theft as it happens and provide near real-time stock control - the system flags an alert if five or more razor blades are moved from the shelf at the same time - highlighting that a theft may be in action. Additional trials in Fort Devens Pack and Distribution Center in Massachusetts, USA, aim to enable 100 per cent verification of Venus razor blades' cases/pallets from assembly to order loading.

Tesco antitheft trial

The 2003 trial in a Tesco supermarket in Cambridge, UK was aimed at combating theft. It is a coincidence that this is also the UK base of the Auto-ID Center, and the highest density of RFID companies in the world, but Gillette were selling tagged MACH3 razors from four smart shelves in the store. "We haven't had a single customer ask what the tag is doing in their packet of razors", said store manager Alan Robinson at the time. The products, which contained a 13.56MHz tag from Philips for the trial, were prepared in the USA before shipment to the store. The 50mm x 20mm tag was held in place with a piece of tape but work was progressed in integrating the tag and the packaging. At 915MHz, this tag was legal for the US market only.

World's most stolen branded product

While the area covered by RFID in the store was small, the level of sophistication was certainly not. The MACH3 razor is the world's most stolen branded product, and so one of the biggest paybacks for the introduction of this technology on the shop floor is in anti-theft. The importance of this was made clear in the integration of the store's own security system with the smart shelf. When a customer removed a packet of razors, a photo was taken of that customer and temporarily stored. When the barcode of a Gillette razor was scanned at the check-out, another photo was taken of the customer. Backroom staff compared the two sets of photos to make sure they always had a pair. If they did not, they had reason to suspect that packets were leaving the store without going via the check-out! In this case, they were able to blacklist certain shoppers and keep a closer eye on them.

Success

Mr Robinson was delighted with the project. "We are co-operating with this trial in every way we can - we would like to be a test bed for many more trials of this kind in the future. We believe that this technology is coming to our supermarkets, and it will be a great advantage for Tesco to implement it first."

High level of shoplifting

He was also keen to point out its effectiveness, particularly for anti-theft. To understand the scale of the problem, since the store's opening seven months before, there had been 117 arrests for shoplifting. And while many different methods are used to deter would-be thieves, including infra-red systems on high-value whisky bottles, and the standard range of EAS tagging, the Gillette trial has thrown up one particularly satisfying example from Mr Robinson's point of view.

"We had a guy in a couple of weeks ago", began Mr Robinson, "whom we suspected of taking some razors out of the shop in a metal lined bag (to fool the EAS readers at the door. All the Gillette razors, as well as being RFID-tagged, are also kept in an EAS-tagged case which is removed at the check-out. At present, there are no RFID readers at the door). We watched him go, but he was back a couple of hours later and swiped four PlayStation games. This time we caught him, and when the police searched his bags, they also found two packets of Gillette razors, which by now had been removed from their EAS-tagged cases. In normal circumstances we couldn't have pinned the razor theft on him - he could have bought them from anywhere. But with our handheld reader, we were able not only to read the tag hidden in the packet, but also to show the police a photo of the crook at the time the crime was perpetrated, removing the two packets from the shelf. The police were completely flabbergasted, having never seen anything like it before in their lives. Clearly they were impressed".

Real-time stock detail

A computer was also installed in the control room to give real-time stock level information and other statistics to those working in the store room. While this functionality was not being used currently, this should add benefits in due course, particularly in reducing stockouts.

The real benefits that RFID can offer will only be realized with full-scale implementation throughout the supply chain and across many product groups. However, we should not forget that the barcode revolution began in a similarly humble manner, with a single packet of chewing gum.
Gillette has since then implemented full-scale RFID with its newest line of razor blades "Fusion". They expect to get an ROI within 1 year of the product rollout.

Supply Chain Case Studies (Retailer)

Company: Wal-Mart

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Application: Retail, Consumer Goods
Level of RFID usage: Pallet, Cases, Items
Benefits sought: Cost Reduction, Theft Prevention, Customer Service, Convenience and Speed of transaction.
Project Status: Initial Pilot completed, Trials ongoing
Tags: UHF Gen2 tags
System: Various Providers.

Wal-Mart has been the single largest influencer adoption of RFID due to a mandate. We have asked our 100 top suppliers to have product on pallets employing RFID chips and in cases with RFID

chips," says Wal-Mart spokesman Tom Williams. "By 2006, we will roll it out with all suppliers." In mid 2004, Wal-Mart began what it termed as trials of RFID technology, through its Sanger distribution centre and in the Dallas Fort-Worth area and seven Dallas stores.

Eight suppliers involved

The eight suppliers participating in the test are Gillette, Hewlett-Packard, Johnson & Johnson, Kimberly-Clark, Kraft Foods, Nestlé Purina PetCare Co, Procter & Gamble and Unilever. Initially, only 21 of the 100,000 products an average Wal-Mart store carries are being tracked from the warehouse to the stores. Tagged pallets and cases of those products arrive at Wal-Mart's regional distribution centre and interrogators placed at the loading dock doors scan the tags.

Information to Wal-Mart and its suppliers

The data are passed to an application that lets Wal-Mart's operations and merchandising teams know that the specific shipment has arrived. This also feeds back to the product suppliers. Cases are then removed from the pallets and processed in the normal way before being shipped onwards to the seven participating Wal-Mart stores. When tagged cases arrive at the back of one of the seven stores, the tags on the cases are again read and the shipment is confirmed as having arrived at the right place.

Seeking 100 per cent accuracy

Wal-Mart has announced that it expects to be able to achieve 100 per cent read accuracy but suppliers of RFID have pointed out that such things are usually impossible and Wal-Mart has now defined this more realistically. It was foreseen that the pilot marked the beginning of Wal-Mart's roll-out of RFID throughout its operations. The plan was that the scheme will be extended to more than 130 stores by January 2005. Most will be in north texas but some will be in the south central Oklahoma region. Carolyn Walton vice president of Wal-Mart's Information Systems Division and responsible for EPC rollout said in late 2004 that, *"We've seen tremendous progress in the EPC initiative around the globe. Tag prices have fallen dramatically since June of last year. They certainly need to fall further to allow RFID to achieve its maximum potential and we believe this will happen as more and more technology vendors enter the marketplace. We also see more retail pilots and pilots in other industries ready for launch. Consumers too continue to demonstrate a commonsense approach to the technology's rollout, something we believe comes from concerted effort to educate customers on how EPCs will ultimately improve their shopping experience."*

"We believe in this technology and we are extremely proud to be helping end the chicken and egg cycle that it has been stuck in. We sincerely believe that there is ROI for any company willing to approach this technology as a way to improve their own business and not just a way to meet our milestone.

Wal-Mart's initiative for tagging drugs

The Wal-Mart initiative is focused primarily on following to the FDA's track-and-trace requirements. The FDA is keenly interested in the project. Indeed, some of its officials attended the Wal-Mart meeting with suppliers in Bentonville. The FDA sees RFID to the EPC conventions as a way not just to track drugs but also as a way of ensuring that counterfeit drugs do not make their way into the legitimate supply chain. This has been an increasing public health concern and a serious issue for pharmaceutical manufacturers.

An EPC tag on each sealed bottle containing 100 tablets, for example, links the EPC with shipment information in a secure database. When the pharmacy receives the shipment, staff verifies that the safety seal on each bottle is intact and an RFID reader can automatically scan the EPC tag on it. The computer system accesses the secure database of the drug company and confirms that the specific bottle was shipped and what it was should contain. If the EPC number on the bottle does not match the code in the database, or if the contents do not match the information or if the bottle's seal has been broken—then those concerned can mount an investigation.

Pharmacy staff currently has to scan each bottle's bar code to ensure 100 percent accuracy. With shipments containing ten or more bottles of say six different Class 2 products, the RFID system should save labor cost and tedious tasks for retailers while helping to protect drug makers from counterfeiting. However, even if the systems work, calculation of paybacks from such factors may be a complex matter.

Wal-Mart's RFID system requirements

As yet, Wal-Mart's RFID system requirements only relate to pallet and case level but the company will sensibly try to make these the starting point for item level tagging as well, only adding complexity on an as-needed basis. These are their tag and interrogator requirements.

Tags

Durable, temporary or permanent read only 96 bit (for retailer – means 128 bits for all) UHF Class 0 (factory programmed), Class 0+ (read write version of Class 0) or Class 1 version 1 (write once read many), EPC-compliant. Driving to Class 1 version 2 when specifications and compliant products are available.

Interrogators

One antenna required on each side of dock door/portal; one antenna above dock door; one each side or underneath a conveyor moving up to 600 ft/sec for case tagging. Cases have to be read 100% of the time at 540 ft/sec. The electronics should be agile, largely due to eventual migration to Class 1 Version 2 EPC tags that allow for one common protocol. They should be Power over Ethernet based and have flexible output options and RF Environment awareness, include security and have the ability to disenable unused features such as web servers.

Update October 2005

Using RFID to increase sales works Wal-Mart has issued a press release on their results using RFID to monitor stock levels, based on initial findings of an independent study from the University of Arkansas.

Researchers at the University of Arkansas found a 16 percent reduction in out-of-stocks. Additionally, the study also showed that out-of-stock items with EPC (Electronic Product Code) tags were replenished three times faster than comparable items using standard barcode technology. Equally important, Wal-Mart experienced a meaningful reduction in manual orders resulting in a reduction of excess inventory. "This is no longer a take-it-on-faith initiative," said Linda Dillman, executive vice president and CIO for Wal-Mart. "This study provides conclusive evidence that EPCs increase how often we put products in the hands of customers who want to buy them, making it a win for shoppers, suppliers and retailers." The 29-week study analyzed out-of-stock merchandise at 12 pilot stores equipped with RFID technology and 12 control stores without the technology. All Wal-Mart formats - Supercenters, Discount Stores and Neighborhood Markets - were included in the study.

While Wal-Mart commissioned the study, it was conducted independently by the University of Arkansas. Specific items were selected to be analyzed at the beginning of the study and these items remained constant throughout the entire process to ensure data consistency. To both establish a pre-study baseline and to measure the impact of RFID, out-of-stock items were scanned every day throughout the study period, at the 24 stores. The study design allowed the researchers to examine differences between the 12 control stores and the 12 RFID-enabled stores. It also provided the ability to compare performance in the same stores through analysis of the baseline data and the data collected during the use of RFID. "The study showed RFID-enabled stores were 63 percent more effective in replenishing out-of-stocks than the control stores," Dillman said. "The Wal-Mart RFID team knew that this technology would have a huge impact on out-of-stocks. Now we have an

independent study that confirms RFID has a significant impact in retailing," Dillman continued. "However, we are not stopping there. This is only one of many changes that RFID will bring. We are already working on initiatives and enhancements that will build on this success."

What's next for Wal-Mart

As Wal-Mart announced earlier this year, it is currently more than tripling the number of stores where RFID has been installed. By the end of October, Wal-Mart will have more than 500 stores and clubs and five distribution centers live with RFID. As of January 2006, Wal-Mart's next top 200 suppliers were live, shipping EPC-tagged cases and pallets. As with its top 100 suppliers, Wal-Mart has collaborated with these next top 200 suppliers, hosting a number of briefings and seminars to share knowledge back and forth. A number of the suppliers who went live in January 2005 also participated with the next 200, passing on their learning and areas of benefit within their organizations.

In addition to the store and distribution center expansion this year, Wal-Mart will continue its rollout during 2006 and double the number of stores that are enabled, along with distribution centers that service the enabled stores. By the end of 2006, more than 1,000 stores, clubs and distribution centers will be using RFID to deliver improved service to customers.

For 2007, Wal-Mart expects the next wave of 300 suppliers to start shipping tagged cases and pallets by January 2007. Combining the 100 suppliers from 2005 with the 200 suppliers during 2006, this will bring the total number of suppliers live in early 2007 to over 600. Wal-Mart will be ready to accept Gen2 tags during January 2006, enabling its next wave of suppliers to start with Gen2 tags from the start. As Wal-Mart increases its enabled facilities and as costs continue to fall, Wal-Mart expects its suppliers to tag more volume.

Company: Best Buy

Application: Retail, Consumer Goods

Level of RFID usage: Pallet Level

Benefits sought: Cost Reduction, Customer Service

Project Status: Planned for Q1 2006

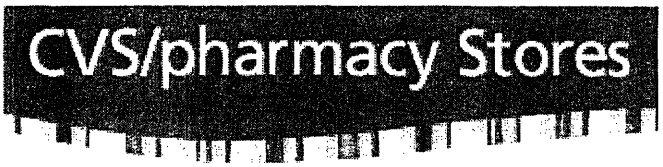
Tags: UHF Gen2 tags
System: Unknown

In late 2004, consumer electrical goods retailer Best Buy announced its plans to roll out an electronic product code (EPC) strategy that the company hopes will increase the efficiency of its supply chain. The decision was been made to rollout by January 2006. Minneapolis-based Best Buy has more than 750 retail stores across North America.

Best Buy hopes its EPC strategy will improve customers' in-store experiences, particularly given the ability of RFID systems to rapidly read multiple tags. The company expects the strategy to improve product availability, reduce processing times in distribution centers and stores, enhance real-time product information capabilities and increase speed to market - all of which will lead to increased efficiency for Best Buy.

Best Buy will work with Accenture to further define its RFID program strategy, manage rollout and implementation and assist suppliers with meeting its integration and compliance requirements.

Company: CVS Pharmacy



Application: Retail, Consumer Goods
Level of RFID usage: Contact less payment
Benefits sought: Speed, Fast turnaround
Project Status: Ongoing
Tags: UHF Gen2 tags
System: Unknown

Contactless Payment Application

The 5,400-store retail pharmacy chain - CVS Pharmacy, has purchased 12,000 Hypercom Optimum L4100 RFID-enabled card payment terminals, according to Hypercom. The Optimum L4100 is a compact, high-speed signature capture card device specifically designed to speed checkout lines in

multi-lane retail environments and supports the innovative contactless payment cards from Visa, MasterCard and American Express.

Image Source: Hypercom, mastercard

The Hypercom terminals, configured to CVS Pharmacy specifications, accept magnetic stripe cards, smart cards, and contact less cards or key fobs that eliminate swiping and signature requirements through the use of embedded radio frequency identification (RFID) tags. The payment terminal can support the American Express ExpressPay, MasterCard PayPass and Visa Contactless payment programs as well as the contactless payment system being used by CVS to help speed transaction times, all through the terminal's RFID reader.

Company: Electronics City Retail Park, India

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Application: Retail, Consumer Goods, Apparel
Level of RFID usage: Item Level
Benefits sought: Showcase Technology
Project Status: Trials Completed
Tags: UHF Gen1 tags
System: Alien Technologies, Wipro Technologies

In 2004, Wipro Technologies tested RFID in a retail store on the campus of its headquarters at the Electronics City industrial park, Bangalore, India. Apparel in the concept store is tagged at item level. Since the RFID tags make it possible to track and trace goods in the store, the system makes tasks such as stock maintenance automatic and enables intelligent shrinkage avoidance. Tagging the store's

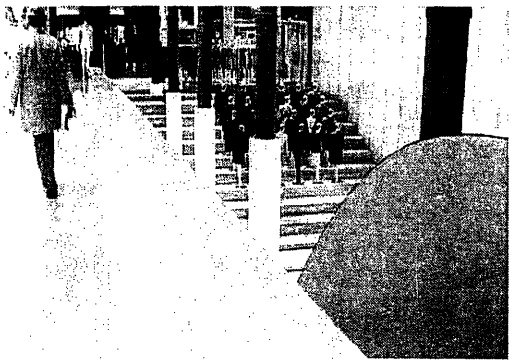
goods also makes it possible to provide customers with automatic check-out facilities and to report when stock levels are low or items have been placed on the wrong shelf.

The system The system uses two 915 MHz Class 1 specification ALR 9870 interrogators from Alien Technology, with five linearly polarised Alien antennas. The interrogators are connected to an Ethernet hub, which is connected to OAT Systems Senseware 3.0 Beta middleware. Both Alien read-only and programmable Class 1 tags were used to identify items in the trial.

Staff cards There are two antennas near the entrance of the store, one of which records which products are leaving the store and the other to read the RFID tags of people entering and leaving the store. Six thousands employees working at the Electronics City campus have an RFID tag as part of their employee ID card.

Centre of excellence The concept store is part of Wipro Technologies' RFID centre of excellence and demonstrates how RFID technology can be used across a variety of business processes within a retail store. The aim of the project is to assist customers in understanding how RFID works in a real-world environment and existing and potential customers have been invited to the store to see how RFID works.

Company: Prada

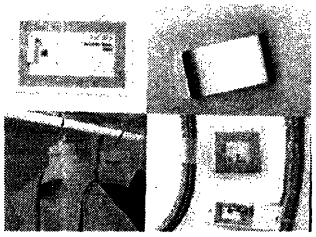


Application: Retail, Apparel
Level of RFID usage: Item Level
Benefits sought: Improved Customer Service, Improved Loyalty, Improved Sales
Project Status: Trials Completed
Tags: HF 13.56MHz
System: Texas Instruments, Trenstar KTP

Prada sells bags, shoes, and clothing on the cutting edge of Italian fashion. Prada explored a unique interactive shopping experience in New York. It used a new RFID system developed by UK-based system integrator KTP, a division of the US company Trenstar. The system was installed as Prada's new Epicentre fashion store in New York City and used Texas Instruments' Tag-it™ RFID smart

label technology to automatically identify customers and merchandise. It automatically provided shoppers with personalised information about their selections before and after they make a purchase.

Seamless shopping experience

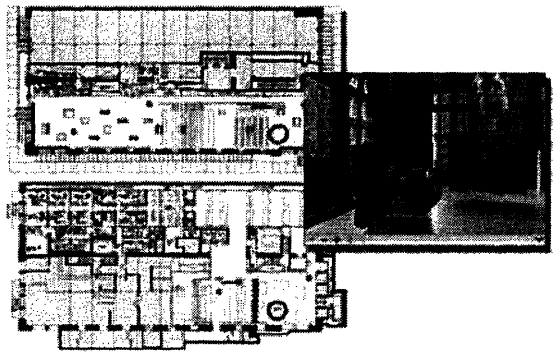


The Prada system sought to create a seamless shopping experience to enhance customer relationships. At numerous interactive 'touchpoints' throughout the Prada Epicentre store, interrogators uniquely identified the RFID tags carried by customers, products and staff and linked them to a database. When a customer approached one of the 'touchpoints', the tag triggered an interactive video screen display showing live video of the relevant products on the catwalk as well as collection photographs and designer sketches. Touch screens provided in-depth information about the colours, cut, fabrics and materials used to create the particular Prada merchandise.

Identifying what a customer takes into the dressing room

RFID interrogators identified all the goods a customer took into the dressing rooms, and automatically displayed information on the chosen garments on an interactive video touch screen. Customers could also access product specifications as well as alternative and complementary items and accessories from the touch screen. Using RFID technology linked to customer information stored in a database, Prada guaranteed a high-quality customer experience across multiple sales associates and subsequent Epicentre locations. Prada sales personnel had wireless RFID handheld interrogators that give instant access to stock inventory and customer information stored in a centralized database. Staff could be identified using RFID badges for management control.

The tag did not replace anything directly but it made something new possible. However, in late 2003 the system was removed . Two problems were cited but there may have been more. There seem to have been difficulties in using HF smart labels at relatively long ranges in many orientations. Secondly, Prada's female customers were concerned that the system was recording their personal details (eg clothing sizes etc) so the system was not well received.



Challenges to innovation in Retail:

To realize Prada's vision for a new shopping

experience, Prada engaged in a unique collaboration to lead the development of the new Manhattan store – the first of its kind. Working in partnership with renowned architect Rem Koolhaas, AMO, and IDEO, Prada's New York team was involved from early on to design, develop and integrate the systems that form the store's technical backbone and the foundation for enhancing the customer experience.

Solution - Priority in building the applications and interfaces for in-store devices was to enrich the customer visit and empower sales associates. A particular focus was the customer experience surrounding inventory inquiries. Conventionally, sales associates leave the customer to find out whether an item is in stock. Prada deployed a wireless device that is RFID-enabled and allows sales associates to check inventory in real time, maximizing the time they spend with customers. The device further supports the customer-associate relationship by activating flat screen monitors to display product images and runway video on demand. Dressing rooms are also RFID-enabled: a touch screen within provides details about the customer's selections and information about related items. Customers can save item information in their 'profile'.

This partnership has delivered powerful tools for building customer relationships within an unparalleled shopping experience. Prada is now leveraging the knowledge gained from the Manhattan store to develop new applications regionally and internationally, to achieve a more personalized service. It particularly feels that RFID can help to build loyalty.

Features of Prada's RFID initiative:

- RFID/ Wireless inventory management system
- Handheld device delivers real time inventory, customer information, and controls ubiquitous multimedia displays
- Internal application for staff to manage assets and products
- Designed to be useful and usable within an operational context
- Content management system that manages tens of thousands of assets
- Web site to extend and support in-store experience

The new Manhattan store has received widespread attention including from Forbes, Business Week, Vanity Fair, The Associated Press, Executive Technology, CRN, Stores, iMarketing News, VAR Business and Entertainment Design.

Supply Chain Case Studies (Closed Loop within Supplier and Retailer)

Company: Benetton Apparel

Application: Apparel

Level of RFID usage: Item Level, Embedded on clothing

Benefits sought: Cost Reduction, increased sales

Project Status: Withdrawn

Tags: UHF Gen2 tags

System: LAB-ID, HF tags

Benetton has been closely watching its competition and now has its own trials, similarly based on read-write tags. However, it feels that read-only tags interrogated on the internet may be practicable and lower in cost. The company points out that as a vertically integrated company from manufacture to retailing, it may achieve paybacks earlier than others. Marks & Spencer is another example. That also means that it does not necessarily have to wait for the agreement of global standards.

Benetton announced an order for 15 million smart labels to be delivered in 2003. The labels were to be based on the Philips I.CODE chip, the system frequency was 13.56MHz and they were compliant with ISO15693 but subsequent announcements were more modest. Privacy campaigners have targeted the company. Philips had partnered with LabID and Psion Teklogix to provide the complete system. This would have been the world's largest roll-out of smart labels in the retail supply chain, following Marks & Spencer's use of 3.5 million smart labels.

Clothes produced under Benetton's core brand Sisley were fitted with RFID-enabled labels based on the Philips I.CODE semiconductor technology. These labels were part of a complete system solution by LabID - the Italian system integrator owned by Benetton - and were being used by Benetton to track its garments throughout the company's entire supply chain. As part of this initiative, all garment box shipments from United Colors of Benetton were also to be labeled with I.CODE-based smart

labels. These were tracked using I.CODE-compatible readers and wireless LAN netpads developed and manufactured by LabID and Psion Teklogix respectively.

"Benetton has thousands of retail outlets worldwide and therefore wanted to put in place a future-proof technology to bring clear cost benefits to the business whilst seamlessly enabling garments to be tracked throughout their lifetime," said Terry Phipps, Electronic Data Processing (EDP) Director at the Benetton Group. Several million smart labels were put into use. Benetton produces over 110 million garments every year, 90 per cent of which are manufactured in Europe. Its retail network of 5,000 stores around the world is increasingly focused on large floor-space point of sale offering high quality customer services and now generates an annual turnover of €2.1 billion, net of retail sales.
Benetton used the smart labels to address three main issues in the fashion industry:

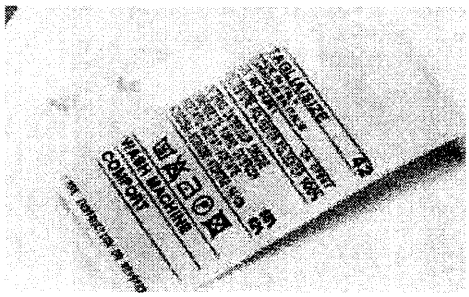
- Fashion products typically have a three month product life, therefore it is vital to optimize supply chains to get a product to the store as quickly as possible.
- The fashion industry greatly suffers from lost sales due to correct size or color items not being on display. The shelf time of products needs to be maximized, and where space is limited the store needs to be able to get the correct item for the customer quickly.
- Branded clothing is a high target for counterfeiting and theft, and product diversion (grey markets) where items are sold in countries they should not be at high prices.

LabID provided the converting technology and worked closely with Psion to develop different readers for use throughout the supply chain. One of the toughest challenges of the project, was making a totally new label which could be used in the garments. Depending on the garment, these were combined with the existing label either in the collar or seam. These are based on the I.CODE chip, and being smaller in size, the labels have a range of about 40 centimetres. The tags meet the ISO 15693 standard. Production lines have been installed at Castelmaggiore in Bologna.

The system

Benetton is using read-write labels because the information about the destination of the product changes as it passes through manufacturing, distribution centres and stores. The smart labels are stitched into the garment at the point of manufacture of the garment. They are imperceptible to the wearer and remain in individual items of clothing throughout their lifetime. They are killed off at the point-of-sale. The construction, which is shown below, is based on a polyamide substrate in order to survive stitching and laundering.

Figure: Benetton garment tag sewn into the seam of a garment



Source: Benetton

At the manufacturing plant, the garments are put in boxes which have their own 13.56MHz smart label. This is again based on the I.CODE chip but has a much larger antenna to maximize read range, and stores information about the destination of the box, and all the garments inside of it. At this stage the authenticity of the items is confirmed and recorded, including volumes, sizes and colors. The clothing labels store information relating to the style, size, color and intended destination of items, radically automating key aspects of Benetton's supply chain from manufacturing and distribution through to inventory control across the company's 5,000 stores worldwide. The box labels are used to track box shipments throughout Benetton's logistics process enabling improved identification and item to box correlation, while optimizing the timing of shipments and inventory control and minimizing distribution errors. From the manufacturing plant, the boxes are shipped to distribution centers. Rather than reading all the tags of the garments inside the box, only the tag on the box is read as this contains the required information. At the distribution centre the garments are separated and entered into a conveyor system to direct them to the correct destinations. RFID readers on the conveyors automatically read each garment's tag and divert it to the correct place. Other garments without RFID tags are sorted in the conventional way. Garments are then re-boxed and shipped to stores. Stores selling the Sisley brand are equipped with RFID readers on shelves to monitor stock outs and inventory, as well as readers at point-of-sale and in the storerooms. They have also planned for readers to be fitted in changing rooms to aid theft prevention. RFID technology in smart shelves and in dressing rooms is used to highlight where individual garments are located. This technology will also be employed at the point-of-sale, automatically registering sales and returns and feeding information back into the company's ordering system to ensure that stock levels are replenished in the most efficient way possible.

Appliances that talk to tags

Appliance manufacturer Merloni has been developing appliances that communicate with LabID tags in Benetton apparel. Thus we may have the washing machine that selects the washing cycle depending on what it detects has been put in the machine.

Roll-out

It was reported that several million tags were being used in this way, with most of the system infrastructure in place in distribution centers that sort the Sisley brand. Implementation in some stores selling the brand was said to be complete, with others being fitted with the system. In 2003, Mauro Benetton, Marketing Director of Benetton Group and President of LabID in charge of the programme, said, "By equipping each individual product with an RFID chip at the start it is possible, with the appropriate reading infrastructure, to trace and analyze each item's journey through the production cycle and distribution chain. The same item can furthermore be identified at the retail outlet up until it is purchased by the final customer. All of this can be achieved without any dramatic changes in the existing production processes and logistic channels. The adoption of RFID technology does not imply any traumatic side effects and is beneficial across all activities that concur in the timely creation, production and marketing of a new product meeting specified cost standards and cost target."
He sees benefits to sales not just the potential to take cost out of the supply chain. In an interview by Global ID Magazine in 2003, he said, " ...by extending to the Benetton stores the reader infrastructure that monitors the movements of garments and identifies them with item level resolution, we would give our retailers – at extremely competitive costs – a powerful and easy to implement tool that would allow them to know at any moment the exact location of every product on display, to efficiently make detailed plans for restocking the store, to measure the level of appeal of each product with their customers. How many times was each type of garment tried on? How many customers bought the item after tryout? And to cut the time spent making inventories of the stock on hand. We estimate that equipping the store with innovative furnishings integrating RFID terminals, at a cost of around €200 for each smart shelf, it is possible to achieve a significant increase in profits, with a return on investment of just over one year." However, in 2004, the Benetton family had sold LabID to another family dynasty in Italy.

Company: Marks and Spencer, UK

Application: Retail, Apparel

Level of RFID usage: Item Level

Benefits sought: Improved Customer Service, Improved Loyalty, Improved Sales, Less OOS

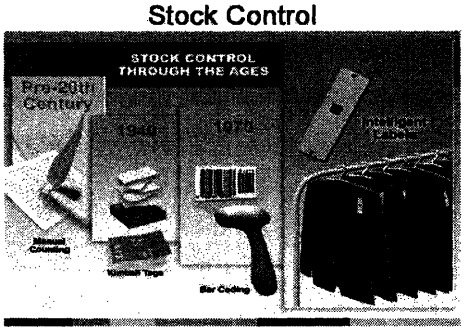
Project Status: Trials Completed

Tags: UHF 868 MHz (Not EPC)

System: Paxar, Intellident

Marks & Spencer is one of the leading retail stores in the UK. They have over 400 stores located throughout the UK, this includes their largest store at Marble Arch, London. In addition, the Company has 150 stores worldwide, including over 130 franchise businesses, operating in 30 countries.

Stock Control



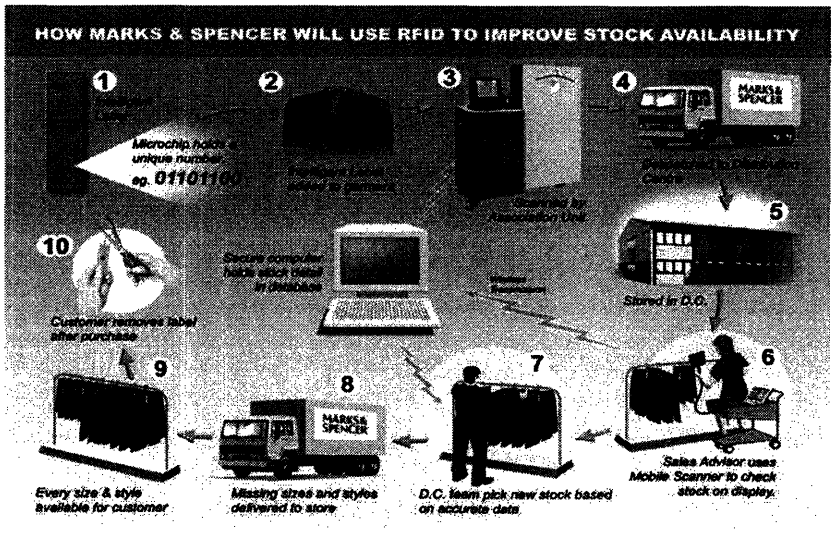
Marks & Spencer is interested in item level RFID to:

- Improve stock availability for its customers
- Create a more accurate and efficient supply chain working at Item level
- Ensure that the right goods are in the right place at the right time.

The company sees RFID as the latest stage in the evolution of stock control, as follows

Item level trials

The High Wycombe trial was completed in three months. It established the feasibility of using the technology. Further trials will now take place and tagging the 350 million apparel items that Marks & Spencer sells every year is now a distinct probability. However, as yet, there is little interest in tagging the billions of food items that Marks & Spencer sells every year. These have a much lower average price. Executive James Stafford says, "RFID technology is the next big thing in retailing. It means we can aim for perfect availability for customers. We can also reduce handling and counting to free staff to spend more time serving customers." The system was used to automate the process of receiving apparel stacked in boxes and clothing on racks. Handheld scanners and portal readers were successfully tested, and point-of-sale applications will be tested later. M&S flow diagram is shown below.



Source: Marks & Spencer

A mobile scanner used to read the UHF swing tags on clothing. Eventually M&S would like to see this functionality in a handheld device. One store was equipped with the RFID system and by the first quarter of 2004 the system was rolled-out to several stores. At this stage Marks & Spencer is analyzing the paybacks from the technology, and with a sound idea of detailed costs, it will then decide on the extent of the roll-out across all its stores.

Closed system – why Marks & Spencer can adopt RFID quickly

Marks & Spencer only sell their own branded products, unlike other retailers such as Tesco and Wal-Mart which sell many different brands. This means adoption of RFID technology by Marks & Spencer is simpler as it effectively has a closed loop system and does not need to converse with hundreds of different suppliers with their own agendas - a mammoth global task faced by most other retailers. However, although Marks & Spencer could implement a proprietary system, it has rightly decided to progress as far as possible with an open system, and wishes to use this project as a showcase to the world. This would also help future-proof Marks & Spencer and ensure all the advantages of multi-source purchasing.

Marks & Spencer requires garments to be tracked with the following data:

- Manufacturer
- Product
- Version
- Serial number
- A unique identification number.

Items need to be identified uniquely, which is vital in the tracking of fast moving items through the supply chain. To keep the tag cost as low as possible, only a unique item code is expected to be on the tag, with the associated data on a database. This research is vital to ensure the implementation goes well as this may be a pivotal case study that other users will consider when deciding to implement RFID. Intellident and Marks & Spencer established their reputations by rolling-out 3.5 million tags for dollies and carton tracking - the largest project yet for RFID in the retail environment.

UHF preferred

M&S selected a number of UHF (about 915MHz) chip and inlet manufacturers and evaluated their capabilities. It chose EM of Switzerland (EM Marin/EM Microelectronic). This tag technology is discussed further at the end of this section. To avoid privacy issues, the RFID tags form part of the swing tags on apparel etc that customers throw away on purchase. This denies Marks & Spencer a number of paybacks and so it may only be an interim stage but at least there is plenty of space for the pallet style UHF tag on the swing tag.

Tests of different frequencies

Most of M&S previous work has been at 13.56MHz including the 3.5 million Marks & Spencer bins. They arrived at this UHF decision after setting up and testing mock-ups of systems at both frequencies in retail store environments. Such environments are subject to RF interference, and the application demanded the ability to read tags in a high density of products, coping with the random orientations of tags and focused reading directions for some applications, such as reading tags on shelves and goods at the back of the store. In these trials UHF proved the most suitable system choice. As with any application of RFID, Tim Hankins stresses that "The application environment defines the system".

UHF power regulations differ

However, the power levels of UHF systems in Europe and Japan must be lower than those in the USA, which means read range is less (and currently less than the range of 13.56MHz systems). However, M&S points out that long range was not their priority – speed and reliability of read and (in trials) read/writes were. This is achieved at UHF due to the faster data transfer. Range at UHF is now less of a problem - in October 2004 the change in European radiation laws at this frequency means read range is increased, and is comparable to that in the USA. M&S was aware of the Magellan protocol that achieves similarly high data rates at 13.56MHz, but did not favor it.

Portable readers

The tags are read by portable readers, and an optimal range of 35 centimetres has been met. Larger portal readers ensure that the tags can be read through doorways or gateways. A proposed 'wardrobe' trial where the RFID recommends matching accessories seems to have been put on hold after Prada New York withdrew its similar facility. Unusually, Marks & Spencer does not envisage having smart shelves because all its racking is on wheels and is frequently moved and providing power is perceived as a problem.

Business case trial April-July 2004

The second trial of item level tagging of clothing sought to establish the business case. It took place from April to July 2004. Three suppliers were involved in labeling all men's suits and these passed through one distribution centre to six stores, a total of 200,000 items. It monitored:

- Better stock availability
- Increased sales
- Increased productivity in counting
- Staff and customer reaction, which was good
- Customer orders, which increased.

Improved stock management

This project will enable Marks & Spencer to manage its stock more effectively throughout its distribution chain and into the stores themselves. RFID will provide a step-change in stock control and will ensure the availability of garments to customers in stores.

Uniqueness of EM tag

EM Microelectronic, part of the Swatch Group, may be the world's largest supplier of RFID chips not used in cards. It has developed a new UHF RFID integrated circuit, EM4223, which is fully compliant with the international standard ISO18000-6A and EPC 64-bit and 96-bit code structure. The EM4223 is a high-performance 128-bit read-only UHF circuit with a robust anti-collision protocol. It is frequency-independent from 865MHz to 2.5GHz and is compliant with global radio regulations. It works with very low radiated power, not only in the USA but also in Europe and in Japan. The EM4223 has been designed using EM advanced CMOS technology optimized for RFID and will be produced in EM's own lab in Switzerland. The circuit layout has been conceived for easy assembly by antenna manufacturers.

Superior multitag reading

EM4223 can read tags at a distance of more than 15 meters when using an optimized transponder antenna. It also has an enhanced anti-collision (multitag reading) protocol which performs without saturation effect – with other RFID chips the transmission channel can become saturated if the reader attempts to read more than a certain number of tags simultaneously. "The saturation limits of the transmission channel of EM4223 are extended to such a point that a reader is able to read more than one thousand tags simultaneously present in the field", said Mougahed Darwish, President of the management board of EM Microelectronic. "Due to its high-speed anti-collision feature, it is also possible to read two hundred EM4223 tags per second. This high throughput will set new performance benchmarks, especially when operating under the prevailing ETSI regulation."

Another advantage of this protocol is that EM4223 tags can enter and/or leave the field without corrupting the anti-collision protocol itself, ensuring that all tags are read. This key feature is particularly important in logistics applications where tracked items are always in motion.

Good communication with customers

COMMITMENTS TO OUR CUSTOMERS

We believe every new technology must be used responsibly. We are therefore committed to using Intelligent Labels in a manner which is acceptable to our customers.

During the trial of this new technology we are making the following commitments to customers:

- Intelligent Labels will be clearly identifiable and visible paper labels
- Our Intelligent Labels do not contain a battery, cannot emit any power or signal and are completely harmless
- Customers do not need to keep the Intelligent Label in order to return or exchange items
- We will not link garment information on the Intelligent Label with customer details
- We will not scan the Intelligent Labels at the till
- Customers may throwaway the Intelligent Label after purchase

In a classic example of how to communicate well with customers, Marks & Spencer displays the following notice concerning its item level RFID.

Current State:

Marks & Spencer is expanding the current item-level RFID tagging trial taking place at nine of its stores to include 44 more locations. Beginning early 2006, men's suits, bras, and other merchandise will be tagged at item level, progressing to all 350 million non -food items yearly by 2007-8. British telecom will be system integrator, with assistance from Intellident, the original system integrator.

Other Non Supply Chain Case Studies

Company: Census for Marine Life

CENSUS OF MARINE LIFE

Application: Fish Tagging

Level of RFID usage: Controlled Sampling of fish

Benefits sought: Conservation, Information, tagging

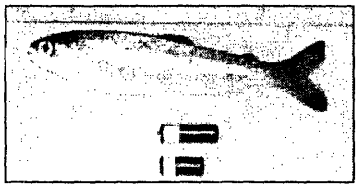
Project Status: Ongoing rollout

Tags: Unknown

System: Unknown

The Census of Marine Life describes itself as a growing global network of researchers in more than 70 nations engaged in a ten-year initiative to assess and explain the diversity, distribution, and abundance of marine life in the oceans -- past, present, and future. The Census of Marine Life has enjoyed revelations from researchers conducting a census in 2005 that used high-tech tracking devices for monitoring the migration of endangered marine animals in the Pacific Ocean.

The system



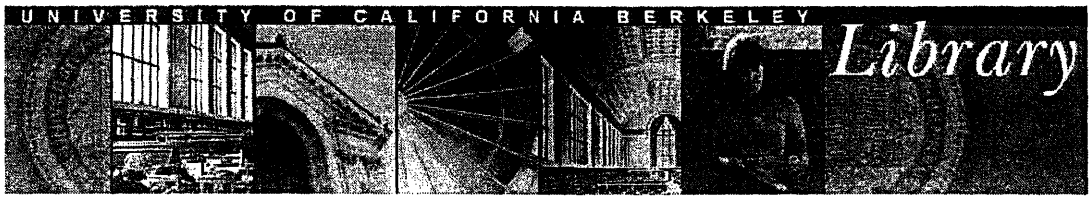
Arrays of underwater monitors will be expanded in the vicinity of British Columbia, Alaska and California. This will be an expansion of a Census project tagging thousands of endangered salmon to chart their individual travels, with profound implications for protection of threatened stocks. The system could spread worldwide to monitor traffic and tribulations of the many species that migrate along the shallow coastal highways. Meanwhile, Census scientists increased by more than 50% from 2004 the number of reporting devices on the large animals that typically venture from the shallow shelves into the deep Pacific Ocean. Some 1,800 open ocean animals of 21 species, including sharks, turtles, seals. sea lions, and seabirds carried Census tags during 2005.

The results

It is possible for the public to log on to www.topcensus.org, to follow in near real-time, some of the animals that have tags, resembling cellphones, that transmit information to scientists via satellite.

Tags have shown that tuna travel vast distances. A tagged bluefin tuna recorded its stunning trans-Pacific migration - three crossings in 600 days, a distance of 40,000 km, greater than Earth's circumference. The research spans species from microbes to whales, from near-shore to mid-ocean, from the world's deepest mud in the abyssal plains to the foamy and sparkling surface, from hot seafloor vents to the ice oceans at both poles. Areas of exploration include the submerged edges of continents, seamounts dotting the ocean's floor, and coral reefs.

Company: Berkley library



Application: Library books

Level of RFID usage: Unit Level

Benefits sought: Cost reduction, reduce repetitive motion injury, Identify misplaced items

Project Status: Completed, 1 year payback, cost $650,000

Tags: HF 13.5 MHz, 80 cents each

System: Unknown

The ILS (Intelligent Library System) , which is being used by the prestigious Berkeley Public Library in California, the University of Southern Indiana's library and the New York Institute of Technology's library provides a one-step process for issuing library materials. The checkout procedure is now much faster, as the system can update information on the library's circulation system and simultaneously deactivate security devices. Also significant for Berkeley Public Library is the prospect of reducing repetitive strain injuries - these have cost the library $2 million over the past five years. Another advantage is easy identification of (intentionally / unintentionally) misplaced books within the library thus improving availability and reducing search time.

"The Berkeley Public Library, California is implementing an RFID tracking system and will be tagging half a million of its books in preparing for a launch In June this year. Checkpoint Systems are providing the application, which is estimated to be costing $650,000." Library administrators are hoping it will allow self-checkout of books, freeing up library employees to devote more time to helping customers.

The ILS also allows for individual self-checkout, enhanced security, circulation management and efficient inventory management, all integrated into a single system. Faster checkout, of interest to Berkeley, is a certainty. Libraries that have installed the ILS have reported significant operational improvements due to the reduction in materials handling time, of up to 75 percent.

The ILS employs a single technology to deal with both materials handling and security applications. An RFID tag placed on or inside items operates within its own LAN of RFID interrogators placed at appropriate locations in the library, such as the entry/exit, where it functions as a security alert by setting off an alarm if books are removed from the library without being properly checked out and recording the item's identity. The ILS can process up to 20 items per second, making it the fastest library system available.

The Inventory Wand is a lightweight, handheld sensing unit that facilitates fast and accurate inventory of the library material. Librarians simply walk down the shelf passing the Wand over books etc and the tag on each item is read. Thus, the library's database is automatically updated with the details of each items whereabouts. The Wand can also be used to locate lost items.

The ILS's Patron Self-Checkout Station allows library patrons to check out items from the library themselves in a matter of seconds. All they need to do is wave their card over the unit, place the items they are borrowing on the Station and touch the monitor. A receipt is automatically generated for the items being borrowed and the patron can exit the library.

Company: Bank of Japan

BANK OF JAPAN

Application: Currency Authentication
Level of RFID usage: Individual Currency Notes
Benefits sought: Crime Prevention
Project Status: Trials
Tags: 2.45 Ghz, Chip and Antenna embedded in paper
System: Hitachi mew chips

The Bank of Japan issues banknotes (officially referred to as Bank of Japan notes) as the nation's sole "issuing bank." It employs a wide range of measures to prevent counterfeiting, including watermarks, special inks, and micro-lettering. Worn and soiled banknotes make it more difficult to distinguish genuine notes from counterfeits, which may proliferate as a result. Therefore, the Bank of Japan checks the validity and cleanness of each of the banknotes which return to the Bank, destroying badly worn notes and putting only those that are in good condition back into circulation. Because banknotes are used in all kinds of transactions, the Bank pays close attention to the control of the physical quality of banknotes so that the public is able to use the notes with confidence.

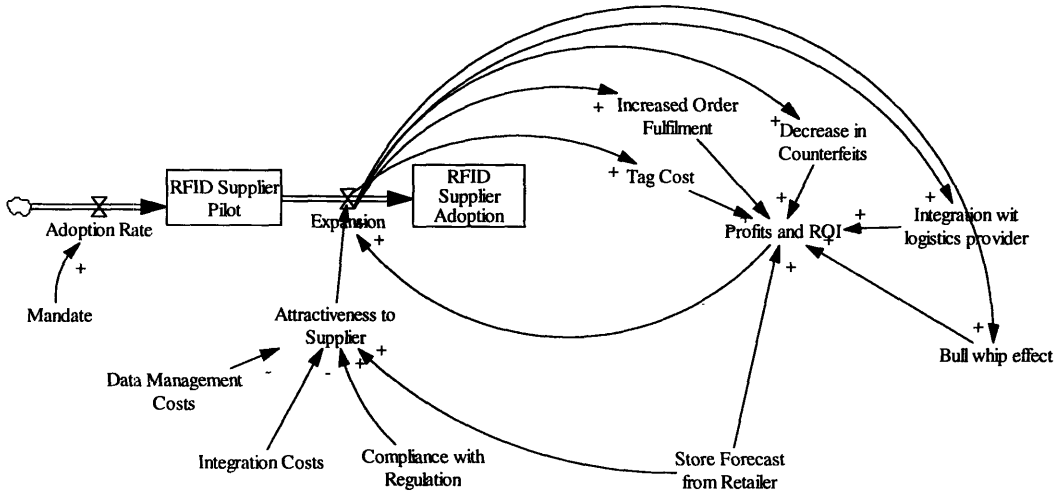
Hitachi has developed the ultra small RFID - Meu chip. The ultra small size (300 μm sides and 60 μm thick, this size includes the RF circuit) permits new applications. For example it can be embedded in a banknote - a Japanese banknote is 100μm thick and in order to embed, the tag thickness must be under half of it (this is the requirement of Bank of Japan). The ROM size is 128 bits (38 digits) and frequency is 2.45 GHz. The unique ID code/number called "Meu number" is written when the chip is produced. An encrypted security number is also provided. The Meu chip tag has an antenna on the chip and the operating distance is about one centimeter, but with an external copper/aluminium foil or printed antenna, the range can be 30 centimeters. Today, this is a tiny strip of metal. Hitachi say that, later, it will be incorporated onto the chips.

- The ultra small size to fit in almost any place.
- Read-only (no adding data capability) provides very low cost security.
- Non contact external antenna is possible and this permits 30 centimeter range.
- Low cost, therefore disposable.
- The main potential applications are:
- Anti-counterfeiting for banknotes, cheques, etc.
- Brand protection for designer clothes, accessories.
- Adding number of capabilities to bank cards and credit cards.
- Replacing existing documents for logistics.
- ID for passports, and so on.
- Membership tickets.

Future

This first generation Meu chip does not have anti-collision or re-writeable capabilities. Hitachi has been developing a next generation Meu chip with anti-collision and write once capabilities. At this moment all "Meu numbers" (the ID numbers) are registered in Hitachi's database and managed.

Analysis: Supplier / Manufacturers value proposition[11]

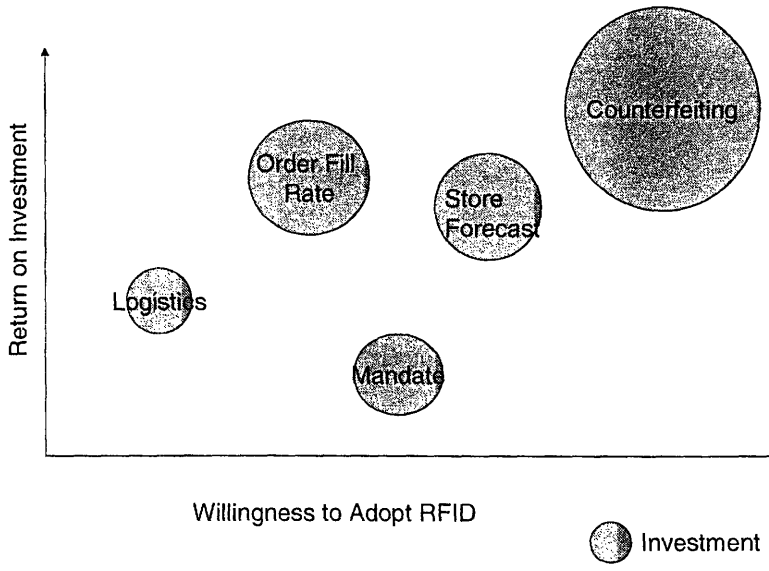


The retail vertical has traditionally been an adopter of track and trace technologies such as bar-codes. The vertical therefore would represent significant potential for the natural progression of bar - codes to radio frequency identification (RFID) technology. The market is witnessing contrasting approaches towards the adoption of RFID technology. Retail suppliers stand divided between compliance requirements and integrating the technology to further their business case. Compliance of mandates by large retailers such as Wal - Mart, Target, Tesco, Metro and Marks & Spencer has been a primary driver for RFID adoption within the retail vertical. While most suppliers continue to remain motivated by the mandate compliance, there is an increasing awareness towards using the technology to improve operational and process efficiency. The mandates have necessitated the use of RFID in the retail supply chain and suppliers are looking to build a definite return on investment (ROI) that would gain them a strategic advantage in the market.

Retailers have well - defined benefits that are guiding their RFID investments. Retail suppliers on the other hand are unable to discover immediate returns on their investments. While there is significant activity among large global suppliers, most of the smaller suppliers have been focusing only on the compliance of existing mandates and are overlooking the potential benefits of RFID adoption within their business process.

[11] Data collected from case studies and research reports published by analysts: Gartner, AMR, Frost, IDTechEX

Diagram below presents overview of the drivers and value dynamics that exists while implementing RFID technology for the suppliers in today's market.



Potential Benefits of RFID Adoption for Retail Suppliers

Information access would be better facilitated through collaborative efforts between suppliers and retailers. Information received from the store end could facilitate suppliers in accurate demand forecasts. This would enable suppliers in containing carrying costs and increasing the productivity of existing warehouse facilities. Improved process efficiency resulting in higher order fill rates, increased inventory velocity, faster order processing and shorter lead times would ensure a truly responsive supply chain. Enhanced service levels would also ensure better supplier - retailer relations. RFID technology enables track and trace applications of high value assets aimed at improving utilization and productivity rates. The productivity of high investment assets would have a significant impact on reducing cost and thereby increasing profit margins for most suppliers. The high value of the assets being tracked would enable the supplier in justifying the cost of RFID adoption.

Suppliers would benefit from transport efficiencies that would accrue as a result of automated route management based on information from RFID systems. The technology also has the potential to significantly reduce demurrage costs and impact cross docking initiatives. A significant challenge within the retail supply chain exists in overcoming the 'bullwhip' or 'whiplash' effect wherein a small change in consumer demand could account for a large variance in supplier order. Demand variations tracked through RFID technology would enable suppliers in maintaining optimum inventory levels thereby reducing the need for huge buffer and safety stocks.

The use of RFID technology would enable automated processes resulting in quicker transaction turn-around. Expediting the transaction process would enable suppliers to realize their payments faster. This would alleviate locked up working capital and provide suppliers with greater financial flexibility. Product recalls and returns management is a key feature of the retail supply chain. RFID would enable suppliers to strengthen their reverse logistics. Visibility along the supply chain would also support suppliers in settlement of warranty claims.

Increased focus on quality control along the supply chain translates into a significant opportunity for the RFID industry. Ensuring maintenance of product quality through the transit process is a challenge faced by most suppliers. Products such as pharmaceuticals and perishable foods would necessitate specific environmental conditions to avoid alterations in product composition and quality. RFID tags with temperature sensors would support supplier monitoring systems during transit. Suppliers could utilize the technology to comply with regulations necessitating specific labeling and product information requirements. Other legislation such as FDA's endorsement of RFID for the pharmaceutical supply chain, traceability requirements of the food supply chain and the cold chain compliance regulations in North America and Europe are expected to validate supplier investments in the technology.

One of the most important benefits of adopting the technology relates to establishing the authenticity of inventory along the supply chain. Counterfeit and diversion activities, especially in high value retail products such as electronics and pharmaceuticals are significant challenges faced by suppliers. RFID enables high levels of inventory visibility that could assist suppliers in countering future claims.

The market is slowly progressing away from the 'slap and ship' approach adopted by most suppliers who were focused on meeting the mandate deadlines. Integration of RFID technology within each step of the business process would necessitate significant investments by retail suppliers and consumer product goods (CPG) manufacturers. The market is currently concentrated on tagging returnable transport items (RTI) such as pallets and cases. The existing cost of technology does not allow for a favorable return on investment (ROI) at the individual item level for low value consumer products. Most of the retailer mandates have also necessitated their suppliers to tag pallets and cases with RFID technology. Individual retail consumer products are likely to be tagged after 2008 when the prices are expected to witness a further decline.

The ROI at the item level tagging is immediately evident to retail suppliers in the following scenarios:

- In case of high value consumer products such as electronic durables and apparel where the cost of the tag is absorbed without any significant effect on the profit margin.
- In case of products such as DVDs, CDs and pharmaceuticals that are highly susceptible to counterfeiting and diversion activities.

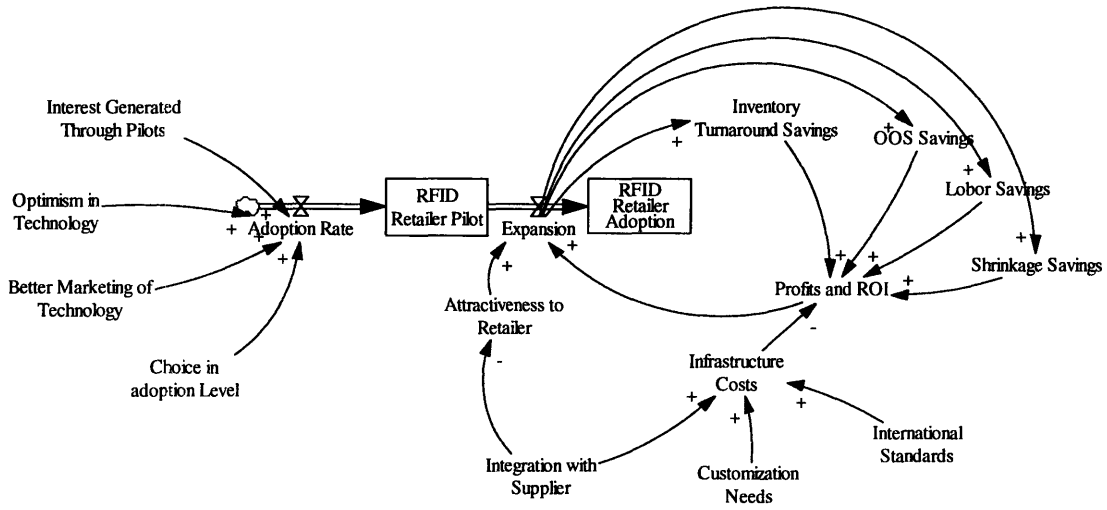
The demand for tags is therefore expected to witness a significant increase with suppliers tagging most of their product lines by early 2008 in North America and Europe. The market for RFID tags is expected to maintain steady growth rates after this period since investment in this regard is likely to be of recurring consequence. The demand for other hardware components such as readers and middleware integration services is expected to grow with an increase in the number of suppliers adopting the technology.

The entry of large software and consulting companies into the RFID space is expected to further the evolution of the technology with enhanced research and development (R&D) efforts. The trend towards technological maturity is expected to drive interest levels among major retail suppliers. The sustainability of growth within the market would depend on end - user approach towards employing the technology. RFID adoption is likely to be more focused on business change rather than merely technological changes.

Constraints for RFID adoption:

- Anything more than slap and ship needs significant more investments
- Item Level Tagging is cost prohibitive for most items in the supply chain
- Lack of collaboration amongst trading partners especially retailers and logistics providers.
- Data Management Capabilities lacking at suppliers end.
- No clear ROI benefits seen yet.

Analysis: Retailers Value Proposition



What do retailers want?

Retailers are currently the most likely beneficiaries from RFID initiatives. They have demonstrated tangible ROI as seen in the case of Wal-Mart's ROI case study by University of Arkansas. What has not been clearly demonstrated or captured is the effect on retailers due to better customer service. Superior end-user experiences drive the need for the synchronous response in a retail enterprise. With products being packaged differently to suit retailer needs, and with more value-added resellers finding favor with retailers, the retail landscape has reached a phase where retailers are deliberating upon balancing better ROI with better shopping experiences for costumers at the point of sale. Hence, retailers prefer vendors that have a partner-like approach in this regard, sharing the dangers of risks and losses, as well as the rewards. In the current scenario, the market needs hundreds of systems integration companies with RFID capabilities; and hundreds of thousands of individuals knowledgeable in this technology to meet current and future demand. The industry has a gamut of participants including RFID solution/product suite providers, RFID middleware, software or hardware providers and participants who partner with companies who have technical expertise in some other arena. Shortage of skilled manpower is one of the many challenges facing the industry.

Retailers are allocating more budgets for RFID these days and that is very encouraging considering the opportunities for the vendors that exist in this rapidly burgeoning market. In short, the rate of technology adoption in the retail industry is accelerating and retailers are using RFID for supply chain, demand forecasting, and integrating that into business systems for overall enterprise function success.

Interests Generated Through Pilot Trials

Three of the world's largest retailers, Wal-Mart, Tesco and METRO, including many others, have made significant advancements in their RFID programs. Target and Albertsons are the other major retailers who have been the early adopters of RFID. Reportedly, the benefits have surfaced prominently, including reduction of inventory and out-of-stock conditions at the store level, which has led to a situation which could lead to demand being forecast better. In this scenario, Wal-Mart has installed close to 15,000 pieces of RFID related hardware at more than a hundred Wal-Mart outlets, club stores and distribution centers. Tesco is hoping to save better in the supply chain and reduce costs, through the use of RFID. Hence, with such aggressive RFID ambitions and vision, the end result could be the advancement of the use of EPC and RFID worldwide and hence the technology compliance and adoption could fall within the fixed timelines. An analysis into exactly where costs could be cut down reveals that right now, transponder costs are huge, and that seems one area where cost reduction could happen without sacrificing efficiency of operations. Item level tagging is currently not prevalent and is expected to take a few more years to completely gain ground. Electronic Data Interchange is a major process with function involving RFID. The pilots have revealed that the data generated through the RFID scanning process could enable better stock handling. RFID offers the potential of eventually moving toward a totally automated warehouse thus helping in achieving productivity gains. Pilots' successes have indicated that improved decision-making is the advantage involved : Real-time visibility to supply chain assets is provided and detailed product info is gathered. Pilot trials are expected further realize better and bigger advantages, and the interest level created through success of these pilots done for a particular product portfolio at a store or a distribution center could see the implementation gain a clearer picture.

Case Level RFID

Case level implementation involving RFID is what retailers are after right now. Streamlining the supply chain operations, including better knowledge about goods shipped and received, have had an excellent impact already. The retailers have realized that whether it is a pilot or roll out, ROI would just be a matter of time, with success almost assured, though timeline for predicted ROI is a factor. When a read/write RFID tag is used, it is possible for retailers to reuse the tag over and over again,

eliminating labor costs and the expense of repeated bar coding. The advantage is that read/write tags offer the ability to read and overwrite stored information. Inventory control is best achieved through RFID. Accounting discrepancies are now eliminated through the use of RFID. Another reason RFID is initially taking root in the warehouse environment vs. the store is the cost. The focus is on shipping containers, pallets and cases because there are fewer of them. Companies actually bear more cost in this arena than on the front end, primarily because the tags can be reused.

More Choices in Level of Adoption

A significant driver of the overall cost incurred in RFID is the level of adoption. The retailer can choose whether to track inventory at the pallet or the case level. The highest level of tracking is at these two levels and due to the typical ratio of cases to pallets, it has the highest associated implementation costs. Another key driver in determination of the business case for RFID is the average cost price of the cases/pallets that are being tracked. It is possible to introduce RFID technology to control the movement of higher value goods within the supply chain.

Supply Chain Applications-Increasing ROI

Supply chain applications are the fastest-growing RFID segment. Most pilots revolve around placing RFID tags on cases, pallets or reusable plastic containers. The benefits, thus far, include improved inventory control, reduced labor costs, greater control and accuracy involving data and reduced shrinkage. The supply chain applications that have evolved over the years have become the main points where RFID has been applied in the RFID processes cycle. With increasing ROI always being realized over the supply chain, this is a major driver for the market, and the impact is likely to be high in future.

Word of Mouth

With better marketing of the technology, the industry is now at a point where there is huge interest in the technology and the features that make it special. The retailers who are interested in it cut across the revenue barrier as such, but the practicality allows only the biggest retailers(typically $5.00 billion and above in revenues) to pilot and roll out the RFID technology across their stores and distribution centers. The interest that has been created due to the better marketing of the technology is tremendous and is likely to see the technology become available to retailers at a much lower price than what is offered to them now. Better marketing has certainly been an effective driver and is likely to be one in the years to come, as more retailers equip their stores and distribution centers with RFID.

Prevalent Optimism Regarding Huge ROI

The RFID market for retail is big business and the retailers including the biggest in the world like Wal-Mart, Target and Albertsons have sped up operations on this front and are very optimistic about the huge impact and ROI RFID can have in return on the expensive initial investments. Hence, the

market is set for a bright phase, with companies willing to spend a million on pilots alone and hence, test the veracity of the solution design for their business case. This optimism is seeing the vendors bring out specific solutions that fit each retailer and do feasibility analysis with them that could lead into pilot trials and a roll out, ultimately.

Along with all the encouraging critical success factors to adoption, the retail RFID market has been impeded in its growth by quite a few factors. These are analyzed as follows.

High Costs Involved in Implementation

Though RFID being a technology for the future, the benefits associated with RFID come at a huge price. The benefits of RFID related to lower labor costs and reduced theft represent only one portion of the advantages. To gain the biggest benefits of RFID, companies will have consider supply chain planning and implement RFID with vigor and confidence. Though the portion involving justifying the costs comes into the picture, the larger picture features retailers of all tiers and segments, and hence costs have to be balanced at an optimum level with implementation or pilots being carried out in the limited capacity. The major point to consider is to find how RFID can help realize better business operations. In such a scenario, the huge costs of deploying RFID and the initial investments towards that prove to be a roadblock in the long run towards complete RFID adoption in the market.

Adoption, Conversion Costs and Patent Royalties

Transponder manufacturers have already developed UHF technology taking into consideration the new power limits (certain restrictions which are in place with regard to technology usage). There are new rules regarding power limits and hence, tests will have to be carried out when the new rules come into force. This is expected to be associated with a sizeable expense, but the market growth is not expected to be deterred in a huge manner due to this factor alone. Patent royalties are extremely critical, and EPC global, the global standards organization, is trying to reach an agreement with all participants to provide the technology without a license. The only catch that exists here is that, not all patent holders are members of EPC global. Thus, general freedom from license fees is not essentially expected to be a fall-out of this. Extremely strong patents' existence translates into better and careful use of the technology and its applications. It is a known fact that, manufacturers will have to pay licensing fees - but that has to remain at an acceptable level, for widespread acceptance of this fact. There are thousands of patents relating to RFID, and the situation calls for better understanding between the patent holder (research person/ IT firm) and the manufacturer.

Issues Over Internationally Usable Frequency Bands

The radio frequency bands are managed by state-run organizations. The 13.56 Mhz frequency (HF) is used internationally and many products have incorporated this particular band, including some

printers interfaced with RFID technology. RFID frequencies in the UHF band are typically from 860 Mhz to 960 Mhz, depending on the region. Currently, in this band, there are no frequencies that can be used uniformly throughout the world. A frequency of 915 Mhz is used in the US and 868 Mhz in Europe. The situation is similar in other countries in Asia, and with Japan soon expected to approve of a particular RFID frequency band. If the RF transmit power level for Europe and the US come closer, then the different RF modulation methods used in Europe and the US will result in discrepancies when the systems are used in the UHF band. Regional differences in the UHF band are compelling manufacturers to offer UHF tags and UHF readers that are specific to certain countries or regions. This is impeding growth of the market right now and should be overcome for better ROI in the future. China has decided to have its own RFID standard called the R1. It is a significant development as china is the first mile in the supply chain for more than 60% items consumed by large retailers like Wal-Mart.

Technology Concerns

High-frequency (HF) technology is hugely regarded as best suited for applications on the item level(because of shorter reach and single window reading system), and ultra-high frequency (UHF) technology, with its greater reach but uneven reading range is favored for reading cases and pallets. When compared with UHF technology, HF is a mature technology that has been in the market for quite some time now. RFID tags, when used for metal and liquids, are recording inefficient read rates. HF tags are better when compared to UHF tags for items involving liquids. That all RFID frequencies are affected by metals is a known fact. The reading range both for HF and UHF technology is reduced by metal. Also, RF energy is absorbed by metal, which is another factor to consider. Tags that have been read simultaneously, also pose a problem - anti collision. Passive tags comply with EPC class 1 or class 2 and hence, have a built-in anti-collision function for all bands. This makes it possible to read tags simultaneously with accuracy of over 98 percent at high speed. Various physical properties make it much easier to read many HF tags simultaneously in a small space than to read UHF tags. In this scenario, with many doubts prevailing over the exact use of the technology and the physics that go with it, the retailers are waiting for more safe and secure technology to fall back on, which acts as a restraint to the market.

Value Proposition through RFID implementation for retailers

Retailers can expect extensive inventory and labor cost savings from the adoption of radio frequency identification (RFID) technology, but some consumer product manufacturers will face higher costs and delayed benefits from adopting the technology. An annual benefit that could evolve from a reduction in store and warehouse labor expenses of 7.5 percent and a reduction in out-of-stock items

is to the tune of $700,000 per $1.00 billion in annual sales for retailers who re-engineer their current shelf fulfillment processes; and these are further advantages RFID offers to retailers. The cost of EPC and RFID adoption for retailers is estimated at $100,000 per distribution center and $50,000 per store, with an additional $35.0 to $40.0 million needed for systems integration across the entire organization (for implementation on a large scale involving many distribution centers and stores).

Areas to Invest and Investment Patterns in In-Store Automation

Retailers most often are faced with issues over excessive data that exists across their enterprise. The key to successfully begin down the path to an RFID-enabled environment is to effectively manage data within their own stores and distribution centers. Retailers are foreseeing the scenario when their systems could be better managed with the help of better data integration. The focus is on synchronizing data and making read points differentiate effectively between chunks of data. The synchronization process involves many thousands of cases and pallets and the products within them. Hence, information on all of these has be accurate and in sync with the other bits. Some retailers deploy software that allows them to better manage customer data across multiple business channels. The intent is to enhance customer service, boost loyalty, and hence better implement customer relationship management (CRM).

Regardless of the path they choose, data integration has been identified as a top priority for most retailers. Data management is the key to unlocking the potential of the inherent power in deploying RFID. It also holds huge potential for cost savings and better customer satisfaction. But, compliance with data security and privacy laws are mandatory. Given that data management and data integration are the prime points of focus, RFID roll outs are increasingly seeing repeated measures to ensure that this could be handled well. An investigation into where retail companies are spending capital reveals that while investments in systems that enhance the back-end have garnered the better share of attention for years, retailers are talking about the role the store environment can play in the quest for competitive differentiation and customer satisfaction. Improving the store experience is extremely critical for the store's expansion. Retailers are also expected to allocate a portion of their IT budgets in RFID-specific hardware, software and middleware, hence suggesting that RFID is a technology for the future. Hence, retailers are pushing to be more successful at using these tools to improve the shopping experience, and hence to realize greater potential to increase revenue through up sell and cross-sell opportunities.

Challenges in the RFID World

Evolution of standards[12]

RFID standards define a set of rules, conditions, or requirements that the components of a system (tag, reader, and database) must meet in order to operate effectively and that are needed to cover the air-interface operational requirements, ensure that tags meet intended designs,

Setting standards in RFID is an extremely complex activity as multiple organizations, including international, national, private-sector, and industry organizations, are involved in the development of RFID standards. Some important players in the standard setting space are:

International Organization for Standardization (ISO)	A network of national standards institutes from 148 countries that works in partnership with international organizations, governments, industry, and business and consumer representatives to develop technical standards.
International Electrotechnical Commission (IEC)	Produces international standards for electrical, electronic, and related technologies. Its members include manufacturers, providers, distributors, vendors, consumers, users, all levels of governmental agencies, professional societies, trade associations, and standards developers from over 60 countries.
International Civil Aviation Organization (ICAO)	Chartered by the United Nations to regulate international aviation and includes the United States and 188 other nations.
Institute of Electrical and Electronics Engineers (IEEE)	With more than 360,000 members in approximately 175 countries, the organization, through its members, works in the technical areas ranging from

[12] GAO report on RFID standards

	aerospace, computers, and telecommunications to biomedicine, electric power, and consumer electronics.
Comité Européen de Normalisation (CEN)	Contributing to the objectives of the European Union and European Economic Area with voluntary technical standards.
European Telecommunications Standards Institute (ETSI)	Produces standards for telecommunications, broadcasting, and related areas, such as intelligent transportation and medical electronics.
American National Standards Institute (ANSI)	Promotes and facilitates voluntary consensus standards and conformity assessment systems and safeguards their integrity.
British Standards Institute (BSI)	Works with government, businesses, and consumers to represent the United Kingdom's interests and facilitate the production of British, European, and international standards.
Japanese Industrial Standards Committee (JISC)	Consists of many national committees and plays a central role in standardization activities in Japan.
Standardization Administration of China (SAC)	Authorized to exercise the administrative functions and carry out centralized administration for standardization in China.
AIM Global	Working with its members, AIM Global develops standards and practices for automatic identification and data collection technologies.
EPCglobal, Inc.	A joint venture between EAN International and the Uniform Code Council. Its subscribers include manufacturers, retailers, wholesalers, carriers, government, hardware and software companies, consultants, systems integrators, and training companies. EPCglobal has developed a series of specifications for use in the supply chain.

Automotive Industry Action Group (AIAG)	With more than 1,600 member companies which include North American, European and Asia-Pacific OEMs and suppliers to the automotive industry, the organization developed standards for use in the automotive industry and its goals include reducing cost and complexity within the automotive supply chain.
International Air Transport Association (IATA)	It is an inter-airline cooperation in promoting safe, reliable, secure, and economical air services - for the benefit of the world's consumers. It has over 270 members from more than 140 nations.
Universal Postal Union (UPU)	With 190 member countries, it is a specialized agency of the United Nations that governs international postal service.

The 3 major types of standards bodies as International Organizations, National (Regional) organizations and Private Sector organizations. International standards-setting organizations generally develop standards through a process that is open to participation by representatives of all interested countries, transparent, consensus-based, and subject to due process. ISO and IEC are actively involved in developing RFID standards for international use. ISO is an international association of countries, each of which is represented by its leading standards-setting organization. The scope of ISO is broad and includes all fields except electrical and electronic standards, which are the responsibility of IEC. ISO and IEC have jointly created several RFID standards.

National standards-setting organizations facilitate the development of national standards for use within their country. For example, the American National Standards Institute (ANSI) represents the United States to ISO and facilitates the development of U.S. standards. ANSI, as well as other national standards organizations, is involved in the development of RFID standards. For example, the Standardization Administration of China has established a National RFID Standards Working group to draft and develop a national standard.

Private-sector organizations involved in the development of RFID standards can represent a single industry or multiple industries. For example, the Automotive Industry Action Group, universal Postal Union, and International Air Transport Association have developed RFID standards for their

respective industries. Private-sector organizations that represent multiple industries can develop a standard for a specific application. For example, EPCglobal Incorporated, which partners with various industry groups, has developed a series of specifications that DOD and various private-sector users are implementing in their supply chains.

Separate Standards Have Been Developed for Specific Applications

The standards-setting organizations have developed separate sets of standards governing RFID systems for specific applications. The standards used often depend on the type of activity the application is used for and the industry or country in which it is used. Requirements of applications often differ, and a single, common set of standards may not meet the needs of all applications.

RFID applications such as supply chain, animal tracking, and access control use separate standards because the needs of these applications differ. As previously mentioned, the frequency used affects the performance of tags in certain environments. For example, an animal tracking application will likely use a standard that specifies the use of the low-frequency range because this range performs well in environments that require reading through materials such as water and body tissue. An access control application that requires a read range of approximately 3 inches and the ability to read multiple tags simultaneously would likely use a standard that specifies the use of the high-frequency range. A supply chain application may likely use a standard that specifies the use of the ultrahighfrequency range because this range provides a read range of up to 15 feet and a read rate of 100 to 1,000 tags per second.

Industries such as the automotive, postal, and aviation, use standards for industry-specific applications. They may use standards developed by industry standards-setting organizations or standards developed by other standards-setting organizations, such as ISO, IEC, and EPCglobal. For example, the aviation industry uses a standard created by an industry organization for identifying airplane parts by means of bar code and RFID technologies. This standard requires the use of an ISO standard for tracking parts.

There are also applications that only operate in a specific country. These applications, such as national identification cards, may be governed by national standards used only within that country.

Global Interoperability of RFID Systems May Require International Standards

For applications where global interoperability between systems is necessary, such as electronic passports or global supply chains, a common set of international standards can assist with proper interaction and interchange of information between systems. For example, global interoperability of machine-readable travel documents requires the use of a common international standard. As previously mentioned, the U.S. Department of State has reported plans to use RFID technology in its electronic passports. The United States and other countries are anticipating using the International Civil Aviation Organization (ICAO) Document 9303 standard, which prescribes an international format for passports, visas, and other official machine-readable travel documents. To maximize the global interoperability of supply chains using RFID technology, it is important to ensure that the standards chosen can be used in all relevant markets. Interoperability of global supply chains using RFID technology means that tags used in one country can be read easily by readers in other countries. ISO's item management standard for frequency interoperability includes its ISO 18000 series. This series addresses issues such as generic air interface parameters for globally accepted frequencies and air interface communications parameters at different operating frequencies. To complement ISO's standard, EPCglobal has proposed its Generation 2 standard. EPCglobal claims that this standard will allow for global interoperability of systems built to it for supply chain management because frequency and power level used within this standard comply with most relevant markets.

Security and Privacy issues

Several security and privacy issues exist that are related to federal and commercial use of RFID technology. The security of tags and databases raises important considerations concerning the confidentiality, integrity, and availability of the data on the tags, in the databases, and in how this information is being protected. Measures to address these security issues, such as compliance with the risk-based framework mandated by FISMA and employing encryption and authentication technologies, can help agencies achieve a stronger security posture. Among the key privacy issues are notifying individuals of the existence or use of the technology; tracking an individual's movements; profiling an individual's habits, tastes or predilections; and allowing for secondary uses of information. While measures to mitigate these issues are under discussion, they remain largely prospective.

Security Considerations Relate to Data Confidentiality, Integrity, and Availability

Several companies identified data confidentiality, integrity, and availability as key security considerations with implementing RFID technology. Few organizations reported having implemented or having a specific plan to implement secure RFID technology. Specifically, these issues included ensuring that only authorized readers or personnel have access to information, maintaining the integrity of the data on the chip and stored in the databases, and ensuring that critical data is fully available when necessary. Other issues with implementing the technology included the potential for various attacks, such as counterfeiting or cloning, replay, and eavesdropping; the possibility of electronic collisions when multiple tags and/or readers are present; and the presence of unauthorized components that may interfere or imitate legitimate system components.

Conclusion

RFID is a business strategy, not an IT strategy. It involves transformation of business processes, collaboration with customers, retailers, other supply chain partners, and third-party service providers. Nevertheless, developing and implementing an EPC-based RFID mandate compliance strategy requires heavy IT involvement along with a deep understanding of current business systems and IT infrastructure and several facets surrounding the exchange of standardized data. As seen via various case studies, every player in the value chain derives benefits from using RFID. Retailers have demonstrated a very clear ROI. Suppliers / Manufacturers will need to identify the right business case for RFID to provide an immediate ROI. RFID is unlike any technology that we as an industry have seen in the past. It's extremely complicated and very costly, yet we believe it is inevitable that RFID will be a transformation agent throughout our supply chain for packaging, manufacturing, logistics, and retailing.

Suppliers and Retailers may both consider the following strategy for deploying RFID:

- Analyze the dynamics in the value chain: RFID has to be looked upon as a continuous process flowing across boundaries of an organization. The entire value dynamics has to be thought of before any single piece of the value chain makes a decision of implementing RFID. Highest benefits are seen where the whole value chain is either a closed loop environment or is very well coordinated / mandated.
- Understand all the challenges: This can be achieved by forming heavy weight innovation teams within an organization and conducting pilot projects
- Get started: Implementing RFID takes time. Waiting until RFID stabilizes or until customers require RFID as a condition of doing business could force companies to rush into less than optimal solutions that cost more and provide greater business disruption. Waiting could also allow competitors to gain competitive advantage by being better positioned to meet RFID mandates.

Costs and complexities related to RFID will be reduced over time, and experiential learning related to RFID projects will make today's hopes for RFID a reality. As with anything new and unproven, each business must choose how and when to adopt RFID. Waiting for RFID to become 100 percent proven, understood, and standardized may seem to be a safe decision on the surface, but we believe it is also a losing strategy. Instead, we believe it's time to move forward with RFID — using clear business goals as a compass. We do not believe RFID is

simply a matter of mandate compliance. Instead, we believe RFID R&D and mandate compliance can ultimately be leveraged for internal operating efficiency and also for competitive advantage. As studied in this exercise, the value dynamics is very different for each individual component in the RFID landscape. Further work as a follow up to this exercise may be an advanced study of value dynamics across the spectrum or a combination.

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