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EMERGING TRENDS IN RFID

Five Questions This Chapter Will Answer

What kind of advances in RFID tag design should I expect?

Are there any emerging computer hardware or software advancements that will help the deployment of RFID applications?

Is item-level tagging hype or reality?

What are the important catalysts for the widespread adoption of RFID?

What does subcutaneous tagging have to do with RFID adoption in the enterprise?

The etymology of the word *trend* denotes both movement in a general direction as well as roundabout twists and turns. Early potters could not possibly have predicted the various turns the wheel would take during the 8,500 years after it was first invented. Similarly, it is unlikely that Michael Faraday could have imagined any of today's RFID applications when he discovered electromagnetic induction.

Technology trends, in particular, are not only shaped by technological invention and advancements but by economic, social, and political factors. These add a new dimension of complexity to predicting the ultimate disposition and acceptance of trends.

Keeping all these complexities in mind, we have identified the top emerging trends associated with RFID that are expected to drive its ubiquitous adoption. These trends fall into the following categories: Technological Advancements, Business Process Innovations, Evolving Standards and Legislation, and Consumer Application Innovations.

In this chapter, we use these categories as anchor to do the following:

- Take stock of where RFID technology stands today
- Discuss the recent innovations around RFID
- Examine key factors that will influence its evolution

Technological Advancements

Technological advancements are the high-octane fuel that powers the continued acceptance and growth of new technologies. These advancements can provide the following advantages:

- Make existing applications easier to use
- Offer more functionality
- Be cheaper to implement
- Drive deployment costs down

Technological advancements open the door for new applications that were not imaginable or possible before. In the following section, we explore some of the more significant technological advancements that are under development today.

New and Improved Tags

Innovation around the design and manufacture of RFID tags is an ongoing process. Some of the most promising new designs are covered in the following sections.

Alternative Tag Designs

Many factors affect the readable range and accuracy of tags including those that are physical and environmental. Some examples are detection near metal or liquid and extreme weather conditions such as low temperature or high humidity. Besides simply improving on existing technology to overcome these limitations, alternative physics are being employed that can sidestep or leapfrog these limitations.

The majority of the work in the alternative physics area includes developments around chipless tags, introduced in Chapter 3, "Components of RFID Systems." Chipless tags promise to improve upon the physical limitations of radio frequency detection while potentially offering reduced costs due to the absence of integrated circuitry. Chipless tags can be more easily applied to metal and liquid or embedded in items like paper, thereby offering greater flexibility and functionality in connection with their use. One chipless tag technology showing promise in supply chain applications uses Surface Acoustic Wave (SAW) technology. SAW technology involves the propagation of radio frequency acoustic waves on the surface of polished crystals. Other promising chipless technologies that have the potential to revolutionize RFID applications use nanotechnology, genomics, or even chemistry to achieve chipless tagging and unique identification of objects such as paper currency and product labels. CrossID, Inkode, Pharmaseq, RF SAW, and Tapemark are just a few developers and suppliers of chipless tag technologies and solutions.

When it comes to major advancements in IC-based tag design, Smart Active Label (SAL) technologies are gaining momentum in the market. SAL offers enhanced range and accuracy attributes while being less vulnerable to liquid or metal. With packaging similar to passive tags that are used in flexible mediums, such as labels, SAL is essentially a semi-active tag with a power source in the form of a thin, flexible battery. Using SAL labels, tagging and detecting cans of soda and bottles containing liquid can become more practical and economical.

Tag Packaging

Tag packaging plays a significant role in the applicability and practicality of specific uses of RFID. Expect to see tag and antenna packaging designs that will continue to push the envelope of creativity and ingenuity, much as injectable and ingestible tags

have done in the past. Chipless tags based on nanotechnology will certainly be at the forefront of such developments.

Another entirely different approach to tag packaging that is very promising is related to printed electronics. This involves the process of "printing", antennae, transistors, or even integrated circuits using conductive ink and standard printing processes. The potential to inexpensively print a tag onto a box or the packaging of an item unlocks a new set of possibilities for the widespread application of RFID in everyday items. Already, a company called Precisia has designed a smart label RFID tag that uses conductive ink—instead of copper—for its antenna.

Sensory Tags

Tags whose packaging integrates them with sensors can monitor, record, and even react to all sorts of environmental conditions. Known as sensory tags, these tag types promote an entirely new set of applications. The major advancements here will be around the coupling or combining of RFID tag technology with sensor technology in very small form factors. Smart Dust is one such combination that offers the functionality of tiny environmental sensors known as MicroElectroMechanical Sensors (MEMS) with active RFID tag-like capabilities. Each such device is expected to be one cubic millimeter in sizei. The potential applications of this technology span a wide area, from monitoring battlefield activities in a military operation to tracking the facial movements of the disabled to control their wheelchairs.

Architecture for the New Network

RFID systems generate mountains of new data that need to be synchronized, filtered, analyzed, managed, and acted upon, often in real-time or near real-time. Each tag is essentially a single computing device, albeit a very simple one, that acts as one node in a network of, eventually, billions or even trillions of such devices. This new network is dramatically different and in many ways more complex than even the Internet, the most complex network ever known. This fact is due primarily to the number of nodes that could exist in the expanded model of a worldwide RFID network, which figures to be several orders of magnitude larger than the number of nodes on the Internet. This simply means that traditional computing architectures and infrastructures will not be adequate to handle the dramatically higher data volumes expected in such a network. Next, we discuss two different approaches under development that address these new requirements, from both the hardware and software viewpoints.

Q: Where will all this RFID data come from?

A: Consider the scenario where a major retail chain will be tagging all its goods in all its stores, at the single item level. The number of tagged items in this scenario can easily reach 10 billion or more. This means that the data identifying the 10 billion items amounts to 120 gigabytes (10 billion X 12 bytes per tag). If these items were read once every 5 minutes somewhere in the supply chain, they would generate nearly 15 terabytes of tracking data every day (120 gigabytes x 12 times per hour x 10 hours per day). That's 15 terabytes of additional data generated by one retail chain every day. Using this formula, 10 major retailers tagging and tracking every item will generate 150 terabytes of data. This is bigger than the estimated 136 terabytes of data from 17 million books in the U.S. Library of Congress[1]. Obviously, a great majority of this RFID data is duplicate and will likely be discarded. However, all this data needs to be processed, examined, and acted upon, even if such action means simply ignoring the data.

We use item-level tagging (a more distant scenario) to demonstrate the eventual avalanche of RFID data. However, you can apply a similar formula to calculate the amount of data for a more immediate scenario: case- and pallet-level tagging. Although the volume of data in this case is an order of magnitude smaller, it still represents several orders of magnitude more data than a pre-RFID scenario.

Microprocessor Design

Several computer giants are revising their microprocessor development roadmaps in favor of a new microprocessor architecture called Chip Multi-Threading (CMT). One of the pioneers in this area is Sun Microsystems which has already introduced the first design of this new architecture. This is just in time for the expected volume spike from RFID data as the US Department of Defense (DoD) and major retailers around the world go into full deployment mode with their RFID mandates. Simply put, CMT architecture bucks the trend of traditional microprocessor design and architecture that primarily seeks to perform single tasks faster and faster. Instead, CMT is an architecture that allows the efficient execution of many tasks simultaneously. This is parallel computing taken all the way to the core of the microprocessor.

1 Source: University of California, Berkeley: How Much Information 2003? http://www.sims.berkeley.edu/research/projects/how-much-info-2003/

Peer-to-Peer Computing

Although the data generated by RFID systems can easily reach trillions of bytes that need to be processed almost instantaneously, in fact, much of the data is disbursed across one or more enterprises, and often, across the globe. This suggests that local processing of data, by RFID readers, before passing it along to a centralized computer can dramatically reduce the burden placed on centralized computing resources. This is an excellent scenario in which to apply Peer-to-Peer (P2P) programming techniques to perform RFID-related data processing locally. P2P technology is a type of distributed computing technique that decentralizes computing tasks across several less powerful cooperating computers (peers) within a network.

Expect RFID readers to become increasingly more intelligent. Readers will perform many of the data processing, analysis, and management tasks within a local network of cooperating tags and readers. They will accomplish what today is mostly done by centralized computers.

Falling RFID Tag Price

With RFID technology, cost of components, especially cost of individual tags, will play a major role in determining its ultimate success and ubiquity. From an economic perspective, the cost of tags is expected to continue to drop as the volume production goes up to meet demand. However, both alternative chipless tag designs and advances in fabrication and manufacturing of integrated circuits (IC) are expected to drive the cost of tags dramatically lower. The *5 cents tag*, as it has been called, has been widely viewed as the inflection point where wide adoption of RFID will quickly occur. To be clear, the supply and demand equation alone is unlikely to drive the price of IC-based tags down to the 5 cents mark. Today, tag prices barely dip below 25 cents, even with existing high volumes. Therefore, alternative tag designs and more efficient tag manufacturing are likely to be important factors in driving the cost of tags down by another factor of five.

Business Process Innovations

As we've already discussed, for a technology to succeed and proliferate in today's world, it must be economically viable. In other words, it must enable businesses to meet one or more of their primary economic needs: reduce cost, increase revenue,

and provide a competitive advantage. These objectives compel enterprises to innovate by examining existing business models and processes and reinventing or realigning them to fully take advantage of a new technology. We have just scratched the surface in business innovation that takes advantage of RFID technology.

Much of the impetus for future waves of innovation in RFID can be credited to the mandates set forth by major retailers around the world and the U.S. DoD. These mandates have created a ripple effect across the entire supply chain industry. Mandates have caused all supply chain partners including manufacturers, packagers, distributors, logistics and transportation agents, retailers, and wholesalers to examine ways in which they can improve the efficiency of their own supply chain systems.

RFID technology is already gaining good traction in certain areas of the supply chain such as warehouse management and inventory control. However, we are far from a fully integrated supply chain model. Although many technology and business leaders across supply chain enterprises agree that RFID offers tremendous promise, some argue that their short term return on investment (ROI) do not justify the initial cost of adoption—process re-engineering, re-tooling, and integration. Others are hesitant to make decisions without stronger standards, and most worry about privacy and related public relations issues. Despite these concerns, analysts have predicted tremendous growth for RFID in supply chain management during the next several years. For example, Venture Development Corporation expects the global shipments of RFID systems in manufacturing, logistics and retail markets to reach $4 billion in 2007, up from $1.25 billion in 2004[2].

In the following sections, we examine the most critical business innovation trends in the supply chain. These will lead the way to RFID's ultimate deployment across the entire supply chain, starting with raw materials, all the way through to the checkout stand at your local retail store.

Item-Level Tagging

Item-level tagging is arguably the final frontier for RFID deployment. This concept permeates almost every type of supply chain application. However, from a practical standpoint, item-level tagging is fraught with challenges. On the consumer side, a number of security and privacy issues create concerns and will impact its pace of

2 Source: Venture Development Corporation. Used by permission.

adoption. From the perspective of cost-effectiveness, the sub 5 cents tag will be key before the potential of item-level tagging can be realized. Although several pilots are under development already—for example, in large specialty retail and drug store outlets—expert and analyst opinion on the pace of adoption varies. Estimates of when item-level tagging at the retail store level becomes commonplace range between the years 2010 and 2020. Expect a slow but steady pace toward the item-level tagging of just about everything as the industry and consumers meet these challenges head on.

Third-Party Logistics Management

Retailers that are implementing RFID will have better and real-time visibility of the goods they carry in their stores. This, in turn, will help them become more efficient by enabling true real-time management of the links in the supply chain. Retailers may be able to eliminate their own distribution centers and receive goods directly from suppliers. Naturally, this will require suppliers to send goods more frequently, and in smaller quantities, directly to a larger number of retail stores, thereby shifting the equilibrium for handling and shipping costs. Expect third-party logistics (3PL) management services to include aggregation and distribution of RFID tagged goods. Major transportation and logistics companies such as UPS, as well as smaller specialized 3PL providers, will play a significant role in this area.

Real-time Inventory Management

Inventory management happens at every level of the retail supply chain: at manufacture time, during transport, around distribution centers and in warehouses, at both wholesale and retail levels. The recent mandates by major retailers will compel suppliers to continue to create new business models and applications that will not only help the retailers but the suppliers themselves, within their own four walls.

Expect a continuous stream of new applications in the inventory management area that offers new ways of making productive use of all the real-time RFID data. Applications already emerging—for example, from Checkpoint Systems, Inc.—include anything from real-time shipment processing and automated inventory updating at the distribution center to more effective merchandising and speedy point-of-sale operations at the retail store.

Business Intelligence

We've already seen how RFID enables access to lots of new data. The real value of this data is in leveraging it to make better business decisions. The capability to ask new questions or discover patterns in the data all provide more intelligence to a business, improve its decision-making capabilities, and help it become more competitive. Expect new data mining and analytics applications that help do that—by efficiently filtering and analyzing data that has never before been so readily available.

IT Outsourcing

Implementing RFID applications by definition means deploying expanded, or in many cases new, IT infrastructure. On the factory floor, in warehouses and distribution centers, in transportation vehicles, and in retail stores, new computers, applications, and RFID-specific components such as readers and antennae must be installed, integrated, and managed. The owners and operators of these facilities are not always ready and capable to handle this infrastructure by themselves. This creates many new IT outsourcing opportunities, particularly in the area of managed services. Expect an evolution of the already popular managed services model to include services that help manage RFID-related infrastructure and alleviate the need to duplicate new IT infrastructure when it can be avoided.

Real-Time Data Sharing for Total Supply Chain Integration

The highest level of efficiency in the supply chain occurs when *all* the participants in the supply chain can share information in real-time, not just between two immediate partners such as the supplier and the retailer. For example, consider a scenario where a retailer is running out of a particular type of sneakers. In a typical RFID application, the retailer would immediately detect this and order more sneakers from one of its suppliers. However, if the manufacturer of the sneaker also had access to this information, it could anticipate the demand and manufacture more of the same sneaker. Similarly, the supplier of the raw material would ensure availability of the appropriate material and the shipping partner would have immediate visibility into when it would be expected to handle the transportation logistics. This might seem like a far-fetched example, and today it is. The problem to be solved here is not so much

about RFID. It's more about the serialization, synchronization, and complex integration of data that needs to be shared among dozens of supply chain participants and partners. RFID has simply opened the door to facilitate this opportunity by making data more readily available and accessible. The recent RFID mandates in the retail industry and the EPCglobal standards for RFID in the supply chain are powerful catalysts that will continue to encourage enterprises to rethink their business models and deploy new processes and applications that extend the benefits of RFID to all their trading partners. Expect this scenario to develop gradually because the underlying economics are still evolving and improving, and the ultimate value proposition to businesses is often complex to articulate and implement.

Evolving Standards and Legislation

Standards and legislation will play a key role in shaping the future of RFID and its applications. In this section, we discuss the key trends related to them.

Industry Standards

As we discussed in Chapter 4, "Standards Related to RFID," EPCglobal established and supports the Electronic Product Code (EPC) Network as the worldwide RFID standard for immediate, automatic, and accurate identification of any item in a supply chain. Similarly, ISO has been developing RFID standards in several industries for two decades. Other local standards bodies and standardization initiatives are developing RFID-related standards in specific industries (for example, livestock), around certain technologies (for example, Smart Active Labels), and even relevant only to certain countries (for example, China). Although the moves toward RFID standards definitely constitute a trend, its evolution is far from complete. The process of developing standards is slow and includes review of opinions from industry participants. Vigorous and sometimes contentious debate and even opposing standards initiatives are often part of the process.

Government Regulations and Mandates

Government regulations regarding what items to monitor and report upon will serve as protections for entire industries or large populations. For example, tracking and reporting data about cattle might help to identify an outbreak of Mad Cow disease,

potentially saving the livestock industry of an entire country. Similarly, tracking the pedigree of dangerous medication can prevent fraud and counterfeiting, potentially saving the lives of numerous patients. Because society as a whole is the beneficiary of these types of applications, expect government agencies to provide subsidies that will offset the costs individual businesses might incur. Although business will indeed benefit from these applications, such benefits are often not always immediate enough to warrant voluntary investment by businesses.

Privacy Related Legislation

RFID's weakest link (from a supply chain perspective) exists between the wholesaler/retailer and the consumer. There are two reasons for this. First, a consumer does not necessarily have, or may not know of, a compelling reason to link one's identity and purchases to the rest of the supply chain. Secondly, consumers may have compelling reasons not to share this information. There are a number of ways that enterprises can foster trust and ways that consumers can benefit from connecting to the supply chain, as discussed in Chapter 10, "Security and Privacy." We can expect continued discussion and debate around RFID privacy from consumer advocacy groups, vendors, and lobbyists. Governments will be pressed to impose new privacy legislation to calm consumer concerns. Their challenge will be to balance the public and business interests.

Consumer Application Innovations

Consumer enthusiasm is a critical factor for the ultimate ubiquity of many technologies. The driving force behind creating such enthusiasm is application innovation that captures the consumer's interest and imagination.

In Chapter 1, "A Better Way of Doing Things," we described a number of RFID-enabled applications that directly benefit consumers. They include: access control, people monitoring, electronic toll collection, payment and loyalty, patient care, sports timing, and many others. RFID and its applications are all around us, and innovations frequently occur. In April of 2004, VIP patrons of the Baja Beach Club in Barcelona, Spain, received's syringe-injected RFID tag implants. This enabled them to pay for their drinks automatically, without reaching for their wallets—and they also enjoyed free access to the VIP area making them permanently "cool."

Elsewhere, a company called has introduced tagged golf balls that can be easily located using a lightweight handheld RFID reader around the golf course.

Expect vendors to continue to capture our imagination and get us hooked on RFID by introducing interesting, creative, and original applications.

Q: Why subcutaneous tagging?

A: Subcutaneous tagging, which involves injecting an RFID tag under the skin for identification and/or tracking purposes, is not a new concept. It has been used for identification of fish and domestic animals for more than a decade. However, innovative applications such as tagging club goers, and even tagging personnel to control access to sensitive offices or documents, leads to more consumer interest and enthusiasm, which in and itself will lead to a more receptive consumer psychology. You can only wonder how quickly subcutaneous tagging would take off if Britney Spears or Justin Timberlake decided to use it at their concerts as a means for purchasing memorabilia at a discount or for gaining backstage admission.

Summary

Thirty years ago, it was hard to imagine that anyone could do their Christmas shopping with a few clicks on a computer keyboard. Today, millions of people Christmas shop from the comfort of their personal computers at home. We now take for granted new conveniences of the Internet; using our computers to communicate with our peers half way across the globe or instantly selling shares of an underperforming stock we just read about moments before. However, back in the 1960s and 1970s, computers were only used by corporate giants or governments to perform complex mathematical tasks. The concept of networks and the possibility of connecting computers together to help make everyday life more convenient was only a vision of a few elite computer scientists. They recognized the inevitable as a function of economic feasibility.

Now in a rapid growth phase, RFID technology holds similar promise and will become as ubiquitous in our everyday lives as the automobile or the wheels that move it. This will happen as RFID technology continues to provide an undeniable value proposition and help reduce cost and increase revenues for businesses using the technology. Thus, the question of mass adoption of RFID becomes a matter of answering the following questions:

- Can RFID enable new profitable products and services?
- Can RFID help improve existing business functions and operations?
- Can RFID help increase competitive advantage?
- Can RFID provide more value-added services and products to the consumer?

The answer to all these questions is, of course, yes. Today, we are well underway toward the ubiquitous adoption of RFID technology. There are already hundreds of millions of tags used in our everyday life—from tags in our car keys to tags around our luggage handles. We use RFID technology when we enter our office buildings or when we pump gas. We use RFID in our hospitals and in marathon races. The next phase for RFID is adoption within the supply chain, the supply chain of anything that ends up in a retail store—bottles of cough syrup, boxes of cereal , children's toys, office equipment, furniture, and so on. The retail store is the last stop for true mass adoption of RFID technology. The journey there requires many steps and will take some time as the economics continue to become more favorable.

Ultimately, RFID will achieve its full potential, as have other great technologies. It will usher in a new economic, business, and consumer revolution much like the automobile did when in 1914, Henry Ford opened the world's first automobile assembly line and revolutionized the face of transportation as we knew it.