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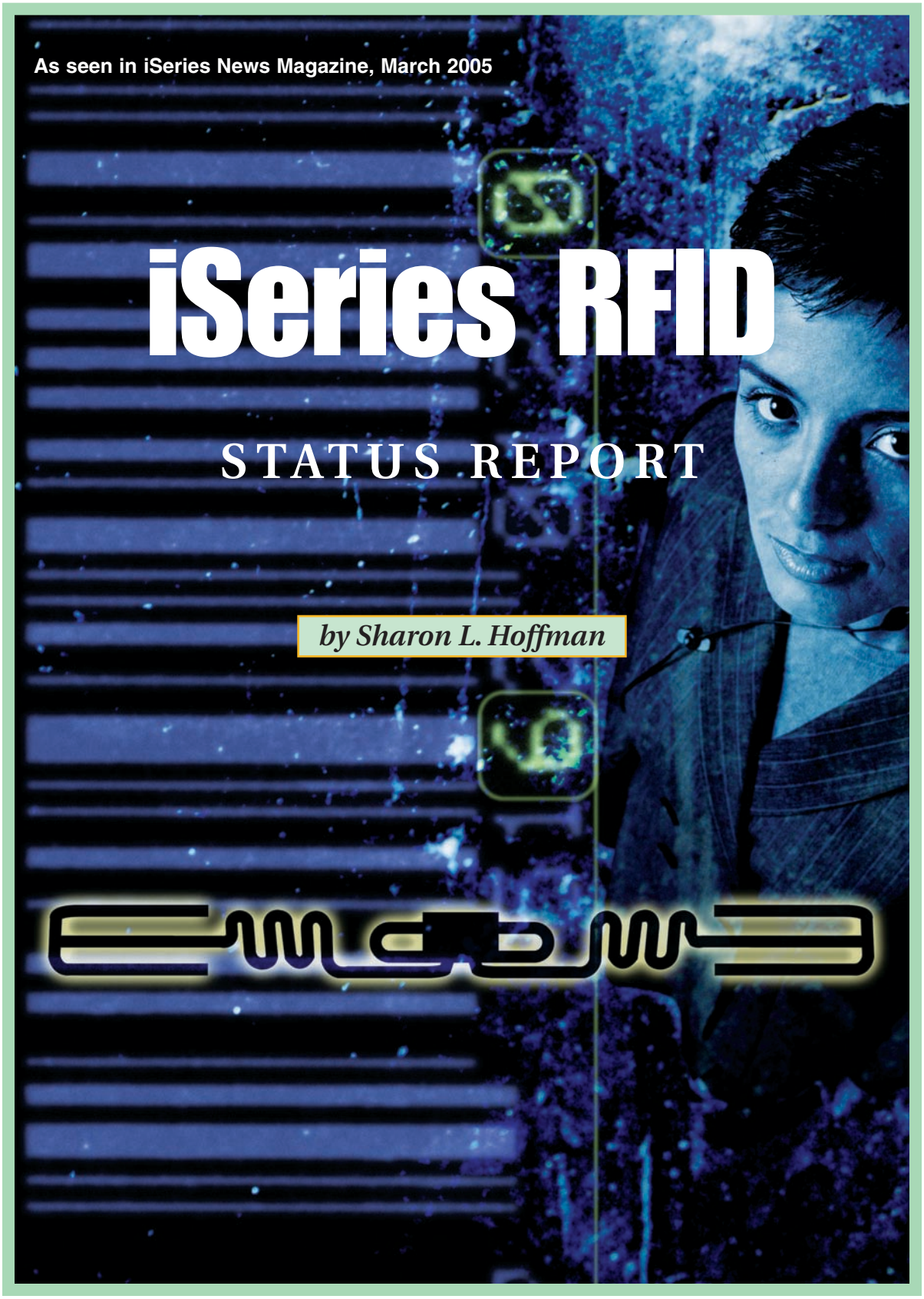
iSeries RFID

STATUS REPORT

by Sharon L. Hoffman



In 2003, Wal-Mart and the United States Department of Defense (DoD) independently issued directives requiring their suppliers to begin labeling shipments using Radio Frequency Identification (RFID). Wal-Mart and the DoD are phasing in RFID by asking large suppliers, such as Procter & Gamble, to RFID-tag selected pallets and cases. Since 2003, dozens of other organizations, including several major retailers and government agencies, have initiated RFID projects. It's becoming clear that RFID will eventually be ubiquitous in industries such as retail, distribution, manufacturing, and health care, but it may take some time before the full impact is felt. At the beginning of 2005, we took stock of the RFID landscape in general and its potential impact for the iSeries.

RFID Capabilities

RFID is often compared to bar codes because the two technologies deal with the same essential task — identifying items such as a pallet of books, a car, or even a human being. RFID tags are available in a wide range of formats, including packages that resist heat and harsh chemicals, thin sheets that can be embedded in a printed label, and miniature devices that can be implanted into an animal or a person. The data on an RFID tag is transmitted to an RFID reader (also known as a scanner) using radio waves.

RFID tags and bar code labels have many similarities, but there are two major capabilities that differentiate the technologies:

- RFID tags can be read without line-of-sight.
- The data on RFID tags can be updated.

Because RFID does not require line-of-sight, RFID tags can be used in conditions where bar codes are useless — for example, in the dark or in a very dusty environment. This is an area where RFID has made significant inroads, and many applications already exist. Examples include collecting highway tolls without requiring the driver to stop, tracking automobile components during manufacturing, and recording marathon race results using RFID tags attached to each runner's shoes.

Because the data on an RFID tag can be updated, you could record product history directly on the tag. For example, as a pallet passes a scanner at the warehouse entrance, you could update its RFID tag with the time and date. Then, when the pallet leaves the warehouse, the tag would be updated again, and at some point, a program would analyze the data to determine how long the pallet spent in a particular warehouse.

It's often said that RFID tags can store more data than bar codes, but that doesn't precisely explain the difference in capacity between bar codes and RFID. Theoretically at least, bar codes could hold any amount of data. However, bar codes typically use a Universal Product Code (UPC) to identify products, whereas RFID tags use a new product identification standard, the Electronic Product Code (EPC). EPCs contain more characters than UPCs, opening up the possibility of identifying individual items. (For more information about EPCs, see "Product Identification" on page 7.)

Balancing the potential benefits of RFID are three major drawbacks: cost, privacy concerns, and evolving standards. While prices are dropping, RFID tags are still substantially more expensive than their bar code label counterparts. Even in very large quantities, the minimum price for RFID tags often exceeds 20 cents per tag. In addition, implementing RFID may require significant hardware and software upgrades.

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Privacy concerns — both real and perceived — may also be a concern for some applications. Imagine the possibilities of a pair of eyeglasses tagged using RFID. Any optometrist could retrieve your prescription and the date of your last eye exam directly from the glasses. Add a phone number or an address, and if you lose your glasses, somebody could return them to you. This sounds like a great idea until you realize that even if you haven't lost your glasses, a total stranger could potentially use them to obtain information about you.

Finally, there's the question of standards. RFID requires a cornucopia of interrelated standards ranging from the codes used to track individual items to the frequencies used to transmit data. RFID standards are being developed by EPCglobal, a non-profit consortium of organizations interested in RFID. EPCglobal standards will ultimately be submitted to the International Standards Organization (ISO), but because the ISO approval process can take several years, organizations anxious to launch their RFID initiatives chose to develop standards through EPCglobal.

Since Wal-Mart and the DoD issued their mandates in 2003, there has already been a major revision to RFID standards. Early adopters face the dilemma of sticking with older technology or modifying their equipment and processes to handle new RFID technologies as they become available. Incompatibilities between older readers and newer tags may be an issue as well. These problems are likely to continue for several years as RFID standards emerge and stabilize.

The instability of RFID standards may increase your RFID implementation costs significantly. If you choose the latest technology, you'll pay a premium for the equipment (e.g., scanners and tags). New standards will probably also increase your deployment costs as bugs are worked out of the new standards and hardware. On the

other hand, if you stick with older RFID standards, you'll have a more stable development environment, but you'll likely have to replace some or all of your hardware and software as the new standards become established. For example, older scanners may not be able to read the latest Gen2 RFID tags.

Now that you have a sense of the possibilities and pitfalls of RFID, let's take a brief look at how the technology works.

Technology Overview

RFID requires two physical components: an RFID tag and an RFID reader. Because RFID tags contain a microchip, they are sometimes referred to as RFID chips, especially in their smallest form factors.

Data is stored on the tags and communicated to the reader via radio waves. RFID tags can be divided into two general categories, passive and active; there are also semi-passive tags. Passive tags, which are by far the more common type, contain an antenna and a small amount of data. They are activated when they come within range of an RFID reader. Active tags can store significantly more data than passive tags and can be read at a greater distance. Active tags also have their own power source — hence the name. In either case, the tags may be read-only or read/write, allowing the tag itself to be updated throughout a product's lifecycle. Passive tags cost less than active tags and raise fewer privacy concerns because of their shorter range.

It's difficult to be specific about RFID capabilities because there's a lot of variance among different types of tags, and if you read 10 documents about RFID, you'll get 10 different ideas about tag capacities and ranges. At the low end, passive tags may store only an EPC and have a range of just a few inches. At the high end, it's safe to say that passive tags can store up to about 16 K of data and be read at distances up to approximately 30 feet. Active tags can store up to about 2 MB of data and can be read from as far away as 400 feet.

Different types of tags also use different frequencies to transmit data. Each frequency has different capabilities and uses. For example, low-frequency tags (usually below 135 kHz) generally cost less and transmit a shorter distance than their higher-frequency cousins. The frequency also affects how well a tag can handle interference from factors such as liquids, metals, and electronic noise. The frequency and type of tag used is often dictated by the application for which you plan to use RFID.

RFID readers collect information from RFID tags and store it in a database or pass it along to an application such as inventory control. However, RFID reader is somewhat of a misnomer. Many RFID readers can also update RFID tags.

Armed with an understanding of RFID technology, let's consider applications that use RFID and the strengths and weaknesses they expose.

RFID, Bar Codes, or Both?

It's important to understand that, initially, there won't be a widespread replacement of bar codes with RFID. Bar codes and RFID will coexist by choice in many situations. For such applications, some bar code printers can select labels with or without RFID tags on a label-by-label basis, creating some labels that contain only printed information, while others contain both printed information and RFID tags. Although RFID is useful in locations where bar codes are useless, there are also situations where bar codes are preferable. (For a comparison of RFID and bar code attributes, see the table below.)

	RFID	Bar Codes
Cost	minimum cost, about 20 cents per tag	minimum cost, less than one cent per label
Capacity	up to 2 MB	usually 15 characters or less
Updateable	yes	no
Read capabilities	multiple tags concurrently	each label individually
Accuracy	varies from 100 percent to 60 percent or less when reading multiple tags under adverse conditions	nearly 100 percent, but may be sensitive to environmental conditions (e.g., dark, dirt, torn tags)
Standards	under development	well established
Item-level detail	possible	usually not
Privacy concerns	yes	no
Complexity	high	low

When comparing RFID with bar codes, the first consideration is cost: RFID tags and scanners are much more expensive than their bar code counterparts. As a result, RFID is unlikely to reach the retail grocery business, for example, anytime soon. On the other hand, at least one large grocery chain is already beginning to use RFID to track groceries at the case and pallet level.

Another reason why RFID cannot simply replace bar codes is that while RFID is impervious to some of the interference, such as dirt or paint, that gives bar code scanners fits, RFID has its own sensitivities. Metal and liquid both interfere with RFID transmissions, making RFID tags on cans of soup, for example, difficult to read. Special care may be needed to read RFID tags in an electronically noisy environment such as a warehouse. To counteract these limitations, you'll need to carefully consider the positioning of RFID scanners.

One of the benefits of RFID when compared to bar codes is that RFID tags can be read greater distances. This means that, for example, material could be tracked as forklifts move it throughout the warehouse, rather than being scanned manually. However, the ability to read tags at a distance can be a drawback as well as a benefit — movements can be recorded accidentally as a forklift passes near a reader on a conveyer belt, for instance.

It also turns out that achieving 100 percent reliability for RFID tags is difficult. There are two kinds of reliability to consider when working with RFID. First, there is the reliability of the tags themselves. Like CDs or DVDs, a percentage of the tags are unreadable, either initially or, even more disconcertingly, sometime during the life of the product. One solution is to use multiple tags on each item. This is possible when RFID tags use EPC codes to uniquely identify items. If the same data is read more than once, the software can simply discard the duplicate information. Using multiple tags substantially increases the cost of tracking items using RFID, so it's impractical in many situations, but it will probably be used where tracking is critical — for pharmaceutical products, for example.

The second aspect of reliability deals with reading the tags. Theoretically, RFID can be used to identify the location of a myriad of items nearly simultaneously, but the reality is still far from this ideal. Read rates, especially for high-speed throughput, seldom reach 100 percent. For example, suppose a forklift moving at 2-3 miles per hour and carrying pallets that contain hundreds of RFID tags passes a scanner. The scanner has collision avoidance software to help it sort out all the conflicting signals, but it's still possible that not all the tags will be registered.

Orientation of the tags may also be critical to achieving accurate readings, particularly with products that interfere with the radio signals, such as liquid soap or cases of soda. Even when these items are traveling on a conveyer belt, you may need to make sure that the tags face the scanners. In addition, because the tags are read remotely, recognizing that data was not read and correcting the data may be more cumbersome than for bar codes. When a bar code scanner fails to register an item, the error is usually apparent immediately. However, if a forklift passes an RFID scanner and some tags are not read, that may not be obvious. This is particularly problematic during the current transition period because not all items are tagged.

Finally, RFID tags generally contain more information than bar codes. However, in part as a result of their greater capacity, reading and writing the tags may be slower than for bar codes. As with the placement of scanners, this restriction could require changes to the warehouse layout or the workflow.

Potentially, RFID can be used to track items through every step from manufacturing to final retail sale. However, in order to make use of such information, you'll need to modify your database and applications.

RFID Application Opportunities

Little or no change to application software will be required if RFID is limited to labeling pallets as they leave the loading dock. This approach, known as "slap and ship," will satisfy Wal-Mart, DoD, and other customer requirements, but it adds cost without delivering collected via RFID must be fully integrated into applications such as manufacturing, inventory management, and purchasing.

At first glance, such software changes might appear trivial, and if no additional data is collected, that may be true. However, RFID offers the potential to track and store much more information than bar codes. Deciding how much information is useful and how long it should be stored is an important part of the design process. For example, you might currently store information about the total number of each item (e.g., books, bags of carrots, television sets) at each warehouse and retail outlet. RFID makes it possible to track specific pallets, cases, or even individual items.

Theoretically at least, you can also track items before they've been delivered to your company or after they've been sent to a customer — either retail or wholesale. For example, the customer's warehouse scanners could notify the supplier or update the EPC database when a pallet is received and again when it is moved out of the warehouse onto the retail floor. Wal-Mart plans to track products when they arrive at a distribution center, when they arrive at a particular store, when they're moved to the store floor, and when the boxes are compacted.

Whether or not there's any benefit to such tracking depends, to a large degree, on what items you're tracking. Just because you can track a specific case of ceramic mugs, soap, or books doesn't mean it's important to do so. In most cases, you really just need to know how many of a particular product are at each location at a given time.

For perishable items, such as the bags of carrots, tracking a specific pallet or case can help ensure that stock is rotated and outdated items are removed from inventory. You can also take advantage of the ability to store information on RFID tags to track other factors that may affect product life. For example, if sensors currently record the temperature of a refrigerated truck whenever it goes out of a predetermined range, that same data could be recorded on the RFID tags of the pallets of carrots inside the truck. Based on the information stored on the RFID tags, you could reject a shipment of carrots that had been exposed to excessive heat or cold, for instance. However, you're probably not interested in tracking each bag of carrots.

It does make sense to track high-ticket, serial-number–identified items, such as television sets, individually so that you can retain sales and repair history, for example. This data will most likely be stored in your database, not on the RFID tag itself. When you track individual items, a whole new set of potential uses for RFID is revealed. For example, imagine the benefits for law enforcement if every gun were uniquely and permanently identified using RFID.

An important caveat for such applications is price.

In most cases, it's not currently cost-effective to tag low-cost items such as sugar, staplers, or books individually. However, such decisions depend on the particular situation. For example, libraries are gradually converting from bar codes to RFID because they need to account for each book individually and RFID reduces their manpower requirements. Instead of locating the bar code on each book and scanning it, an entire shelf can be inventoried quickly using a portable scanner. Similarly, checkout of library books is streamlined, and returns can be logged automatically by scanners in the book drop, for instance.

RFID also looks like a promising technology for baggage-handling applications. Although the items have only a temporary existence (the duration of a trip), each one must be tracked individually. In addition, the ability to update data on RFID tags and to record bag locations without line-of-sight are both very useful for baggage-handling applications. It's easier to move bags through an automated system when they can be scanned in large groups rather than individually.

If a bag is misplaced, the additional information included on the RFID tag versus what might be included on a bar code will help reunite the baggage with the passenger more quickly. Itinerary changes can also be encoded directly on the RFID tags, eliminating special handling for rerouted passengers. Baggage-handling is an example of an application where bar codes and RFID will likely coexist for a long time because not all airports will be equipped with RFID scanners.

The ability to track individual items using RFID is one of the most significant benefits of the technology, yet it is a major contributor to privacy concerns about RFID, which are discussed in the following section.

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Privacy Considerations

The fact that RFID communicates via radio waves is responsible for most of the privacy concerns about RFID because, potentially, unauthorized parties could simply retrieve data as RFID tags pass near a hidden scanner. Other aspects of RFID that raise privacy questions are the amount of data that can be stored on the tags and the fact that tags can be associated with an individual item.

Concerns have been raised about criminals or companies obtaining information from RFID tags without their owners' knowledge. In particular, there's been a lot of publicity about how RFID tags on retail products could be used to track purchasing habits. RFID advocates point out that in many cases, such tracking is already possible using credit card records. However, there are two additional insidious privacy issues related to RFID for retail products.

First, the retailer could monitor customer activity within the store. While such a system could be used to deter shoplifting, it could also be used to sell additional products or to track customer interest levels even when no purchase is made. Many people are uncomfortable about the potential profiling of customers and their shopping habits.

Even more disturbingly, unless RFID tags are removed at the time of purchase, criminals could essentially inventory your home using an RFID scanner. The current short range of RFID tags minimizes this threat, but both advocates and opponents of RFID expect the distance between scanners and tags to increase. A simple solution to this dilemma would be to remove the tags when an item is purchased. While that solution works well for many items, it negates one of the major benefits of RFID — the ability to track individual product history. Another concept that is under discussion is *blocker tags*, which produce a radio signal that interferes with the one used by RFID and thus prevents unauthorized scanning.

Among the most controversial RFID applications are those that identify people. For example, beginning in 2005, United States passports will include an RFID tag containing information about the passport holder and a digital picture. Several other countries already use RFID for passport information, and more are likely to adopt RFID for passports. The United States has chosen not to encrypt information on passport RFID tags because of the complications inherent in making encrypted information readable by other governments. Government officials point out that plucking passport information out of the air will be difficult because of the short distances that current RFID tags transmit their data. Nevertheless, many people feel that using RFID for passports is a major privacy exposure.

At least one state (Virginia) is also considering including RFID tags in driver's licenses, and new federal rules may soon force all states to follow suit. In addition to the standard information that already appears on a license, RFID tags could be used to record unique identifiers such as fingerprints, retinal scans, or facial recognition information. Recording information directly on a license would make it available to a much broader range of government agencies. Of course, the danger is that the information would also be available to identity thieves and other criminals.

Opponents of RFID for passports and driver's licenses also point out that the tags could be used to track citizens' movements within the United States. A simple way to counteract such unauthorized scanning would be to shield the RFID tags using metal. For current scanners,

wrapping a document in aluminum foil would probably be an adequate protection.

Not all personal identification applications are so controversial. For example, many parents seem excited by the concept of using RFID to track their children — both for routine parenting (What are you doing at the mall? I thought you were going to the library) or in case of an accident or an abduction. Transportation companies, which have used RFID for years to identify containers, trucks, and so forth, are beginning to use RFID to identify employees. For example, a delivery person may wear an RFID-encoded wristband or badge that gives that individual hands-free access to a truck or a warehouse.

It's obvious that as RFID matures, we'll be faced with many decisions that balance the benefits of privacy versus information.

Some of the most promising uses of RFID for human identification are in health care. In the hospital, RFID wristbands can give medical professionals access to patient records, but they can also be used in conjunction with other RFID applications. Currently, if you need to receive blood, a nurse might scan your bar-coded wristband and the bar-coded label on the bag of blood to verify compatibility. However, if both patient and blood are identified using RFID tags, the system could automatically make the comparison and alert your caregivers of any conflict. For example, if your RFID bracelet identifies your blood type as A-positive and the blood you are about to be given is B-negative, perhaps an alarm would sound. Using RFID in such situations reduces the burden on the hospital staff and ensures that the verification takes place even under the stress of an emergency situation.

So far, RFID for humans has been restricted to removable identification, but in October 2004, the United States Food and Drug Administration approved implantable RFID tags for humans similar to those currently used for pets. Initially at least, the plan is to store an identifying number and perhaps some limited medical information such as drug allergies. Authorized facilities, such as hospitals, could then access a database with more-detailed medical records.

Looked at from a benign perspective, implantable RFID tags for humans expand upon the simple technology of the medical identification bracelets that have been available since 1956. While the intent of medical identification using RFID is laudable, the potential for abuse is enormous. It seems that many people would hesitate to be permanently identified using a technology that could potentially be read surreptitiously. The trade-offs are far from clear, but it's obvious that as RFID matures, we'll be faced with many decisions that balance the benefits of privacy versus information.

Looking Ahead

RFID grew out of radar research during World War II and has been widely used for specialized applications since the 1970s, but in many ways, RFID is still in its infancy. However, the DoD and Wal-Mart mandates have dramatically altered the RFID environment. As 2005 begins, RFID is a major force across a broad range of industries and applications. Many iSeries companies will be affected by RFID as its use becomes more widespread. If you're faced with a requirement to implement RFID, it makes sense to consider how you can use RFID to improve your internal processes as well. Even if you're not currently required to use RFID, you may want to explore both the potential benefits and the roadblocks you'll need to overcome to use RFID effectively.

Because so many RFID decisions depend on your company's industry and your existing application environment, it's impossible to create a simple road map to implementing RFID in an iSeries environment. For example, companies that are being forced to implement RFID in response to customer mandates (e.g., Wal-Mart, DoD) may have no choice but to prepare for a two-phase implementation: Meet the customer requirement, and then assess how you can reap internal benefits from RFID. However, you can minimize redundant development by considering long-term goals for RFID, even if you cannot implement them immediately. For example, when purchasing bar code printers, you may want to invest in models that can also encode RFID tags. Similarly, if you are making modifications to applications such as purchasing, it's useful to keep in mind the greater data collection capacity of RFID, and you could perhaps expand your database design accordingly.

Even companies not facing immediate RFID requirements may want to take similar steps. For example, it's clear that over time, EPCs will replace UPCs for many distribution applications. Even if you have no RFID projects on the horizon, you could make some decisions about what level of tracking (pallet, case, individual product) makes sense for the types of products you distribute and begin expanding field definitions to accommodate the new codes. Similarly, companies dealing with any aspect of health care should be aware of current guidelines concerning RFID.

Regardless of your current RFID requirements, RFID is definitely a technology to watch. Approval of the Gen2 RFID tag standard in December 2004, for example, is a significant milestone. Keeping up-to-date on RFID can help you determine when your company should move beyond the spectator stage and embrace RFID. "RFID Resources" on page 7 provides links to some of the most important RFID-related Web sites. ■

Product Identification

There are many different types of bar codes, and they can be used to store all sorts of information, but one of their most common uses is to label products such as groceries and office supplies. The familiar bar code on such items designates the type of product with a Universal Product Code (UPC) in the United States or a European Article Number (EAN) in other parts of the world. There are a number of different UPC and EAN codes, and the two types of codes (UPC and EAN) are compatible.

Instead of UPCs or EANs, RFID tags usually identify items using the much newer Electronic Product Code (EPC), which has enough characters to uniquely designate individual items. Of course, EPCs could potentially be stored using bar codes, but so far plans to use EPCs seem to be contingent on RFID implementations. When bar codes are used to track individual items, most often the manufacturer adds a separate bar code label that contains a serial number. The serial number bar codes are ignored by most retail applications and may even be affixed to the item itself rather than to the display packaging.

Although EPCs can be used to track individual items, each manufacturer and distributor can determine the level of granularity they want to use for tracking. This means that, for example, a manufacturer could use a single EPC to track an entire pallet of wireless routers, or assign an EPC to each case of wireless routers, or even assign an EPC to each individual wireless router. As the items move through the supply chain, they could be retagged as needed. For example, a distributor might break up the pallet of wireless routers, creating a new pallet that contains three cases of wireless routers, five cases of network cards, and so forth. If the router manufacturer had tagged at the case level or lower, those tags would still make sense, but the distributor could add its own pallet-level tag.

Long-range plans call for a centralized, Internet-based database that could be used to share information about EPC-coded items among interested parties. Potentially, the manufacturer, distributor, retailer, and customer might all have access to the data for an individual product.

— *S.L.H.*

RFID Resources

The Association for Automatic Identification and Mobility (AIM) is an industry organization of manufacturers and service providers working with RFID and related technologies, such as bar codes.
http://www.aimglobal.org/technologies/rfid

EAN International maintains the European Article Number standard.
http://www.ean-int.org

Electronic Privacy Information Center (EPIC) has a page devoted to RFID privacy concerns.
http://www.epic.org/privacy/rfid

EPCglobal maintains many RFID standards.
http://www.epcglobalinc.org

The Uniform Code Council maintains the Universal Product Code standard.
http://www.uc-council.org/index.html

You'll also find lots of other resources on the Web, as well as several books on RFID. When selecting materials for further study, it's important to be aware of the publication dates — RFID information can become out of date very quickly.

SANYO Depends on Barcode400 to Ensure Wal-Mart RFID Compliance

SANYO Manufacturing Corporation, located in Forrest City, Arkansas, produces millions of television sets for retailers worldwide. Almost 3 million sets are shipped to Wal-Mart alone, according to Ron Proctor, operations manager for SANYO. When Wal-Mart announced its RFID requirement to its top 100 vendors (SANYO included), Proctor had to find a solution, and fast.

The requirement from Wal-Mart is based on the Electronic Product Code (EPC) specifications set forth by EPCglobal. Labels must be affixed to products at the carton and/or pallet level and contain human-readable, bar-coded and RFID-encoded electronic information. The top priority for Proctor was to find a solution that could be implemented quickly. He wanted a "slap and ship" solution. Generate the necessary label, "slap" the label on the product, and "ship" the product to Wal-Mart. "We looked around, and everybody we spoke with only had complete warehouse systems," Proctor says. "[Most vendors] did not have just something that we could use just to do RFID tags with. They wanted to start from the receiving dock, and trace everything all the way through to being shipped out. They were talking about $400,000 projects. We didn't want a system that elaborate."

"They had what we were looking for, which was a way to produce an RFID tag that we could put on a single product, that would only cost us the price of a tag, a $1,500 upgrade to our bar code system, and an RFID printer."

When Proctor contacted T.L. Ashford, he found his solution — Barcode400 and its accompanying RFID Tag Module. "They had what we were looking for, which was a way to produce an RFID tag that we could put on a single product, that would only cost us the price of a tag, a $1,500 upgrade to our bar code system, and an RFID printer," he says.

Barcode400's RFID add-on allows "Smart Labels" to be encoded with data directly from the iSeries system and printed to RFID thermal printers. Each label is embedded with a miniature chip and antenna. As the bar code label prints, the chip is encoded with the EPC, which is the electronic equivalent of the Universal Product Code for bar codes. Barcode400 supports Class 1 and Class 0 RFID labels and is ready for Class1, Gen2 EPC as the printer technology becomes available.

Implementation of the Barcode400 RFID add-on was simple, according to Proctor, and the results were as advertised. "Implementation was very easily done. They just sent us a CD, we loaded it, and it's there. It is working absolutely great. Wal-Mart has verified that our tags are being received by their system, and everything seems to be working fine," he said.

Providing timely support has always been a priority for T.L. Ashford, and SANYO's case is no exception. "Their support has been absolutely great," says Proctor.

As Wal-Mart and RFID smart-label requirements evolve, Proctor will need a software product and software developer capable of supporting change. Barcode400 is designed to be flexible and will evolve as well, always providing customers with cutting-edge bar code solutions.

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