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White Paper

Networks to Unlock the Value of **RFID**

Speeding the Adoption and Lowering the Costs of RFID in the Retail Supply Chain

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If you are waiting for radio frequency identification (RFID) to catch on before developing an implementation strategy, then you have some catching up to do. Offering end-to-end product visibility, RFID is poised to revolutionize the supply-chain industry, driving down costs and enabling differentiation. With support from industry heavyweights such as IBM, Wal-Mart, and Procter & Gamble—who have each committed large Research and Development (R&D) budgets to RFID opportunities—the momentum is clearly behind this technology. In fact, Wal-Mart and the U.S. Department of Defense have mandated that by 2005 suppliers must deliver ePC-tagged cases and pallets that are ready for RFID tracking. Broad adoption of case- and pallet-level tagging is expected by 2007 or 2008.

While the pressure is on, however, RFID technology solutions are still maturing. Funding or implementing current RFID models is generally considered impractical, and most companies are also skeptical about the ability of these often-conflicting solutions to support robust AutoID functions.

Tagged cases and pallets will arrive at your receiving doors within 12 to 18 months. When they do, the resulting cultural, technological, and financial challenges to your enterprise will threaten your competitive edge. You need to be in the RFID pilot phase now, learning about and preparing to leverage this technology and to face the funding issues and business process changes it will bring. If you do not begin to explore RFID and work with your technology partners to define an appropriate solution for your company, you may end up with the wrong RFID business model as well as staggering implementation costs as you update your infrastructure accordingly.

Technology Barriers

Powerful and versatile, the benefits of RFID include:

- More informed planning of allocated or constrained goods.
- Timely, accurate product tracking and cycle counts, decreased out-of-stocks, and greater customer satisfaction.
- Increased visibility and control of controlled and hazardous materials and dated products.
- Reduced counterfeiting of goods and currency.

The list goes on. The biggest RFID advocates, however, tell us that technology providers must solve a host of issues to fill the current gaps in their solutions sets:

- Technology solutions must be AutoID compliant (to enforce standards compliance and interoperability), enterprise hardened, and ready for deployment by 2005.
- ePC tags and readers (sensors) are still too expensive.

- Reader (sensor) performance must be improved to increase read range, read quality (accuracy), and data integrity.

The solutions currently forwarded by RFID technologists and academics alike are built on a server/software model. To solve ePC data relationships and delivery issues, this model uses readers connected to a reader management appliance that interacts with server-based software. Licensing and maintenance costs for this model are high and integration options limited. When readers become commodity devices with plug-and-play capabilities, customers will be able to buy the lowest cost reader regardless of manufacturer and have it work with existing RFID solutions. Today's proprietary solutions, however, do not share this cost-effective trait. Most software models also require controlling both ends of the process: store software and corporate software need to "match" in order to reduce integration costs and deliver full RFID functionality. In addition, the software involved requires space on a server at each site, or the purchase of new servers, and must be licensed per site as well.

There is, however, an alternative approach that significantly reduces costs and implementation time. In this more-effective model, ePC information services and RFID devices, rather than operating within the network as a separate entity, are fully supported by core network services. We believe our customers require this type of support. They continually tell us, for example, that networks must provide the following if RFID technology is going to prove successful:

- Networks must manage lower-level events such as the timing and routing of data from ePCs. Execution should take place at the lowest level possible.
- Readers, sensors, and savants (essentially, ePC routers) must be remotely configurable and manageable to support distributed operations and control costs.

Robust, efficient RFID solutions will leverage the network to supply complete AutoID functionality end to end, including these core functions:

- *Hardware abstraction*—The network must manage edge devices such as readers, temperature sensors, moisture sensors, position sensors, and so on. This includes managing software updates to readers and sensors and providing power to wired readers and sensors and wireless connections to wireless ones. Networks must also provide diagnostics, plug-and-play capabilities, and central configuration and monitoring, and they must support read/write tags and filtering at the reader level.
- *Association and interpretation*—With information already cached or stored, the network must interpret actionable from non-actionable ePC data and also resolve the associated context.
- *Communication*—The network must distill ePC data into significant business events, such as inventory movement, or state changes related to environment, and then synchronize the distribution of data in a standard format to a secure list of recipients. Recipients may be enterprise resource planning (ERP) systems, business intelligence systems, warehouse management systems, and even e-mail or alert and alarm applications.

The functions of this type of intelligent ePC network are summarized by what the Auto-ID Center dubbed the "savant"—more accurately referred to now as ePC information services (eIS). eIS are delivered via servers or intelligent appliances and act as the buffering layer between readers and enterprise applications: they manage readers and other RFID devices, gathering and analyzing information and passing on what is relevant. In case- and pallet-level tagging initiatives, these "ePC routers" in retail stores or mobile ePC routers in trucks will simply need to recognize, store, and associate business rules with events signaled when ePC-labeled products, for example, change location or state. eIS devices in core areas such as corporate headquarters or distribution facilities, however, will have intelligence to resolve more complex exceptions and relationships and to support ePC resolution processes.

Robust networks hold the key to unleashing the value in this technology. For example, because ePCs represent valuable information to businesses and their supply partners, the transmission of ePC data requires the kind of secure, guaranteed delivery that only robust networks can provide. These networks can also support ePC data with other integrated services such as conflict resolution, priority setting, and synchronized distribution (multicast). Finally, robust networks offer the kind of open standards support that allows information written in a common data language to be routed and accepted by all.

Companies that have embraced robust infrastructures to drive speedy communication and execution are clearly best positioned to understand and implement an intelligent ePC network. Modern network infrastructures inherently support hardware abstraction, for example. Network-based tools and services tuned to manage devices are part of nearly every wired and wireless network. The operating systems in routers and appliances in modern networks currently perform association and interpretation decisions and reliably deliver critical business transactions according to centrally configured business rules. Modern networks are also a natural platform for housing the AutoID communication capability. Network solution providers already support multicast capabilities, and network appliances support the special needs that some data such as video and telephony traffic requires.

All that remains is for network technology companies to provide optimized RFID solutions. For example, ePC information services require functionality that packetizes the data and translates it into Physical Markup Language (PML), the AutoID standard for ePC data transmission. New network appliances that provide this functionality—serving as mini business-to-business (B2B) gateways—will fill this gap.

The Network and Item-Level Tagging

Scenarios suggest that in seven to 10 years widespread item-level tagging will present significant challenges to any technology platform. The density of readers, volume of data created and transmitted, and potential uses of the information will be staggering.

At this point, the role of the network will be that much more critical. For example, stores, branches, and delivery vehicles will create enough data to overwhelm industry networks as they exist today. Networks will need to filter a tremendous amount of non-essential ePC data as close to the source as possible so that it is invisible to applications and will not overwhelm the system.

Storage and analytics will also surge once point-of-sale (POS) and supply-chain applications move to support item-level tagging. RFID technology will one day enable machines to associate the movement of an item with a customer's actions and to deliver targeted information relevant to the time, place, and need of that individual. Retailers could then automate service extensions, up-sell and cross-sell products and solutions, and deliver very relevant special promotions and targeted advertising. They could reinforce brand decisions or tempt shoppers to defect to more profitable brands. Pharmacies and beauty counters could offer advice on product use and compliance. Apparel retailers could provide accessory or ensemble solutions based on single items or even historical purchases. The possibilities are endless, but only if tried and true network services are in place to support RFID technology once this level of demand is placed upon it.

Cultural Barriers

Undoubtedly, RFID solutions that solve current technology shortcomings will develop over time; the more important barriers to adoption are cultural. Privacy concerns could significantly delay the acceleration of item-level tagging, for example. The public fears live tags will remain on items after purchase and that unauthorized readers could therefore scan an individual and know the specific items on their person. Technology companies and standards organizations are aggressively trying to prove that RFID solutions can honor a person's privacy. It would be prudent for your company to draft and evolve a privacy policy now.

The other cultural barrier to RFID adoption involves the relationship between retailers and suppliers. Neither culture readily shares information about the movement of its products or the activities of its customers. This kind of information exchange, however, is intrinsic to AutoID and the intelligent ePC network. Until retailers and suppliers can synchronize inter-company processes based on the movement of ePC data, two things will likely occur:

- Suppliers will receive less value from case- and pallet-level tagging, which will slow their compliance with retail mandates. Case- and pallet-level tagging efforts will remain internally focused.
- Without the benefit of consistent store-level information, suppliers will resist moving to item-level tagging except for internally focused initiatives.

Financial Barriers

The final barrier to item-level tagging is purely financial: companies will be faced with staggering implementation costs. AMR Research, Inc. estimates that to implement RFID tagging at item level, companies will spend an amount comparable to that spent on Y2K. Most of the cost will be in upgrading, integrating, and replacing applications. As a result, because most retailers and suppliers expect to receive 70 to 80 percent of RFID's value from case- and pallet-level initiatives, some companies will likely postpone item-level tagging. Exceptions will be opportunistic and largely internally focused, such as item-level initiatives launched to control theft, manage production, and track dated goods.

On the other hand, if you select an RFID model that is supported by your network infrastructure, you should significantly decrease implementation costs—especially if you have hundreds or thousands of distributed sites to outfit. In a network model, for example, eIS functionality is a shared effort involving the edge appliances or mini B2B gateway supplying intelligence; the network access points, whether wired or wireless supporting reader management; and also the routing and switching devices already in your network.

In addition, because this RFID model is an appliance model, it will incur a lower total cost of ownership compared to server/software RFID models. This is in fact the very reason that the world relies on an appliance model to run the Internet: the devices involved are simple, easily implemented, open, and often core aspects of your network—and therefore relatively inexpensive.

Finally and most important, to provide the business intelligence and support for ePC transactions events, this network RFID model supporting PML is designed to communicate and work with any software you choose. The open interoperability reduces the licensing and maintenance costs that are a major drawback to more expensive server/software solutions.

Conclusion

RFID implementation is essential, but given the host of concerns that still must be worked out, you should plan to proceed with caution. Over the next decade, you should progressively investigate and adopt RFID solutions, leveraging your infrastructure and tackling implementation from a network perspective. The following predictions clarify the implementation timeframe that Cisco® envisions as well as the related impact on infrastructure:

- *Over the next one to three years*—Companies will investigate and invest in network-level capabilities to manage readers and filter ePC data. Persistent, high-speed WAN connections will be necessary to achieve the full value of tagging initiatives, but in the short term, bandwidth will be driven by other business needs such as video and IP telephony.
- *Over the next one to five years*—Companies will investigate and invest in network appliances, network tools, and network operating system improvements that will perform ePC information services in the store or truck. Network technology partners will be required to support RFID devices and eIS functionality in the network.
- *Over the next five to 10 years*—Companies will investigate the impact of item-level tagging on their extended supply chain. They will invest, when and where appropriate, in quality of service, increased bandwidth, storage, content, and wireless capabilities that support RFID and related AutoID functionality in an increasingly consumer-facing role.

Obviously, these guidelines do not apply to all industries or to specific, high-value opportunities. Companies able to leverage early opportunities to drive value with RFID have the advantage in influencing technologies and creating the skill sets, both business and technical, to compete at the highest level.

For all companies, the right solution will integrate RFID technology with robust network services. It will require new business models and possibly even new alliances. The reward, however, will be unprecedented efficiency and profitability, and those who fail to make the transformation in the time allotted will ultimately lose their competitive advantage.

APPENDIX

RFID Primer

Someday you'll stroll down grocery aisles with a wireless device that automatically locates products and places your deli or pharmacy orders in advance. When you grab that bag of chips in aisle 4, the shelf will route a message to the store's automated replenishment system, which will then order more chips from the supplier. At the store exit, a "reader" built into the door will detect and total up the items in your cart, and with one swipe of your debit card, you'll be done.

This scenario will become reality sooner than you think. One day soon, tiny microchips using radio frequency to transmit information will replace barcodes on a global scale. These tags will cut out the middleman—the error-prone human element—from communications between objects and computers. Put one of these "tags" on a plasma TV or a chocolate bar and suddenly a computer can track and gather information on that item. Put tags on every item in the global supply chain and suddenly it becomes visible and manageable in real time. No more error-ridden inventory counts or estimates. No more lost or misdirected shipments. No more low-stock shelves and stolen merchandise. As standards emerge and the technology develops, the applications for Radio Frequency Identification (RFID) in virtually every sector of industry, commerce, and services where data is collected will be limitless.

RFID Overview

Most RFID tags are passive: they don't have batteries and are powered instead by radio signals from readers. When a tag receives a radio query, it responds by transmitting its Electronic Product Code (ePC) to the reader using radio waves. The current version of the ePC identifies the product manufacturer, the product itself and the tag's version and unique serial number. The reader converts the radio waves to data that computers can understand and use.

In addition to ePCs, RFID tags have traditionally carried product-specific information such as what color of paint should be applied or a history of the temperature at which a product was stored. The more information you store in these tags, the more sophisticated they must be, and that can get prohibitively expensive. The Auto-ID Center has developed a new approach to RFID tags that aims to make globalization of this technology affordable for all items.

Next-Generation Auto-ID

Automatic Identification, or Auto-ID, is the term given to technologies such as RFID that help machines identify objects. The Auto-ID Center is a unique partnership between almost 100 global companies and five of the world's leading research universities. Their vision for the future of RFID includes product data stored in databases rather than on tags. The tag stores only its ePC. The Auto-ID Center envisions a complete ePC Network that will enable objects and computers to intelligently communicate. The other key components of this system are

- *Object Name Service (ONS)*—The ONS is a directory service that maps a product's ePC to a PML Web page.
- *ePC Information Services (eIS)*—The network's nervous system, eIS reside on servers and appliances and receive ePC data from readers. They track down associated product information using the ONS, interpret events based on ePC data, and execute business rules.
- *Physical Markup Language (PML)*—eIS servers and appliances convert ePC data into a standard language called PML.

eIS are distributed across servers and PC-like appliances in a hierarchical architecture. Running in stores, distribution centers, regional offices, factories, and perhaps even on trucks, each eIS level interacts intelligently. For example, because it "read" an ePC event interpreted as a purchase, an eIS device at a store might inform an eIS device at a distribution center that a re-supply is needed. eIS devices will also analyze ePC data to correct errors and delete duplicate information from overlapping readers, will store data temporarily to compare inventories over time for example and so that databases and bandwidth aren't overloaded, and will offer customizable data monitoring and alerting capabilities.

Features and Benefits

RFID technology offers the following significant advantages over traditional barcode data collection:

- *Provides a per-item identifier*—Barcodes only identify groups of products. There is no way to determine whether a particular item was stolen or purchased, or which of a group of items might soon pass its expiration date.
- *Non line-of-sight*—Barcodes have to be properly oriented, often by hand, for laser scanning. This is a costly and also error prone process, which can lead to mistakes in inventory.
- *Resistant to harsh environments*—Barcode life is limited by how long the printed symbols remain readable and also by the materials on which they are printed.
- *Can be reprogrammed and reused*—New data cannot be written to barcodes.

- *Can be read in groups*—Barcodes have to be read individually. An RFID reader can scan every item in a shopping basket, case or pallet at the same time.
- *Secures data*—Tag memory can be factory or field programmed and optionally permanently locked once written to. Tags can also be "killed" to protect privacy.

RFID already has myriad commercial applications, such as preventing theft of automobiles, collecting drive-through tolls, managing traffic, gaining entrance to buildings, automating parking, dispensing goods and tracking library books. As RFID technology solutions mature, companies everywhere will also experience unprecedented supply-chain visibility and information exchange.

Roadblocks to Adoption

The following considerations currently hinder the wide-scale application of RFID technology solutions:

- *Environmental constraints*—RFID is of course subject to the physical laws that affect all RF transmissions. Noise, interference and distortion must be guarded against, and reader performance must be improved to compensate.
- *Cost*—The high cost of the RFID technology has been one of the biggest inhibitors to its adoption.
- *Manageability*—The amount of information that will one day reside in and be accessed through an ePC Network will be staggering. Successful RFID models will need to be scalable and flexible to store, route, monitor, and manage the expected traffic.
- *Lack of standardization*—Without standards, the cost of tags could take decades to fall to a point where individual items can be profitably managed. Even then, companies may not be able to read each other's tags. In addition, to date there has been little consistency with regard to radio frequency allocation. Thus, a tag operating at a certain frequency in one country might not be readable in another where that area of the spectrum serves a different purpose.
- *Privacy concerns*—Your house, your food, and even your clothes might one day contain RFID tags that can be read without your permission or knowledge. Privacy advocates worry about who will have access to people's buying habits and other personal information, and also that long-term associations between tags and individuals will be established.

Global business and technical standards bodies are aggressively addressing these issues, which must be solved before RFID can become a force within the supply chain. The revolutionary potential of this technology, however, guarantees its eventual worldwide adoption.

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