Category: Concepts, Trends, and Challenges

RFID in the Retail Supply Chain

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INTRODUCTION

The use of RFID (radio-frequency identification) in the retail supply chain and at the point of sale (POS) holds much promise to revolutionize the process by which products pass from manufacturer to retailer to consumer. The basic idea of RFID is a tiny computer chip placed on pallets, cases, or items. The data on the chip can be read using a radio beam. RFID is a newer technology than bar codes, which are read using a laser beam. RFID is also more effective than bar codes at tracking moving objects in environments where bar code labels would be suboptimal or could not be used as no direct line of sight is available, or where information needs to be automatically updated. RFID is based on wireless (radio) systems, which allows for noncontact reading of data about products, places, times, or transactions, thereby giving retailers and manufacturers alike timely and accurate data about the flow of products through their factories, warehouses, and stores.

BACKGROUND

Management research and academic management literature on the use of RFID in the retail supply chain is still scarce. The technical aspects of RFID business applications have been highlighted in recent engineering and computer science publications (e.g., Glidden et al., 2004). Consulting-oriented papers have also offered in-depth technological overviews of state-of-the-art developments (e.g., among many others, Das, 2002; Harrop, 2004). Certainly, the technology has recently also been covered in management-related academic journals, which have focused on different aspects of electronic business and supply chain management (e.g., Angeles, 2005; Juels, Rivest, & Szydlo, 2003; McGinity, 2004; Loebbecke, 2004; Loebbecke & Wolfram, 2004; Singh, 2003).

However, as of late 2004, actual RFID applications in the real world, beyond lab studies or pilot projects, were still so new that academic research into their impact, lessons learned, and recommendations have not been possible. The main discussions of RFID applications currently appear in magazines, such as *Information Week*, *Infoworld.com*, and *RFID Journal*, in pamphlets written by technology consultants, and in the daily press. These publications focus mainly on case studies and discussions of business opportunities, but their life cycle time is too short to be included in this encyclopedia contribution.

TECHNOLOGICAL ISSUES

Using RFID, product data is automatically transmitted by radio signals. The key component of RFID technology is the RFID tag (called a transponder), which is a minute computer chip with an antenna. This tag is attached to transport packages (pallets or cases) or products (items). An RFID tag can carry an impressive array of data. Passive or semipassive tags identify themselves when they detect a signal from a compatible device, known as an RFID reader. As a tag passes through a radio-frequency field generated by a compatible reader, it transmits its stored data to the reader, thereby giving details about the object to which it is attached.

RFID systems operate in free air, that is, nonregulated frequencies of the wireless communications spectrum (called the radio-frequency spectrum). National regulations for radio communications vary and are established by different bodies. In the United States, regulations are less restrictive than in Europe, where the relevant spectrum is partially reserved for mobile telephone networks or medical services.

In retailing, a numeric, article-specific code (electronic product code, EPC) is stored on the RFID chip. The EPC is comparable to a conventional bar code. As soon as the chip comes within 39.37 inches (1 meter) of an RFID reader, it sends its numeric code to the reader. The reading device recognizes the EPC stored and matches it with other pieces of data, such as the price, size, weight, and expiration date of the product, stored in various databases.

Towards RFID Standardization

To achieve large-scale RFID usage in the retail supply chain, RIFD technology needs to be standardized. That process is currently under way. On the global front, two international bodies are involved: EPCglobal™ (http://www.epcglobalinc.org) and ISO, the International Organization for Standardization (http://www.iso.org).

EPCglobal was created in the fall of 2003 as a joint venture of EAN International (http://www.ean-int.org) and the Uniform Code Council (http://www.uc-council.org). The launch signaled the drive toward a worldwide, multiindustry adoption of the EPC, key identification aspects of RFID, and its network of links to Internet technologies. EPCglobal is leading the development of the industry-driven standards for the EPC Network (http://www.epcglobalinc.org) to support the use of RFID in information-rich trading networks. The association is working on the structure of the data stored in the transponder. It aims to define naming standards to foster the use of RFID technology between suppliers and retailers. Comparing EPC to the traditional EAN code, EPC stores only the serial number on the chip while EAN has extensive information on the chip. Hence, for the EPC, only the serial number needs to be coded and understood. The serial number then provides access to databases containing information about specific products.

The ISO standards for RFID, on the other hand, cover the physical characteristics of RFID labels and cards, the air protocols, the anticollision and transmission protocols, and commanded-set and security features.

As these two standardization bodies work on their separate issues, RFID choices made by players along the value chain can be both EPC and ISO compliant.

Technical Challenges on Data, Network, and Application Layers

Any RFID-enabled process begins with an RFID reader reading an RFID tag: The reader hits the tag with a radio beam and reads the data on the tag. Some readers are designed to simply pass the tag read along to an attached computer, relying on the computer to do validation (e.g., reading a check sum, elimination tag collisions, etc.). Other smart readers have the ability to validate data and even perform basic filtering.

With traditional bar code technology, the laser beams must have an unobstructed view of the bar codes to read them. Radio waves, however, do not require a line of sight; the signal can pass through materials, such as cardboard or plastic. With no line of sight required in RFID, multiple tags can be read simultaneously, even when hidden from sight. An RFID portal, for example, can read all the goods on a pallet with one pass. A bar code scanner would require each item to be scanned individually.

This RFID process presents challenges relating to the data, the network, and the application. An RFID reference architecture (RRA) addresses all three.

Data Layer

On the data layer, the RFID reference architecture determines what to do with the data gleaned from the tag. The following are examples of applications with increasing requirements for managing data.

1. **Querying Applications:** A conveyer belt that automatically routes cases to their destination needs to be able to simply pass the tag data on to the appropriate system, receive the response, and then purge the tag scan from its memory.
2. **Mixed-Goods Applications:** Assume a reader on a picking cart scans, say, every 5 seconds all tags within range (e.g., placed on the pallet). Such an application needs to be able to constantly evaluate each scan's results against expected results and alert the operator of exceptions.
3. **Smart-Shelf Applications:** Smart shelves keep track of the products placed on them. Scanning a 96-bit EPC-compliant RFID tag every 5 seconds in a distribution center that holds approximately 500,000 cases generates 32,958 gigabits of data every hour. The majority of this data should simply confirm the existence of the requisite number of cases on each shelf, and should therefore be disposable. The RRA needs to be able to filter and process such large amounts of data.

Applications built to track serialized data (such as EAN-128 numbers on pallets) should be able to accommodate the real-time stream of single-tag reads. Data requirements are much higher for systems that deal with the more granular serialized data that comes from RFID tagging at the case level rather than the pallet level. For example, take a distribution center that ships about 616,000 pallets to stores per year, each of which is duly recorded and serialized. Bringing that serialization down to the case level would require applications to handle approximately 46 million items—a 74-fold increase in data management and storage requirements over pre-RFID requirements (Metro Group, 2004). Systems that track at the item level generate orders of magnitude—more data than is currently common because each item is repeatedly scanned by the multiple readers, which report on everything within their range. The applications must be able to handle these voluminous, multiple real-time streams of data.

Network Layer

RFID-driven network requirements result mainly from the design of the data layer because the network must be capable of moving the quantity of data generated by the scans. For simple applications, 10-megabit Ethernet may suffice. For smart shelves to track individual items, though, the bandwidth requirements challenge even today's sophisticated gigabit Ethernet switches. Calculating-required network bandwidth, though, is straightforward.

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