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Challenges to global RFID adoption

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Abstract

Because of its potential to revolutionize global supply chain management (SCM) systems, ultra high-frequency (UHF) radio frequency identification (RFID) was recently the cause of much optimism. Wal-Mart mandated its top 100 suppliers to begin using RFID on 1 January 2005; this day was viewed as a watershed day in the industry. However, that date has come and gone, and the expected rapid industry adoption of RFID has not taken place. This paper explores the existing challenges and obstacles to RFID's quick adoption, the potential resolutions and approaches to the challenges, and the migration strategies to expand the RFID industry.

Keywords: Supply chain management (SCM); Radio frequency identification (RFID); Industry analysis

1. Background: the promises of RFID

Radio frequency identification (RFID) is a small tag containing an integrated circuit chip and an antenna, and has the ability to respond to radio waves transmitted from the RFID reader in order to send, process, and store information. The RFID system consists of three basic components: a tag, a reader, and back office data-processing equipment. The tag contains unique identification information of the item to which it is attached; the reader emits and receives radio waves to read the information stored in the tag, and the data-processing equipment processes all the collected data. This equipment can be as simple as a personal computer or as complex as an entire networked enterprise management information system.

Low-frequency (LF) and high-frequency (HF) active RFIDs operating with battery power and a moderate sized antenna can transmit over long distances. Thus, they can be used for livestock tracking, access control, point of sale (POS), etc. RFID has also been used for public transportation payment by embedding RFID into prepaid cards. In this example, the reader reads the amount left in the card; then, the data-processing equipment deducts the amount; and finally, the remaining amount of money will be recorded in the prepaid card.

Nonetheless, the biggest potential lies in ultra high-frequency (UHF) passive RFIDs which operate without battery and a very small-sized antenna can be used for item tracking, especially useful for global supply chain management (SCM). Once all goods are attached with RFID tags, their whereabouts can be tracked automatically by radio readers, which give complete inventory visibility and supply chain management efficiency.

Wal-Mart, the world's largest retailer, is expected to handle about four billion cartons in 2004 and five billion cartons in 2005 (Nogee, 2004). Any small increase in the efficiency of tracking goods in its global supply chain could generate tremendous benefits. Wal-Mart not only believes that the RFID system can reduce its labor and inventory costs but also thinks that its revenues will be increased by limiting the out-of stock items throughout its chain stores around the world. The US Department of Defense (DOD) and Wal-Mart both mandated their largest suppliers to begin tagging all goods delivered to their warehouses starting from 1 January 2005, while the remaining suppliers should follow within 1 year. Given Wal-Mart's enormous purchasing power and influence on its global suppliers, it has the potential to become the driving force to push for worldwide adoption of RFID systems.

In the past few years, RFID technology has led to much hope and optimism. The mainstream press hails RFID as

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the avant-garde in technology and business. For example, CNN identified RFID as one of the "Ten Technologies to Watch" in 2004, and ZDNet named RFID as one of the 10 most strategic technologies in 2005. However, RFID vendors are complaining that the business is not growing as fast as expected.

Studies of barcode history (T & W Enterprises) showed that it took approximately 25 years from the development of the first barcode by the Drexel Institute of Technology in Philadelphia in 1949 to the first commercial barcode scanner installation at a Marsh's Supermarket in Ohio in 1974. The developmental timeframe of RFID is similar. Approximately 25 years have passed between the first RFID technology developed by the Los Alamos Scientific Laboratories in 1977 and EPCglobal's announcement of the EPC Generation 1 RFID standard in 2003 (Laran RFID, 2004). What would be a reasonable timeframe expectation for RFID to replace barcode on merchandise label?

The purpose of this paper is to examine the existing challenges that RFID technology is facing, its future development directions and obstacle resolution approaches, and the likely migration path to realize its promises.

Section 2 summarizes the present hurdles and challenges that hinder global RFID adoption. Section 3 describes promising development directions toward facing the challenges. Section 4 recommends strategic perspectives for the growth of the RFID industry.

2. Present realities: challenges to RFID adoption

Despite the promising applications of RFID in SCM, a number of challenges have hampered the adoption of RFID. This paper will address the attitudes needed to face these challenges and reasonable directions to commercialize this technology. The major issues can be broken down into technology challenges, standard challenges, patent challenges, cost challenges, infrastructure challenges, return on investment (ROI) challenges, and barcode to RFID migration challenges.

2.1. Technology challenges

2.1.1. Material effects on antenna power pattern

A passive RFID tag has no power source of its own; it relies on its antenna to receive radio waves emitted by the reader and converts these radio waves into electrical power. The data stored in the chip can be transmitted back to the reader via the tag antenna. Therefore, the antenna plays a key role in the radio communication between the tag and the reader. Radio waves will be reflected and refracted differently by the different materials to which a tag is attached. If UHF radio waves propagate toward liquid, a large portion of the radio energy will become refracted into the liquid. If UHF radio waves pass onto metal, a large portion of the radio energy will become reflected. In both cases, there will be signal strength degradation and interference in the reception quality of the tag antenna (Nogee, 2004; Accenture White Paper, 2001). Consumer products with a high percentage of water such as shampoo or juice, and canned goods with metal cases refract and reflect RF waves, respectively (Mullen, 2004a; AIM, 2000). Radio waves reflected from multiple objects may cause multi-path interference to the receiving antenna.

Fig. 1 shows the difference between the normal antenna power pattern of a stand-alone RFID tag and that of an RFID tag attached to certain radio-absorbing material. A major tire manufacturer once reported that it was difficult to read tags placed on tires because tires are made of reinforced carbon, which absorbs RF energy (RFID Journal News, 2004d).

2.1.2. Tag antenna orientation affects radio wave reception

RFID technology allows non-line-of-sight, non-contact, and multiple-tag simultaneous-reading capabilities, which is more efficient than scanning barcodes for product tracking. However, RFID readability can be affected by the relative position and orientation of the tag antenna and the reader antenna, because antenna orientation affects its power pattern (Finkenzeller, 2003). As a result, if a tag antenna is perpendicular to a reader antenna, the former cannot receive the latter's radio signal. Fig. 2 illustrates that Tags A and B cannot be read by reader antenna C. In addition, if obstacles exist between two antennas, the radio signal strength will be attenuated so the reading range will also be reduced (Accenture White Paper, 2001). In real-world goods-tracking applications, RFID tags attached on variety products will have random antenna orientations, while some tag antennas may happen to be perpendicular to a reader antenna by chance. This will cause such tags to be unreadable as they travel through the portal with just one uni-directional reader antenna (Alien, 2002). As shown in Fig. 2, an additional reader antenna D with a different orientation to that of antenna C could resolve this problem.

2.1.3. Collision caused by simultaneous radio transmission

If an RFID system is designed so that tags are read one at a time by a reader, the chances of successful reading are

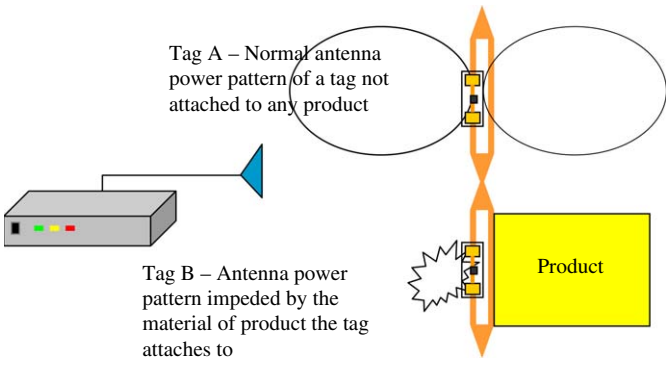

Fig. 1. Antenna power patterns of RFID tags.