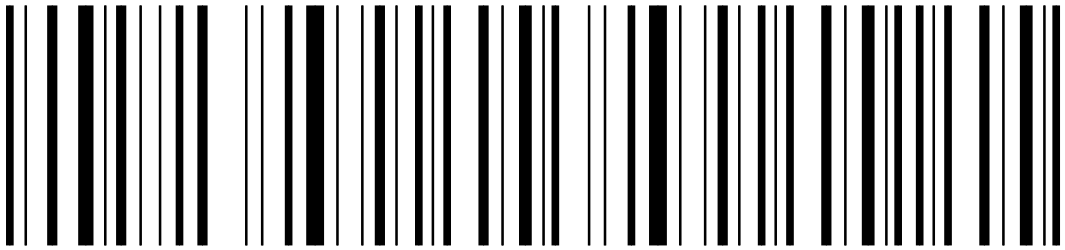
RFID: The Next Generation of AIDC



APPLICATION WHITE PAPER

Zebra Technologies

Executive Summary

Radio frequency identification (RFID) is one of the most rapidly growing segments of today's information technology (IT) and automatic identification and data capture (AIDC) industries. Organizations are taking advantage of the robust, unattended wireless data exchange capabilities of RFID, plus innovations like "smart labels" and Electronic Product Code (EPC) developments, to complement their existing bar code systems and improve numerous business processes; RFID systems have been recognized as an enabler for business process change. RFID technology has received heightened visibility recently because of mandates from leading retailers and the U.S. Department of Defense to incorporate EPC RFID solutions into supply chain operations that support these organizations. However, RFID growth is not limited to these programs and has extended into manufacturing control and materials management, cargo logistics, pharmaceutical security, asset management, patron and patient tracking, and many other areas.

The growing momentum and adoption of smart label-based EPC technology is driving a tenfold increase in supply chain RFID usage according to some estimates. The total, global market for all RFID systems will roughly double in size in just three years, growing from $1.1 billion in 2003 to $2.1 billion in 2005, according to Venture Development Corp. While the numbers and percentages vary, virtually every market research and industry analyst firm offers a bullish outlook for increased RFID use.

For most industries, smart labels will be the most viable means of incorporating RFID technology into existing operations. A smart label consists of a tag embedded in label material that is printed with human-readable text, graphics, and bar codes. The printed data both supplements and backs up the information that is programmed into the tag. Smart labels are an important medium for delivering RFID value. Not only are they are a cost-effective option for many RFID applications, but they also can be efficiently introduced into operations because they complement and leverage legacy bar code systems.

RFID is a foundation for many efficient, competitive business practices. This white paper will give you an understanding of how the technology can impact your business by:

- Providing an overview of RFID technology, performance, and limitations;
- Explaining smart label capabilities and production options; and
- Describing leading RFID applications and their benefits.

Compliance programs and high-profile projects get attention, but the real driver for the explosive growth in RFID use is business value. Improved data synchronization, combined with RFID, could cut between $2 billion and $4 billion in costs from the consumer packaged goods and retail industries, according to a Yankee Group study. Manufacturers could reduce their working capital requirements between two and eight percent, and reduce inventory levels even more with RFID-enabled processes, according to Accenture. RFID is a wireless data collection and communication technology that can provide unattended, automatic monitoring and reporting. These capabilities provide unprecedented visibility into operations that, when coupled with business process changes, can result in the need for fewer assets, lower inventory, and reduced production and shipping, all with a lower labor requirement. Creating new business processes that take advantage of RFID's capabilities is the key to profiting from the technology.

RFID uses low-power radio signals to exchange data wirelessly between chips and readers/encoders. No direct line of sight is needed between the tag and read/write device, eliminating many of the labor and item-orientation requirements associated with other forms of automated data collection. RFID readers can simultaneously recognize and process hundreds of tags within their read fields.

RFID tags consist of an integrated circuit (IC) attached to an antenna—typically printed or etched conductors on a thin plastic sheet. Data is stored on the IC and transmitted through the antenna. Tags can be smaller than a grain of rice or as large as a brick. RFID tags are either passive (no battery) or active (self-powered by a battery). Data transmission speed and range depend on the radio frequency, antenna size, power output, and interference. Tags can be read-only, read-write, or a combination, in which some data (such as a serial number) is permanently stored, while other memory is left available for later encoding or to be updated during usage.

In passive systems, which are the most common, an RFID reader transmits an energy field that "wakes up" the tag and provides power to the chip, enabling it to transmit or store data. Encryption algorithms that ensure security and integrity of the data passing between the tag and reader protect transmissions. In active systems, batteries typically are used to boost the effective range of the tag. Active tags also may transmit a signal periodically, much like a lighthouse beacon, so that data may be captured by readers distributed throughout a facility.

Readers may be integrated into handheld terminals; fixed and positioned at strategic points, such as a facility entrance, dock door, or assembly line; or integrated into forklifts and other equipment. Readers include one or more antennas for sending and receiving signals to and from tags and a processor for decoding received signals and data. Collected data is then passed through normal interfaces (such as a cable or wireless LAN) to the host computer system. Based on the amount of memory in a tag and how it is designed, readers also may program new data into tags. Readers will operate in accordance with local (national) RF emission regulations; tags and readers must conform with particular specifications and standards in order for them to communicate in a well defined manner. "Frequency agile" readers are capable of recognizing multiple frequencies and are highly advantageous in environments where tags of different frequencies must be processed. The alternative is to install multiple readers that support different frequencies at each read point to ensure all tags will be processed.

Application requirements determine the frequency, memory, and performance requirements for the tags to be used. Other considerations include whether the tag will be used globally and what interoperability standards (if any) the tag must meet.

Here are the common types of passive RFID tags and their performance characteristics:

- Low Frequency RFID systems operate at about 125 kHz with a typical maximum read range of up to 20 inches (508 mm).

- High Frequency RFID systems operate at 13.56 MHz with a typical maximum read range of up to 3 feet (1 meter).

- Ultra-High Frequency RFID systems operate at multiple frequencies, including 868 MHz (in Europe), a band centered at 915 MHz, and 2.45 GHz (microwave). Read range is typically 3 to 10 feet (1 to 3 meters), but systems operating in the 915 MHz band may achieve read ranges of 20 feet (6 meters) or more.

Tags and read/write devices must share more than the same frequency to communicate. Encryption and decoding algorithms, data content and format, interface protocols, and other technical specifications must all be compatible for systems to work. There are many standardization and industry initiatives under way to facilitate the development of interoperable systems. A few of the most important are outlined below. Zebra is an active participant in these and other standardization efforts and is committed to providing RFID products that support leading international standards.

E P C

The EPC system specifies technical protocols that define how information is encoded and communicated, and also creates a data structure that defines the content of the information itself. The EPC system was researched and developed at the Auto-ID Center at the Massachusetts Institute of Technology (MIT) under the sponsorship of a broad consortium of consumer goods manufacturers, retailers, logistics providers, other potential RFID users, and leading technology developers—including Zebra Technologies. Responsibility for the commercialization and management of the EPC system was transferred Nov. 1, 2003, to EPCglobal Inc., which is an affiliate of the Uniform Code Council (UCC) and EAN International (EAN); EAN and UCC created and maintain the EAN.UCC System, which covers global e-business communications standards, numbering schemes, uniqueness management, and bar code symbology standards, including the U.P.C. and EAN bar code symbols used on consumer goods around the world.

Each EPC chip will contain an ID number of typically 96 bits that will provide unique, unambiguous, context-independent, unduplicated lifetime identification. Unlike the U.P.C./EAN Global Trade Item Number (GTIN), which identifies the manufacturer and type of product (e.g. 12 oz. can of XYZ Corp. cola) but does not distinguish between items of the same type, the EPC number identifies each individual object, similar to a social security number. The identification scheme supports item-level tracking that can be used to provide greater visibility into operations.

Multiple EPC specifications are differentiated by their class and version. Vendor compliance programs require that specific classes and versions be used. Here is a brief overview of the EPC specifications that have been developed commercially:

- **Class 0** tags are read only, have 64- or 96-bit memory and operate in the UHF frequency band between 868 and 930 MHz. (**"Class 0+" tags, offered by Matrics™,** are re-writeable, but otherwise same the share technical protocols as Class 0.)

- **Class 1 UHF** tags are one-time programmable (OTP, which means they can be updated once after being programmed with their EPC number at manufacture), operate in the 868-930 MHz band and have up to 96 bits of memory.

- **UHF Generation 2 (Gen2)** specifications were developed primarily to overcome concerns about interference and global frequency availability of the original protocol. Gen2 specifies 96 to 256 bits of memory be available on the tag. Many leading supplier tagging programs, including those from the U.S. Department of Defense and Wal-Mart, require the use of Gen2 EPC technology. The operating frequency band for the UHF Gen2 system is specified as 860-960MHz, consistent with ISO 18000-6 standards.

- Globally, readers will operate in accordance with the local (national) emission regulations, for example, 902-928MHz in the USA, new ETSI (Europe +) regulations: 865.6-857.1MHz, Japan: 950-956MHz. (Both soon to be ratified.) Tags will respond to properly coded signals across the 860-960MHz band.

- **Class 1 HF (High Frequency)** defines 96-bit, one-time programmable tags that operate at 13.56 MHz.

The EPC system also specifies Class 3, 4, and 5 tags for use with sensors and for other, more specialized applications.

Software developers also recognized that assigning unique IDs to millions of items would create new data management challenges. To help meet these challenges, EPC developers created a system for managing databases and networks. Key components include Savants (servers dealing with event aggregation, filtering, and dissemination), the Object Naming Service (ONS), and Physical Markup Language (PML).

Savant software helps readers manage the gathering and flow of data and interaction with the ONS. The **Object Naming Service** is a database architecture that serves as a directory for EPC numbers. **Physical Markup Language** holds data that helps describe products by referencing the EPC numbers assigned by manufacturers. Organizations can produce and read EPC compliance without implementing the complete system infrastructure. Savant and ONS components are not required to use EPC technology in applications.

ISO

The Geneva-headquartered International Organization for Standardization (ISO) is the leading worldwide standards body. All standards ratified by the ISO are based on open technology. **ISO 17363 through 17368** is a series of specifications for logistics container identification that have not been ratified as standards. Each specification in the series is intended for use on a different level of packaging, for example pallets, cases, cartons, and individual items. Multiple frequencies are supported. There are additional ISO RFID proposals and standards for cargo seals, toll and fare collection, animal identification, and other applications.

There are numerous parts to the **ISO 18000 series** (e.g. 18000-2, 18000-3, 18000-6) that are standards for item identification and management, using systems that operate at different frequencies. ISO 18000-6 has been ratified as an international standard for item management using frequencies in the range the 868-956 MHz The EPC UHF Gen2 specification is very similar to work done in the creation of 18000-6. An ad hoc committee of ISO and EPC representatives is working to see if their respective specifications can be made compatible and interoperable.

Smart Labels

"Smart labels" are labels with embedded ultra-thin RFID tags, which are often called "inlays." Inlays for smart labels are available in the 13.56 MHz, 860 to 930 MHz, and 2.45 GHz frequency ranges. Smart labels are available for EPC, ISO, and proprietary RFID protocols. A significant number of companies will choose to deploy RFID through the adoption of smart labels. Many leading semiconductor manufacturers, including Philips Semiconductor and Texas Instruments, produce a wide variety of RFID chips. Zebra supports a broad range of RFID technologies in its card and label printer products and sells smart labels through its supplies division.

Smart labels are called “smart” because of the flexible capabilities provided by the RFID tag embedded in the label. The tag, in most cases, can be programmed and/or updated in the field, so the same label can be reused to serve multiple needs and disparate applications. Hence, the label is no longer effectively static, as is a bar code label, but rather is dynamic in its capability when equipped with RFID.

Passive smart label RFID systems overcome the limitations of many existing bar code-based automatic data capture systems in that they:

- Provide error-free, wireless data transmission that is battery-free and maintenance-free;
- Do not require line-of-site read/write devices for operation;
- Allow stored data to be altered during sorting or to capture workflow process information; and
- Work effectively even in harsh environments with excessive dirt, dust, moisture, and temperature extremes.

Incorporating smart labels into existing processes is usually the least disruptive way to add RFID to operations. Because smart labels can carry data in RFID, bar code, and human-readable FORMATS, they provide a convenient way to back up data in case a part of the system or label doesn’t perform properly. Label material can be developed to withstand environmental conditions and protect the tag. An appropriate adhesive can ensure that the label will last the duration required, whether use is for long-term (reusable logistics container tracking) or short-term, such as a cardboard carton that is destroyed after delivery.

Printing and Encoding Smart Labels

Smart label printer/encoders enable users to create smart labels on demand and encode variable information in the tags. Visit www.rfid.zebra.com to learn more about our smart label products.

Smart label printer/encoders function as traditional printers when creating bar codes, graphics, and human-readable text. However, they also have RFID encoders and readers embedded inside. Before the label is printed, the RFID data is encoded on the tag; data for encoding is selected by application design and automatically managed by system software. Following encoding, the tag is read to confirm data accuracy. The label is then fed forward for printing. With Zebra smart label printers, an error message prints over the label if the tag does not read or its data does not verify, voiding the label for use. Hence, smart labels created using a Zebra printer/encoder offer the highest achievable data integrity. Zebra works with its suppliers to ensure that the highest achievable tag quality volumes are achieved as well. Multi-protocol printer/encoders allow end users to support current protocols as they exist today and to upgrade to new protocols as they are developed. Because RFID technology is so dynamic, end users should look for this significant feature which allows them to ensure that the equipment they buy today can support the protocols they need in future.

Encoding and verification—which can take milliseconds to seconds depending on the amount of data to be stored in the smart label tag—make smart label throughput slightly slower, but still very comparable to bar code printers. The tags used in smart labels are made from flexible material that does not damage the print head. The integrated circuit may create an uneven surface, which can affect print quality, but this problem is easily remedied by using thicker label material or by avoiding printing directly over the IC.

Zebra's intent is to provide flexible solutions for encoding and printing RFID smart labels, so that producing smart labels on demand can be done in a straightforward and familiar manner with minimal change to software printer drivers. In addition, Zebra is committed to releasing products that support new RFID protocols and standards as they are adopted.

Applications

RFID provides a quick, flexible, and reliable electronic means to detect, identify, track, and manage a variety of items. The technology is well-suited for many operations in all types of industries—provided that users develop new business processes to take advantage of RFID's special abilities. Merely substituting RFID for bar coding will not give users all the benefits that the technology could provide. Many potential users of RFID technology try to make comparisons between the relative cost of RFID and bar code, when comprehensive business process return on investment (ROI) analyses should be conducted.

In recent years, interoperable products have emerged, helped by renewed standards efforts by EPCglobal and other standards bodies. In addition, major systems integrators have introduced RFID offerings and products that can make the adoption of RFID, especially in the enterprise, more straightforward as they build on existing and familiar systems. These efforts have enabled many companies to implement RFID pilots in their organizations and begin to calculate the ROI this technology can bring to their operations. The following brief examples show how RFID can improve efficiency and save money in different industries and applications.

Manufacturing

Manufacturers can take advantage of smart labels for work-in-process and lifetime tracking, materials management, inventory control, equipment service and maintenance, and more. RFID tags can withstand exposure to heat, moisture, solvents, abrasives, and other conditions that impair bar code performance in industrial environments, so the technology provides a way to gain new visibility into manufacturing operations. By creating processes to take advantage of the visibility that RFID can provide, manufacturers can reduce their inventory holdings between 10 percent and 30 percent and produce associated benefits related to reduced out-of-stocks, improved asset utilization, and reduced working capital requirements according to Accenture.

Consider how RFID could improve raw materials management. Pallets of goods arrive at the dock door where stationary readers pick up information about the nature of the items and which supplier sent them. In a just-in-time environment, the reader could trigger an alert that needed materials have arrived and direct a forklift operator to deliver the materials to a workstation. A forklift-mounted reader would record receipt of the materials and a reader at the workstation would record delivery there. Alternatively, tagged items could automatically be directed through a conveyor system for delivery with no labor intervention. Inventory records would be automatically updated with each transaction. Parts bins can be managed in a similar manner.

Smart labels applied to subassemblies and components automate accurate work-in-process tracking and could be used for lifetime product identification, which would be useful for return, service, and warranty operations. Smart labels have enough memory to store configuration information in addition to a unique identifier. As part of quality control prior to final assembly or packaging, products could be read to verify that all the required components in the proper configuration are present inside the assembly. The process could avoid rework and could be completed more quickly than manual testing and inspection. Unattended, high-speed reading makes it practical to validate every assembly, rather than to spot check.

Product Security

A smart label can provide secure, lifetime tracking that can facilitate accurate warranty and returns authorization and anti-counterfeiting protection. The U.S. Food and Drug Administration (FDA) Anti Counterfeiting Task Force recommended wide-scale adoption of RFID to stop counterfeiting, which now accounts for between six percent and 10 percent of all pharmaceuticals worldwide. The task force report, which earned widespread industry support, singles out RFID as the "most promising" tool to combat counterfeiting. For more information about how RFID can be used to protect pharmaceuticals, see Zebra's white paper, "*Track and Trace Solutions for the Life Sciences Supply Chain*." RFID systems and business processes to prevent counterfeiting, provide brand protection, and improve channel integrity can be adopted for use in many industries. Zebra's white paper, "*Brand Protection in the Supply Chain: Protecting Products and Profits with Secure Media Solutions*," describes these applications in more detail.

Warehousing

Procedures similar to those described for receiving and materials handling could be applied to warehousing operations. RFID's unattended, orientation-independent reading capabilities can be highly valuable for warehouse operations. Reading zones can be created to automatically monitor certain areas of the facility, such as a shelf location, secure storage area, or container yard, and automatically record all movements. Business rules can be created to issue alerts if certain conditions are present, such as items being moved after hours, unusual transaction volume, or any movement of items with a certain dollar value. By integrating the RFID system with enterprise networks and applications, monitor and alert data can be automatically communicated to managers or security personnel, plus integrated into warehouse management system (WMS), asset management, and other software applications.

For picking operations, workers could scan shelves and bins with an RFID reader to automatically detect the storage location of the sought items. The system also can detect items that are stored in the wrong location and alert operators to the problem. Using RFID for these applications enables items to "self-report" their locations, rather than requiring human intervention to find them, thus reducing errors, saving labor, and lowering costs.

Strongly expected warehouse and distribution center benefits are a big reason leading retailers and the DoD are committing to using RFID technology and requiring their suppliers to apply tags to cases, pallets, and other logistics containers. A business case analysis by A.T. Kearney predicts warehouse labor expenses can be reduced 7.5 percent by implementing RFID systems. Tracking inventory with RFID also will also significantly improve accuracy levels, enabling companies to reduce safety stocks and increase sales through improved product availability.

Shipping

The benefits of improved inventory accuracy translate into improved distribution operations by reducing shipping errors. RFID smart labels can provide additional safeguards to ensure shipments are complete with the correct items. Fast-reading RFID enables instant identification of the shipping container plus all of the individual items inside. For shipping, RFID readers can help packers quickly locate and aggregate all the items needed to complete an order. A reader could instantly identify all the items packaged within a case, carton, or pallet, then direct a printer to create a master bar code/RFID shipping label while simultaneously preparing and sending an EDI Advance Ship Notice (ASN). If automated readers and printer/applicators were used, no manual labor would be required to complete these activities.

Logistics

Global supply chain logistics is the fastest-growing application for RFID and may well become the largest. Most applications involve applying a smart label to the logistics container, which could be a pallet, case, carton, keg, cylinder, tote, etc., to provide shipment information or for lifetime container tracking. According to an Aberdeen Consulting report released in June 2004, 69 percent of study respondents planned to implement an RFID system to manage logistics assets within the next 24 months.

The key benefit of using an RFID system isthe ability to read the entire contents of mixed pallets all at once during material handling operations such as truck loading or unloading. RFID readers can identify dozens of tags simultaneously and can read through packaging. These features create interesting opportunities for unattended identification of the entire contents of pallets, transit containers, and the items inside them.

Managing pallets, totes, and other returnable transit containers with RFID represents one of the most dramatic cost-saving opportunities this technology can provide. Many returnable containers are never brought back from customer sites after shipment, forcing companies to carry excess inventory to ensure adequate supplies of shipping materials where they are needed. Almost half of the respondents to the Aberdeen study reported that logistics asset operations consume 5 percent or more of corporate revenue. Twenty-five percent of companies say they lose in excess of 10 percent of their container fleet each year. Identifying returnable containers with smart labels or fixed tags enables companies to augment their legacy bar code shipping applications by automatically recording materials shipped to customers. Companies can then find their own pallets in shipping yards or docks stacked with thousands of items belonging to dozens of companies. Higher degrees of tracking will enable organizations to lower their material costs and will provide an audit trail that can be used to bill customers if materials are not returned. The value of these applications has been proven in multiple real-world implementations.

Retail

Initial applications for RFID in the retail industry center on improved inventory management and product availability related to warehouse and distribution center applications like those previously described in this paper. RFID tracking is a powerful enhancement to inventory management procedures at distribution centers and the back of stores that translates to keeping more items in stock on the shelves. Improved shelf availability leads directly to improved sales—anywhere from 0.1 percent to 4percent, according to various RFID impact studies prepared for the retail industry. The dual benefit of increased revenues and decreased inventory costs are motivating retailers and consumer goods manufacturers to become leaders in RFID adoption. Retailers can reduce out-of-stocks by 0.07 percent yet still reduce overall inventories by 5 percent through improved visibility from RFID-enabled distribution systems, according to an A.T. Kearney study. Similar figures are reflected in studies by other leading consulting and research firms.

The RFID programs being implemented by Wal-Mart and other leading retailers require suppliers to apply RFID mostly on cases and pallets-not individual items. These activities are a strong indication that immediate RFID value for retailers lies in distribution and warehousing applications. By facilitating improved fulfillment accuracy, cross docking, and faster, more accurate shipments, retailers can increase inventory turns, reduce unsaleables, improve stock availability, and lower warehouse labor and storage requirements.

Item-level, in-store applications also are envisioned, and several high-profile trials have been conducted. Most involve tagging merchandise and tracking it either through zones and portals within the store, or through “smart shelves,” which have built-in RFID readers that can detect and report every time items are removed or returned to the shelf, which can trigger automatic replenishment and security alerts. Item-level RFID also can facilitate

secure self-checkout. Variations of intelligent shelf management and self-checkout have been implemented in libraries and video rental stores.

Libraries and Video Stores

Many large libraries around the world have implemented RFID to speed material check-in, checkout, shelf inventory, and security applications. Low-cost, flexible smart labels are inserted in books and can be made invisible to patrons. Counter personnel can check dozens of books in or out in mere seconds without manually handling and orienting each item. The tags also can be used for theft detection, much like anti-shoplifting technology currently used by retailers. Librarians using portable computers with RFID readers can take inventory and find misfiled materials simply by walking down an aisle of bookshelves. The reader can automatically detect missing materials and alert the operator.

Video stores are increasingly using RFID for similar applications. Readers are positioned at the checkout, unattended return bins, and doorways to record transactions and detect shoplifted items automatically. These library and video store operations are essentially in-store inventory management applications that can be adapted for use in many other industries.

Cashless Payment

Cashless payment is an effective retail application unrelated to item or shipping container tagging. The most widespread example of RFID cashless payment is ExxonMobil's Speedpass program, which is saving millions of drivers countless hours at the pump. Participating consumers can opt for either a passive tag, which is clipped to their key chain, or a battery-powered active tag attached to a car window, similar to one of the families of "toll tags." The tag contains a unique identification code. When the tag enters the reader field at a gas pump, it turns on the pump and automatically charges the gas purchase to the driver's registered credit card account, promoting quicker service while maintaining complete account number confidentiality. McDonald's restaurants now are offering a similar application to speed transactions at the counter and drive-thru window. This class of RFID application is growing rapidly.

Personal Security and Patron Management

Flexible RFID tags can be incorporated into wristbands, temporary visitor ID badges, and employee identification cards and used for numerous service and security applications. RFID commonly is used on patient wristbands to provide tamper-proof, accurate identification for facility access control and security. Many Alzheimer's disease facilities install RFID readers at all their doors to lock down and sound alarms automatically if patients try to wander through. In pediatric wards, only staff or parents may be permitted to take infants or children from a specific area or confines of a ward.

Hospitals also can use RFID to track medication dispensing, laboratory samples, and blood bags—much like bar codes are used today. RFID saves time and improves accuracy because it automatically records all item movements and does not require human intervention to scan a bar code or record data on a form.

A growing number of amusement parks and recreational facilities give their guests wristbands or ID tags with RFID chips that can be used to control or limit access to certain facilities. Another application is keeping track of patrons, such as children who might become separated from their group. By presenting their ID tags at "location stations," separated individuals can be located more easily by other group members. Hotels, restaurants, and entertainment facilities can print and encode tickets and guest identification or membership cards. The RFID card can be used for cashless payment, as a room key, and for access control to the health club and other facilities.

Cards or wristbands with embedded RFID chips also can be used for a cashless payment system by having guests prepay and loading the monetary value onto the card. Because the tag can be rewritten, guests can recharge the card or wristband after the stored value has been depleted.

Personal badge and tracking systems are very widespread RFID applications to ensure employee security and safeguard corporate property. RFID transponders embedded in employee personnel ID tags provide hands-free access to secured buildings and a tamper-proof form of identification that ensures only authorized personnel are admitted. Smart labels also can also be applied to computers, furniture, files, and other objects for asset tracking and theft deterrence.

Conclusion

RFID is a stable automatic identification technology that holds great promise for improving business processes; its use is becoming increasingly widespread. Indeed, some early adopter companies applying RFID at the carton and case level to mixed merchandise to automate creation of receiving and shipping manifests, have observed that RFID gives them unexpected opportunities to perform goods handling processes in efficient, entirely different ways. RFID should be considered for any application that could realize a clear benefit in terms of efficiency, reduced loss, or improved service. RFID offers strong performance and functionality, but at a price—considering tags relative to simple labels. The added cost of RFID, weighed against bar codes' outstanding value and the enormous installed, working infrastructure (supported by international standards), ensures the two technologies will coexist, just as our nation's roads are still full of cars despite the growth of commercial air travel during the last 50 years.

Because RFID tags can be reusable, don't require line of sight to read or write, enable unattended reading, and offer read/write data storage, they can improve efficiency in many operations by reducing labor and materials costs. Potential users must carefully evaluate the long-term impact for improved business operations relative to total cost of ownership and not automatically rule out use of the technology because of the initial investment required.

Zebra Technologies is a world leader in providing on-demand bar code labeling solutions that deliver information in forms that enable organizations to improve security, productivity, quality, and customer service. This leadership extends to RFID technology. Zebra was the first company to introduce an RFID printer/encoder, which simultaneously prints a bar code and encodes the embedded RFID chip in a smart label. Zebra can offer its customers the expertise and products necessary to support their bar code and RFID label printing needs. As a member of EPCglobal and the DoD RFID Expert Group, Zebra has access to and supports the latest supply chain EPC RFID technology and standards development activities. Contact Zebra to see how your organization can gain a competitive advantage by using the right combination of bar coding and RFID smart labels.

Not all products are available worldwide due to country-specific government regulations. Contact your Zebra representative for product availability.

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