Radio Frequency Identification

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Someone once said "You're never more than 10 feet from an arachnid." Today, the expression might be, "You're never more than 10 feet from an RFID." The acronym stands for Radio Frequency Identification, and is used to describe a plethora of applications from loss prevention and unlocking office doors using low-end technology to locating high-cost equipment to providing container inventories at transfer points and destinations using high-end technology.

How can one device do all this? Simply put, it's not one device, it's a system. There are two basic types of RFID tags—passive and active. Passive RFID tags have no battery or external power source, while active tags come in two varieties. Both varieties of active tags have a battery to power them, but the most widely used variety responds (emits a signal) only when interrogated by a compatible device. The other variety transmits its signal continuously in timed bursts. RFID has been used for years in various industries, and within the past 10 years in the healthcare field.

All RFID tags have, at minimum, two basic components, a circuit and the antenna. The circuit can be as simple as a single integrated circuit in a passive RFID tag or as complicated as an entire receiver/transmitter on a printed circuit board (PCB) inside the case of an active tag. The antenna length is tuned to the specific frequency of the RFID system, and often (in active tags) is found in etched copper runs on the PCB itself. The integrated circuit (IC) of a passive RFID tag receives and demodulates the incoming signal, processes information, and modulates a radio frequency (RF) signal or response. When exposed to an intense RF field of the correct frequency, partially determined by the antenna's length, the IC responds with a weak predetermined signal. Power for the IC is derived from the RF field itself, and only a limited amount of data is contained in the broadcast signal. Sometimes, as is the case in many shoplifting detection systems, the mere presence of the return signal provides sufficient information to initiate action. In other applications, such as access control systems, the passive RFID returns a coded (up to 16-bit) number linked to the access device (car key, badge, card, etc.) thus providing a means to identify the credential presented. Linking this to a PC or server with the appropriate software allows the designer to tie a particular coded number to a user, then admit or deny access to a room or area based upon access privileges granted to that user. Since passive RFIDs rely on the nearby transmitter to provide operating power, the distance at which they provide a reliable signal is quite short, ranging from a few inches to a few feet or more. These devices can be very small, as small as one-eighth inch by about one inch. Interestingly, that is the approximate size of the RFID "chip" commonly implanted in pets for identification.

Active RFID comes in two varieties, those that emit a return signal when interrogated and those that emit either a continuous signal or (to increase battery life) a brief signal burst every 15 to 30 seconds (depending on the program). Both varieties of active RFID contain an internal battery in addition to circuitry designed to store information and provide a stronger signal. The information contained in an active RFID is not limited to the 16 bits of the passive RFID, therefore its signal can be more meaningful. Common applications of RFID that return its signal only when interrogated include passports, loss-prevention systems, and so-called "E Toll" systems on toll roads and bridges. When interrogated, the active RFID returns pre-coded ownership information. Since this information is both digitally encoded and encrypted, it represents a safe and secure method of transporting and broadcasting sensitive personal information. The second variety is used in applications where an item or situation is continually tracked. For instance,

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A typical passive RFID tag used with a loss prevention system at a home center store. This tag was removed from a blister pack for cordless drill batteries.

one museum employs this technology to track visitors throughout the facility as they stop to look at exhibits and take photos that can be picked up at the museum's gift shop. Active RFIDs can range in size from about an inch square by a half-inch thick to as large as four by six inches by up to an inch thick. These larger active devices can be affixed to equipment and programmed with service literature and maintenance history (for a truck, for example) or the inventory of an entire shipping container.

Current Technology

RFID systems are found in a number of applications and take on different forms in the healthcare facility. The RFID tag can only be read by a compatible interrogator, and the two, along with various other peripherals, combine to become a system. An RFID tag may appear in many forms. One application imbeds the microchip and antenna inside a small plastic card about the size of a credit card. The card carries a unique identification number both imbedded in the chip and printed on the outside. Using a dedicated PC or server and proprietary software, a hospital security officer laminates a staffer's photograph and other information to the card, making an identification badge which can be both worn and used to unlock certain doors. In another part of the facility, a small band weighing less than one-half ounce (about 13 grams) is placed around the leg of a newborn baby as part of an infant abduction system. Removal of the tag upon discharge requires a special tool secured at the nurses station. Removal of the band from the baby, or the baby from the nursery, sets off an alarm, security is notified, and doors are automatically locked. These are just a few examples of healthcare adaptations of RFID technology.

When coupled with electromagnetic locks on perimeter doors, active RFID tags can locate, control, and limit wandering or eloping rehabilitation patients and nursing home residents. When someone approaches a controlled door wearing an active RFID tag, the tag is interrogated and returns a signal correlating with the movement permissions of the wearer and thus controls access. More elaborate systems may incorporate hallway and bathroom interrogators and allow for positive tracking of patients or clients within a facility. It is important to note that in these situations, this system must also be tied into the fire alarm system and fire exit system to allow automatic override for emergency egress.

As diverse as these systems appear to be, they all contain common components and operate in a similar manner. As is the case with many medical devices, the heart of an RFID system is a PC or server. Logistics applications, particularly those that involve inventory taking or "reading" a shipping container's RFID, often leverage a handheld PC sometimes referred to as a "scanner" as they frequently have the capability to scan bar codes as well. Some scanners download their data when placed in a charging cradle connected to an office PC or server; others are connected via a wireless local area network (LAN) to the information technology (IT) infrastructure, to the system's computer depending on the system design and its application software.

Physical security, patient wandering and elopement, and anti-abduction systems generally use a desktop PC or server and contain interfaces with electronic locks, motion sensors, and RFID interrogator/reader stations throughout the facility. Usually these interfaces are provided through the IT infrastructure, sometimes as a virtual private network (VPN), to avoid separate wiring. The application software contains an instruction to perform a certain action, such as unlocking a door for physical security systems or locking a door for patient wandering and elopement systems, depending on the permission associated with the interrogated RFID badge. Additionally, the software normally logs the event, may trigger an alarm (particularly in the case of elopement and anti-abduction systems), and/or may initiate a video recording for future reference. If local fire codes preclude automatic locking of egress doors, mobile tracking devices are often available with elopement and child anti-abduction systems.

RFIDs that either continuously transmit a signal or transmit an intermittent signal (continuously broadcast their signal every 15 seconds, for example) are often employed in the so-called "nurse locator" portion of nurse call systems. These systems utilize a network of interrogators/readers strategically placed throughout the area to determine where the RFID wearer is at any particular time. Properly installed with interrogator/sensors located in patient rooms, hallways, nurse's stations, and other ward areas, this system can handle multiple staff members and keep a log of staff activity. "Intelligent" nurse call systems utilize a combination of RFID and two-way communication to provide information and improved communication between staff members. Some systems can even direct patient calls to the available staff member nearest to the call's origin.

Equipment and personnel tracking systems, often termed real-time location systems (RTLS) in healthcare, work in much the same manner as other RFID systems, utilizing tags on devices and interrogators located throughout the facility. To cover a much wider area and reduce cost, some equipment tracking systems use passive or active RFID tags and locate their interrogators only at high-traffic intersections such as elevator lobbies, wards, and clinic entrances, etc. As equipment is moved throughout the facility, the tag is queried as it moves near a sensor and responds with its unique identification number. This number is returned to the system computer which has been loaded with a floor plan (usually from a compatible Computer Aided Design [CAD] program) for the facility as well as its proprietary application software. By superimposing the location of the equipment over the floor plan for the area, the user gets a visual impression of the device's location.

True real-time asset tracking systems rely on constantly signaling active RFIDs and a plethora of receivers throughout the facility. Their placement allows several receivers to simultaneously receive the unique identification number from the RFID tag and forward it to the system PC or server. Using information from several receivers, simultaneously collecting location data, the system is able to determine the location with improved

The Evolution of RFID

It is generally agreed that the first use of "passive RFID" occurred during World War II. A returning German aircraft pilot discovered that if he rolled the aircraft as it returned to base it would change the reflected radar signal. This maneuver allowed the German ground radar sites to distinguish between returning friendly German aircraft from approaching enemy Allied aircraft and react accordingly. Likewise, World War II also saw the first use of "active RFID" technology as well. The British claim credit for being the first to install a transmitter in their planes that would broadcast its signal in response to radar signals it received from the ground. This was the first active identification friend or foe (IFF) system, and its transponder concept is the functioning principle of RFID even today.

Improvements in radar, radio frequency (RF) communications, and IFF systems continued after the war, but were hampered by the size and weight of the equipment. In the 1960s, loss prevention systems using single-bit passive RFID tags began appearing in stores as large panels flanking patron exit doors, forcing patrons to walk between them when departing the store. These first-generation eventually evolved into disposable devices capable of being switched off at the cash register.

It was not until the advent of solid state electronics, and another unexpected aspect of the Cold War, that facilitated the quantum leap necessary to bring the concept of a Radio Frequency Identification system to fruition. At the height of the Cold War, the Energy Department needed to develop a system for tracking nuclear materials. The idea was proposed to place a transponder in a truck and readers at the gates of nuclear facilities. The antenna at the gate would trigger the transponder in the truck, which would respond with certain information relating to the shipment. This concept eventually became the basis of the automatic toll payments used on bridges, toll roads, and tunnels around the globe.

In the 1990s, RFIDs exploded on the transportation scene and were used for automatic toll payments in several states, implantable RFIDs used on cattle, reusable container tracking, antitheft devices on automobiles, fleet vehicle fueling and fast food purchasing dongles, and a number of other applications. Between 1999 and 2003, 100 of the largest companies, including some of the largest retailers in the world, as well as the U.S. Department of Defense, jumped on the RFID bandwagon mandating its use by their suppliers to track goods in the supply chain.

resolution. As with the previously discussed configuration the system is loaded with the floor plan, allowing a visual representation of the asset's location.

Although these RFID systems appear to be vastly different, they all are applications and variations of the same basic technology using passive or active RFID, an arrangement of one or more interrogators, and a PC or server to control everything.

How to Manage the Device

Management of RFIDs is not so much a matter of managing the device itself, but management of the entire system—tags, interrogator/receivers, and the computer tying everything together. Most often, this will not be the responsibility of the clinical engineering (CE) department, but in healthcare facilities operating a combined IT/CE maintenance shop, biomedical maintenance personnel may be called upon to perform preventive maintenance, maintain the system, or assist in system troubleshooting and repair. If the system is maintained in-house and falls within the responsibility of clinical engineering, then preventive maintenance (especially with wandering and anti-abduction systems) should be uniquely scheduled and meticulously performed.

Regulations

The primary regulatory body governing RFID technology in the United States is the Federal Communications Commission (FCC) and its regulatory actions apply primarily to design and engineering aspects of RFID systems. Legacy RFID systems operate low-powered transmitters under Sections 15.225 and 15.240 of 47 CFR, below the criteria requiring FCC licensing.

Risk Management Issues

The biggest risk management issue applies to those systems that prevent patient wandering, elopement, and infant abduction. Both elopements and infant abductions create negative publicity and leave the facility open to lawsuits, especially if a patient is injured during wandering, or an infant is not recovered. Also, false abduction alarms are a concern since this may lead to unlawful detainment of an individual, resulting in litigation against the facility. The next biggest concern is physical security of the facility.

Troubleshooting

RFID systems are relatively trouble-free, owing partially to their being primarily software-based and lacking mechanical parts. Normal remedial maintenance involves replacing long life batteries in RFID tags, malfunctioning interrogators, antennae, and other relatively simple tasks. Even with the best technology, false alarms will occur and must be dealt with from a maintenance and education perspective. The most common issue for many systems stems from human error—staff forgetting to deactivate signaling tags when removing them from patients, or entirely forgetting to remove the tag upon discharge.

Training and Equipment

Working knowledge of the particular system coupled with extensive knowledge of its installation is necessary to service RFID systems and their components. Conventional troubleshooting skills are required to maintain the PC or server and ancillary devices. Other than possibly a band removal tool, no special tools or test equipment are necessary for basic servicing. Networking knowledge or a good relationship with those responsible for maintaining the wired and wireless network is also essential.

Future Development of RFIDs

Since the technology is still in its relative infancy, many changes are forecast—reduced cost and size, increased range, data capacity, battery life, and three dimension location resolution—that will tremendously increase the use of RFID. RFID tags already have had an impact on the standard of care by replacing physical and chemical restraints for patients inclined to wander and elope in many healthcare settings. Aside from these healthcare applications, there are myriad uses on the horizon, including tracking medical consumables within the facility.

Better technology is in use in global commerce and possibly even in the materials management area of healthcare facilities. This technology already may be antiquated compared with recently developed RFIDs that are about the size of a grain of sand, consuming a mere eight microwatts of power, which have been prototyped for use in the transportation sector. These RFIDs will eventually migrate to the healthcare community. Someday RFIDs capable of being implanted under a patient's skin can be used to store medical information such as identification, personal physician, history, medications, etc. for use by emergency personnel. The only impediments to the proliferation of this technology throughout the healthcare arena are physical size and our own squeamishness at the thought of being microchipped. ■