Implementing RFID Technology in Hospital Environments

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INTRODUCTION

A promising approach for facilitating cost containment and reducing the need for complex manual processes in the healthcare space, RFID (Radio Frequency Identification) technology enables data transport via radio waves to support the automatic detection, monitoring, and electronic tracking of objects ranging from physicians, nurses, patients, and clinical staff to walkers, wheelchairs, syringes, heart valves, laboratory samples, stents, intravenous pumps, catheters, test tubes, and surgical instruments (Karthikeyan & Nesterenko, 2005). RFID implementations streamline hospital applications and work in concert with WLANs (wireless local area networks) and mobile devices such as cellular phones and personal digital assistants (PDAs). RFID technology also safeguards the integrity of the drug supply by automatically tracing the movement of medications from the manufacturer to the hospital patient.

This article begins with a discussion of RFID development and RFID technical fundamentals. In the sections that follow, the work of standards organizations in the RFID space is introduced, and capabilities of RFID solutions in reducing costs and improving the quality of healthcare are described. Descriptions of RFID initiatives and security and privacy challenges associated with RFID initiatives, are explored. Finally, trends in the use of RFID-augmented wireless sensor networks (WSNs) in the healthcare sector are introduced.

BACKGROUND

RFID technology traces its origins to 1891 when Guglielmo Marconi first transmitted radio signals across the Atlantic Ocean, and demonstrated the potential of radio waves in facilitating data transport via the wireless telegraph. During the 1930s, Alexander Watson Watt discovered radar, and illustrated the use of radio waves in locating physical objects. Initially used in World War II in military aircraft in what is now called the first passive RFID system, radar technology enabled identification of incoming aircraft by sending out pulses of radio energy and detecting echoes (Want, 2004). Libraries have used RFID technology for electronic surveillance and theft control since the 1960s.

Present-day RFID solutions track objects ranging from tools at construction sites and airline baggage, to dental molds and dental implants. RFID systems monitor the temperature of perishable fruit, meat, and dairy products in transit, in order to ensure that these goods are safe for consumption, and facilitate the detection of package tampering and product recalls (Want, 2005). The U.S. Department of Defense (DoD) mandates the use of RFID tags as replacements for barcodes for tracking goods (Ho, Moh, Walker, Hamada, & Su, 2005), and requires suppliers to use RFID tags in equipment and clothing shipped to military personnel. RFID technology is widely used by major retailers that include Home Depot and Wal-Mart in the U.S., and Marks and Spencer in the United Kingdom to track inventory. In the transportation and education sectors, credit cards that incorporate RFID technology enable automatic transactions at gas stations and toll plazas and at university bookstores, libraries, and cafeterias. RFID systems also facilitate building access, port security, vehicle registration, and supply chain management; verification of the identity of pre-authorized vehicles and their drivers at security checkpoints; and reduction in the circulation of counterfeit goods and paper currency (Garfinkel, Jules, & Pappu, 2005).

Developed by the U.S. Department of Energy Oak Ridge National Laboratory (ORNL), the RFID-enabled Protected Asset Tracking System is the first instance of RFID technology installed at the National Nuclear Security Administration site (Oak Ridge National Laboratory, 2007). Capabilities of the ORNL-sponsored RFID accountability system (RAS) in accurately tracking assets and monitoring the location of personnel were validated in a pilot test conducted in a large-sized facility at the Washington Navy Yard. This initiative also demonstrated the role of RFID technology in facilitating the safety of rescue workers responding to crisis situations and national emergencies in federal facilities, and the importance of using RFID tags on miners, firefighters, and other workers in hazardous occupations, so their location and safety can be monitored as well.

RFID TECHNICAL FUNDAMENTALS

RFID systems consist of RFID tags or transponders, and interrogators or readers. Classified as passive, semiactive, or active, a RFID tag is an extremely small device containing a microchip, also called a silicon chip or integrated circuit that, at a minimum, holds digital data in the form of an EPC (Electronic Product Code). RFID tags are affixed to or incorporated into objects, such as persons or products (Weinstein, 2005).

A RFID tag is also equipped with an antenna for enabling automatic receipt of and response to a query from an RFID interrogator, via radio waves (Myung & Lee, 2006). The RFID communications process involves the exchange of an electromagnetic query and response, thereby eliminating RFID dependency on direct line-of-sight connections. Subsequent to transmission of the EPC from the RFID tag to the RFID interrogator, the tagged object can be monitored and traced.

Passive RFID tags are inexpensive and limited, in terms of functions supported (Weinstein, 2005). In terms of transmission, a passive nonbattery operated RFID tag makes use of incoming radio waves when it is within range of a RFID interrogator to transmit a response. A passive RFID tag contains the EPC in the form of eight-bit data strings associated with a distinct object and several bits of memory for storing data describing the tagged object. When multiple passive RFID tags transmit EPCs concurrently in response to RFID interrogators, collisions occur, thereby disrupting information flow. Designed to support passive RFID tag operations, the adaptive binary splitting (ABS) collision arbitration protocol diminishes the occurrence of collisions, thereby significantly reducing delay and communications overhead in the transmission process (Myung & Lee, 2006).

As with passive tags, semiactive and active RFID tags also feature EPCs or unique identifiers, and utilize the RF spectrum for data transmission. Batteries in semiactive RFID tags remain dormant until signals are received from interrogators. When sufficient power is available, semiactive tags initiate data transmissions in response to interrogator queries.

An active RFID tag features an onboard battery that serves as its own power source for performing operations, and transmitting the EPC and related data on-demand in response to interrogator queries. An active tag also supports security functions, and can contain an environmental sensor (Karygiannis, Eydt, Barber, Bunn, & Phillips, 2006). Moreover, an active tag enables transmissions over longer distances than passive and semiactive tags. However, an active tag is limited in sustaining continuous operations as a consequence of battery constraints. Since active tags are larger and more costly to implement than passive and semiactive tags, these tags typically monitor large items.

Classified as active RFID systems, wireless sensor networks (WSNs) contain sensors for monitoring the environment (Philipose, Smith, Jiang, Mamishev, Roy, & Sundara-Rajan, 2005). To conserve available power and provision efficient operations, active RFID tags that are part of WSNs are also equipped with battery-powered four-byte or eight-byte processors, and employ cryptographic algorithms to facilitate secure transmissions. Next-generation sensors are expected to operate without batteries by harvesting power from ambient sources.

RFID operations are typically carried out in the unlicensed portion of the RF spectrum, and are dependent on the availability of suitable frequencies and bandwidth at affordable costs. Generally, active RFID tags operate in allocated spectrum in the UHF (ultra high frequency range) between the 300 MHz (megahertz) and 3000 MHz frequencies, and the SHF (super high frequency) between the 3 GHz (gigahertz) and 30 GHz frequencies. These tags carry more data, and support operations over longer distances than passive RFID tags operating in allocated spectrum in the LF (low frequency) between the 30 kHz (kilohertz) and 300 kHz frequencies, and the HF (high frequency) between 3 MHz and 30 MHz frequencies (Littman, 2002). It is important to note that while increased transmission rates and operating range are advantageous in the UHF and SHF spectrum, data transmitted via RFID systems in these frequencies are also vulnerable to interception. Spectrum allocation for RFID utilization differs between countries and regions, and between member states in the European Union.