Radio Frequency Identification (RFID) Applications in the Medical Field
Shelton Houston\textsuperscript{1} and Wesley Blackwell\textsuperscript{2}

Abstract - Radio Frequency Identification (RFID) is a technology that has existed for many years; however, industry opted not to pursue any of the suggested uses for this technology when first introduced due to the high cost associated with implementation. A RFID system consists of two major components, the first being a tag which is placed on the object that is to be tracked and the second is a reader that propagates a signal to and from the tag. Over the past several years this cost has gradually declined because of the reduced manufacturing expenses for developing the hardware required to operate an RFID system. Companies have begun to re-evaluate a variety of uses for this technology in their current infrastructure to accommodate a wide array of needs that were previously financially unviable. This paper examines an application of RFID tags in the medical field as well as legal and societal issues associated in any medical implementation.

Keywords: RFID, barcode, reader, tag

Introduction
Automatic product identification procedures are popular in industry. Automatic identification procedures exist to provide information about people, animals, goods and products. Barcode labels triggered a revolution in product identification, but have limitations of storage capacity and one time use. To meet increased industrial requirements for product identification, other solutions had to be considered. One possible solution was to include a film silicon chip combined with a magnetic strip on products to accommodate additional data storage; however, technology still required direct contact with the magnetic strip to transfer information. Not a practical solution, since barcode technology did not require direct contact with a product. A contactless information transfer process would be needed to meet the requirements of increased data storage and the advantage of contactless barcode technology. In the ideal case, the power required to operate the silicon chip would also be transferred using contactless technology.

Background
Historical records indicate that the first known instance of an RFID like technology was found in the Soviet Union during the 1940's when an inventor by the name of Leon Theremin introduced a device for military operations; however, after further investigation this was not completely accurate. The device that was utilized by the Soviets was a secret listening device and was never used for identification purposes. Other reports placed the RFID system as far back as the 1920's while some argued that the technology was not discovered until the 1960's. One British report mentioned a device called an IFF transponder that was used during World War II by the allied forces to quickly identify aircrafts to determine if they were friendly or the enemy. Historical reports, while not completely accurate, provide a certain amount of truth because without these early developments, the RFID system that was officially introduced in the 1970's would not have been possible.

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RFID System

Figure 1 shows the three basic components of any RFID system: 1) the tag or transponder, 2) the reader or interrogator, and 3) the antenna. The tag is affixed to a product to be identified or tracked. The reader obtains or reads the information contained in the tag. An antenna is required by each component and establishes communication between them.

Figure 1- Typical RFID System

Frequency Bands

Table 1 lists RFID frequency bands currently in use. Each frequency band has advantages and disadvantages for operation. The lower frequencies < 135kHz and 13.56MHz are better able to penetrate and read through materials than higher frequencies. Lower frequencies usually have less range and have a slower data transfer rate while higher frequency ranges have can support higher bit rates of the data transfer and greater range.

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>&lt; 135 kHz</th>
<th>13.56 Mhz</th>
<th>400 - 930 Mhz</th>
<th>&gt; 2.45 Ghz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>~ 18&quot;</td>
<td>~ 3'</td>
<td>~ 15'- 30'</td>
<td>~ 3'</td>
</tr>
<tr>
<td>Pwr Source</td>
<td>Passive</td>
<td>Passive</td>
<td>Active &amp; Passive</td>
<td>Active &amp; Passive</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Low Cost &amp; Speed</td>
<td>Med Cost &amp; Speed</td>
<td>High Cost &amp; Speed</td>
<td>Highest Cost &amp; Speed</td>
</tr>
</tbody>
</table>

Table 1 - Typical RFID Frequency Bands

Regardless of the frequency band selected, data will be transmitted to a reader using some type of radio communication technique. The digital data from a tag will be encoded utilizing one of three common techniques: Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), or Phase Shift Keying (PSK). For ASK, binary data
is encoded by amplitude modulating the carrier frequency. FSK encodes data by transmitting a different frequency for a binary one or zero. PSK encodes binary data by changing the phase of the carrier frequency 180° between a binary one and zero.

Operation

Designs of RFID tags vary, but all require a silicon chip or integrated circuit and an antenna. There are three groups or classifications of RFID tags. The first classification is “Passive” tags that does not have an internal power source and requires a reader to function. Power is derived from the RF signal coming from the reader. The RF signal is rectified to supply DC power to the tag circuitry. Passive tags have essentially no shelf life or electrical expiration. The second classification is “Active” tags indicating that a unit contains an onboard power source and does not require a reader to function. Active tags utilize an internal battery for circuit power and communication. Active tags are reported to last up to ten years depending how often the tag is scanned and operated. The third classification is “Semi-Passive” or “Semi-Active” tags which has onboard power to operate, but requires a reader for communication.

Limitations

All methods of implementation have benefits and downfalls associated with them. The active or semi-active systems excel in the areas of range and overall functionality due to the internal power source that is integrated in the tag. The capabilities of the active or semi-active tag far exceed that of the passive tag due in part to the amount of information that can be transmitted to a reader. The use of an internal power source hinders the active and semi-active tags when considering the cost and lifecycle of the product. The larger size of active or semi-active tags due to the internal power source is another factor that passive tags are more desirable for medical applications.

Medical Applications

The major hurdle when considering any RFID tag system for humans is the United States Food and Drug Administration (FDA). Most individuals would not think that RFID technology could be approved; however, in October 2004 the FDA approved VeriChip by Applied Digital Solutions for human implants. Applied Digital Solutions has been marketing animal tag systems for a number of years, but the approval for human implants has created a large debate in the medical community.

The proposed medical applications have not been well received due to the social and legal issues raised. RFID is considered by some medical professionals as the answer to many of the current obstacles related to the transfer of personal information to and from a patient and a hospital. Patients in certain Mexican cities have the option of receiving the VeriChip implant which contains a complete medical history of the patient. The medical information can be scanned, reviewed and updated by each medical facility that the tagged patient enters. This seems a likely answer to the current problems associated with collecting and updating patient information, but one major concern is the lack of security utilized in passive tags. The manufacturers of these passive tags ensure that the devices are secure by the fact that tag ranges are limited to a few millimeters to transfer data to a reader. Some industry experts disagree and state that the information sent to the reader can be intercepted using a high gain antenna positioned outside a secure area.

A number of RFID medical applications have been accepted by the medical community. One of these is the "Talking Prescription." When used with a special reader, the name of the medication is announced, along with the dosage and special warnings associated with the drug. The product is targeted for the visually impaired population and will allow them to medicate themselves. RFID is also being used to track certain medications that fall within the narcotic category. A RFID tag placed in prescription bottles can be tracked through the supply chain. Another application invokes RFID tags to track medical waste. The purpose of this initiative is to eliminate any guess work concerning the location of medical waste. Garbage yards would be aware of containers holding medical waste and could dispose of the containers properly. SurgiChip has also been accepted by the medical community. This is an external RFID placed on a patient. Once the patient enters an operating room, the RFID tag is scanned and a
complete record of the patient is obtained. It is used to minimize wrong site operations, wrong patient operations, or wrong procedure operations.

**Future**

Like any new technology, standards will be required before large scale applications are possible. Currently, seven governing bodies exist for RFID. The Federal Communications Commission (FCC) governs the technology in the United States, Canada has the Department of Communication (DOC) and Europe has three agencies (ERO, CEPT, ETSI). Japan has the Ministry of Public Management - Home Affairs - Post - Telecommunication (MPHPT). China has the Ministry of Information Industry, Australia has the Australian Communications Authority, and New Zealand has the Ministry of Economic Development. These agencies are developing standards for RFID, but no two agencies are working together to provide a universal standard. Healthcare implementations will also have to be taken into consideration for any universal standard, given that every country’s healthcare profession has appended guidelines of patient privacy. It is easy to predict that this technology will be as common place as barcodes in years to come. However, solutions must be developed in the areas of security, cost, and standards before RFID will reach its true potential.

**References**

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