APPLICATION GUIDE FOR RADIO FREQUENCY IDENTIFICATION IN ELECTRONIC MEDICAL RECORDS

A professional project presented to

the faculty of

the College of Communication of Ohio University

In partial fulfillment

of the requirements for the degree

Masters in Communication Technology and Policy

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August 2004

This professional project entitled

APPLICATION GUIDE FOR RADIO FREQUENCY IDENTIFICATION

IN ELECTRONIC MEDICAL RECORDS

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DAVIS, NICOLE M. M.C.T.P. August 2004. Communications Systems Management

Application of Radio Frequency Identification in Electronic Medical Records (69 pp.)

Director of Professional Project: Andrew Snow

Abstract

This project explores the role of technology in healthcare. Within Appalachian Ohio there is a need to connect a person's medical data to a uniform database in an electronic medical record (EMR) system. The Appalachian Regional Informatics Consortium Planning Project grant was established to accomplish such a task. This project paper will indirectly address the objectives of the imminent EMR system that will serve the Appalachian region. Instead the focus of this paper is to provide a capable guide for rural health care facilities to use if there is one day a need to integrate a wireless local area network and radio frequency identification (RFID) system into their networked system.

Approved: ____

Professor of Communication Systems Management

Acknowledgement

Foremost appreciation to my advisor and mentor, Dr. Phyllis Bernt, has been directly involved with many aspects of this project and further exemplifying what a real educator should be. Your guidance, patience, and selflessness during the development of this project were greatly appreciated. I also want to express my gratitude to my committee members: Dr. Trevor Roycroft and Dr. George Johanson. You each have provided kindness, insight and suggestions which improved my understanding, and broadened my vision for this project.

I wish to thank my colleagues and friends, Mr. Marcos Vergez, Ms. Jing Liu, and Ms. Shweta Agrawal. Thanks for all the help you gave me during this project. Thanks go to the Office of Information Systems and Instructional Technology, in particular Mr. Roy Johnson, Brian Phillips, Mrs. Jill Breeze, Mrs. Hope Fauber, and Mr. Daniel Smith, for your support under Appalachian Regional Informatics Consortium Planning Project grant.

Finally, special thanks go to my parents, Ronald and Maureen Davis. It was your encouragement and support that led me to face up to difficult challenges and realize goals that I thought were far from possible. I want you to share the joy of my achievement and be proud of your daughter. Thanks go to my sisters for their love and encouragement.

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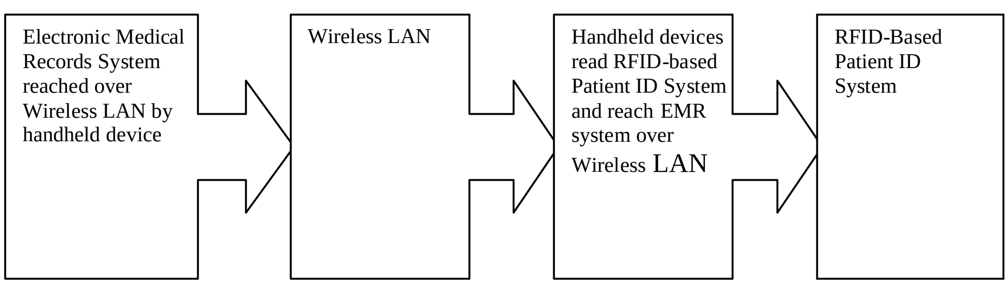
EXECUTIVE SUMMARY

The primary goal of this professional project is to consider how an electronic medical records system can be reached over wireless LAN by a scanner and assure successful systems integration, leading to interoperability with the wireless LAN. The secondary goal is to assess the specific issue of integrating radio frequency identification into patient ID system and using handheld scanners capable of reading RFID-based patient ID system and capable of reaching EMR system over wireless LAN. Interoperability is the main objective for this system to work. After examining the concepts of that make up an RFID system and wireless LAN, it is concluded RFID-based patient identification system could be a very useful took for patient management in Appalachian Ohio. Figure 1.1, shows the relationship between an RFID, WLAN, an EMR system, and handheld devices or scanners.

Figure 1.1

RFID Application Diagram



The organization of the professional project essentially follows the outline presented below.

Chapter 1: Introduction. Describes the ARIC and the federal administration objective of an EMR being used by healthcare institutions by 2014.

Chapter 2: General Overview of Telemedicine. Describes in detail telemedicine, various applications in telemedicine, Appalachian telecommunication infrastructure, and telecommunication policy concerns that may affect Appalachian Ohio.

Chapter 3: The Basics of Spectrum. Describes the spectrum management at a fairly detailed level as well as wireless LAN, RFID, and government use and regulation.

Chapter 4: Wireless Patient Monitoring Network. Describes the issue of RFID-based patient ID system. Discusses software and system requirements. Evaluate the pros, cons, and tradeoffs of using such a system.

Chapter 5: Conclusion. The content of this chapter is a brief summary of research result.

CHAPTER 1

INTRODUCTION

The Appalachian region, with 29 counties in Ohio, is an environmentally beautiful area which resonates a rich quality of life and an attractive place to call home. However there are significant socio-economic challenges and health care problems that plague the area. In order to address these issues rural development must be identified. Much of development literature fails to provide a well-accepted definition of rural development, which makes discussion of development strategies difficult. It is an area of study that is broad and encompasses a wide range of disciplines. Sustainable rural development is based on political, social, and economic concepts. Based on Richards (2004) rural development is devoting resources to all socio-economic conditions that affect the countryside. Providing resources to telemedicine would be a form of rural development. Investment in telemedicine applications has substantially improved conditions in rural areas. Telemedicine refers to the use of electronic communication technologies to provide health care. Telemedicine, a form of rural development can strengthen rural health care infrastructure by improving access to health care services.

Many federal initiatives are being driven by technological and economic criteria that emphasize cost reduction and efficacy in healthcare. The value of telemedicine for rural development is seen by the Bush administration as a great mechanism for reducing healthcare costs. During the State of the Union address, President George Bush said “by computerizing health records, we can avoid dangerous medical mistakes, reduce costs and improve care" (Bush, 2004). A medical record is a confidential record that is kept for each patient by a healthcare professional or organization (Szilagy, 2003). It contains a patient's personal details and medical history. It is documentation of symptoms, diagnosis, treatment and outcomes. Electronic medical records (EMR) extend the concept of the medical record; an EMR is database software that improves documentation quality and increases productivity in a medical practice. An EMR allows health professionals to access medical data online across great distances. The military already has more than 60 databases linking doctors with on demand access to a patient's medical history (Thompson, 2004). Consequently the Bush administration is pushing for computerization of medical records for every American by 2014 (Bush, 2004).

Development, cooperation, and integration of an electronic medical record (EMR) also facilitates the growth of telemedicine. Using an EMR involves a synergistic critical mass of public and private infrastructure investment that includes and requires telecommunications. In 2002 administrators from Ohio University (College of Osteopathic Medicine, College of Health and Human Services, Edison Biotechnology Institute); 317 Board - Alcohol, Drug Addiction and Mental Health Services; Appalachian Behavioral Healthcare Center; Doctor's Hospital of Nelsonville; Health Recovery Services; O'Bleness Memorial Hospital; Southern Consortium of Children; Tri-Country Mental Health and University Medical Associates collaborated and submitted a proposal requesting a National Library of Medicine (NLM) grant. In 2003 the Appalachian region was awarded an integrated advanced information management system (IAIMS) planning grant from the NLM. The purpose of the grant is to set up an EMR system. A consortium was formed whose member organizations are referred to as the Appalachian Regional Informatics Consortium (ARIC). The purpose of ARIC is to facilitate and create a comprehensive technical plan for a regional electronic medical information system (ARIC, 2001).

A major challenge confronting ARIC is the integration of diverse independent agencies and disciplines into a single integrated advanced information management system. Consortium members know the positive capabilities of EMR technology. The ARIC planning project seeks to articulate the needs of the clinical community of Appalachia and the technological possibilities of an EMR system. ARIC members recognize the probability of failure is high but they have a common vision about the future of telemedicine.

1.1 *Significance of the Project*

One way to gain a better understanding of electronic medical records is to focus on one particular sector. Although the applicability of EMR's in one sector (urban) to another (rural) is clearly problematic, the focal point of this project will be to identify and isolate factors that will be beneficial to rural areas. This project will look at economic, social, and political considerations that rural areas face when they try to amalgamate telecommunication and medicine. Radio frequency identification (RFID) systems are chosen as the subject of this investigation. The significance of this project is to determine how RFID can be incorporated into an EMR system in Appalachia once an EMR is in place. The following chapters will provide details on RFID, EMR, handheld devices, and wireless local area networks (WLAN) which will demonstrate how an EMR can be more efficient once a wireless infrastructure is in place. This paper will be a resource that can be used to answer questions about telemedicine, the impact of wireless networks in health care, the advantages and drawbacks of wireless integration into rural hospitals, regulation, obtaining funding, and finding vendors. This manual will be a guidebook for health organizations who would like to develop an infrastructure that utilizes RFID.

1.2 *Literature Review*

One of the most commonly cited underserved populations are those living in rural areas. Though many urban dwellers often think of people living in rural areas as small in number, there are in fact, 65 million Americans living in rural areas (OTA, 1999). The problems of distance and the delivery of health services by way of telecommunication have been studied for over 50 years. Parker, E. B. & Hudson, H. E. (1992) book provided the conceptual framework for addressing the needs of rural development and telecommunication policies and initiatives. There isn't a very large coherent way of resolving the issue of connectivity and assess in rural healthcare. Although Access Appalachia (2004) reported more advanced telecommunication penetration in Appalachian Ohio had increased since 2002. Parker, E. B. & Hudson, H. E. (1992) believed rural development could be accomplished through the work of organizations rather than groups. One of the reasons ARIC planning project received the grant it did was because the collaboration of several organizations. Both the general principles and proposal of the ARIC project reflect an understanding of interoperability amongst Appalachian Ohio healthcare facilities. An RFID-based patient ID system could take off if organizational groups are proactively involved and have aligned goals. Social organizations have more power in rural communities, such alliances could bring federal funding into a rural area. Emery's (1998) study found federal and state grant programs are important sources of funds for telemedicine investments. To a greater extent grants are becoming more available for rural areas. Once Appalachian Ohio has an EMR system in place they may be ready for RFID-based patient ID system and maybe private and federal grants will be available to support this technology. However organizations should not look to government to provide them with a model to institute new technology. In Thompson & Brailer (2004) report, guidance on how to develop an EMR system by the government is vague at best. Conditions laid out by the government are too broad and unspecific to be implemented in a consistent manner.

Even though RFID-based patient ID system is not being visibly utilized by many hospitals over the United States there are several trials in place (Collins, 2004; PDC, 2004; Collins, 2004). Finkenzeller (1999) examines RFID use in a practical sense. Finkenzeller (1999) was one of the most useful sources used for this paper because he clearly articulated concepts associated with RFID. Johansen (2004) was one of the few sources that addressed RFID use in healthcare. He discussed privacy and security concerns in greater detail because health care facilities have a lot to lose if a patient’s data is compromised. Weis (2003) vulnerabilities to physical attacks, counterfeiting, spoofing, eavesdropping, or denial of service could threaten unprotected tags...which could affect the privacy and security of both individuals and organizations. Most relevant RFID standards are authorized for use, some overlapping and conflicting, but no uniform guidelines are in place for when to use which standards and how. Non uniform standards could also affect privacy and security. Johansen recommends using higher frequency bands in order to decrease these risks. Integration and infrastructure is needed in order to use RFID. Carter, Lahjouji, & McNeil (2003) believe legislation should aim at managing the spectrum more efficiently so an individual’s privacy is protected. There is a need for a long-term roadmap covering EMR, wireless LAN, handheld devices, and RFID-based patient ID system efforts. The roadmap should clearly describe the current IT infrastructure, once EMR system is in place, and operational goals.

CHAPTER 2

GENERAL OVERVIEW OF TELEMEDICINE

Telemedicine is the use of telecommunications to provide medical information and services to people geographically disadvantaged. Telemedicine encompasses everything from the use of standard telephone service through the use of high speed, wide bandwidth transmission of digitized signals in conjunction with computers, fiber optics, satellites, and other sophisticated peripheral equipment and software.

Since the invention of the telegraph and telephone, physician's early uses of these devices were seen as a form of telemedicine application. During the American Civil War, 1861-1865, telegraph services were utilized by the military for various medical purposes. Later the advent of the telephone by Alexander Graham Bell in 1876 made it possible for healthcare professionals to consult with each other and their patients. Radio and television broadcasting changed the way health problems were treated because health professionals were able to reach a larger medium of people (Bauer, 2002). Two early examples included the Nebraska Psychiatric Institute in 1959, which used closed-circuit interactive two way television (IATV) to transmit patient examinations across their campus, and the National Aeronautics and Space Administration (NASA) in 1970s, with the program called Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC). STARPAHC allowed health care to be provided to astronauts in space and general medical care to the Papago Reservation (Bashshur, 1980). Telemedicine programs after the 1970's flourished due to federal grants and advances in technology which in turn decreased the price of the technologies. In recent years, urban hospitals, federal programs like the Rural Utilities Service (RUS, a division of the Department of Agriculture), and Department of Defense (DOD) have become instrumental in developing and implementing telemedicine projects. For instance in 1994, the United States military established the DOD Telemedicine Test Bed which is a system that uses advanced telecommunication to provide medical services around the world (Bauer, 2002).

2.1 *Telemedicine applications*

Telemedicine has a variety of applications in patient care, public health, administration, research, and education. Some uses such as using a telephone to call the doctor are so commonplace that they are often overlooked as examples of distance medicine. Telemedicine applications generally fall into two broad categories: real-time (synchronous) and store-forward (asynchronous). Real-time transfer methods rely on high speed, generally fixed link at low or high bandwidths which has the ability to send data as well as voice. A form of real-time application is videoconferencing using an interactive television (IATV). The use of interactive video for consultations and patients monitoring attracts a good deal attention, although such applications are far from routine in everyday medical practice (Field, 1996). The most obvious store-and-forward application includes sending multimedia or digital images (x-rays, CT scans, or MRIs) to different locations via email or using other web-based tools.

Today, medical images, sound, numerics, texts, voice are being digitized and transmitted via the local area network (LAN), integrated service digital network (ISDN) and the Internet (Emery, 1998). However, fewer than 10% of hospitals around the country use telemedicine networks (Phillips, 2004). Prior to the 1990’s telemedicine had grown due to the use of analog technologies which allowed the sending of images via modem or telephone lines. This was a cost effective way of transferring data. There is a need for telemedicine networks to utilize broadband technologies because the speed is much faster. Broadband aids advanced telecommunication capabilities like telemedicine and EMRs. The FCC defines advanced telecommunications capability as data transmission services with upstream and downstream speeds exceeding 200 kbps. "High-speed" services are those over 200 kbps[1] in at least one direction (FCC, 2003). Additional information on broadband will be discussed in Chapter 3.

More advanced telecommunication systems in hospitals can mean the difference between life and death. Today more and more hospitals realize the most critical aspect of a telemedicine system is the EMRs. Medical records enable health professionals to review previous care events, to reach timely and appropriate clinical decisions, and to develop treatment plans that minimize the risks and maximize the potential benefits to the patient. They offer a chronicled and legal record of the steps taken during care which functions as an instrument to construct account summary. It is important that telemedicine systems include EMR. Given the changes in technology, particularly the move to computerized information storage and increase in consumer involvement in healthcare, one issue that is being addressed by many hospitals is whether the existing paper-based medical record remains the most cost-effective way to conduct business. Electronic exchange of patient information is rapidly developing, because of the potential to save time and money. But in order to take full advantage of this opportunity it is highly desirable that medical data be stored in electronic format. While the benefits are clear,

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[1] Kbps (kilobits per second) which is the rate of speed data is transferred (e.g., 1 Kbps equals 1,000 bits per second).

there are some obstacles to overcome. For example hospital administrators must ensure that medical information is stored in such a way as to ensure data is secure from loss, damage or alteration. It also must be subject to access controls that ensure adequate protection of patient privacy and unauthorized disclosure (Szilagy, 2003).

2.2 *Appalachian telecommunication market*

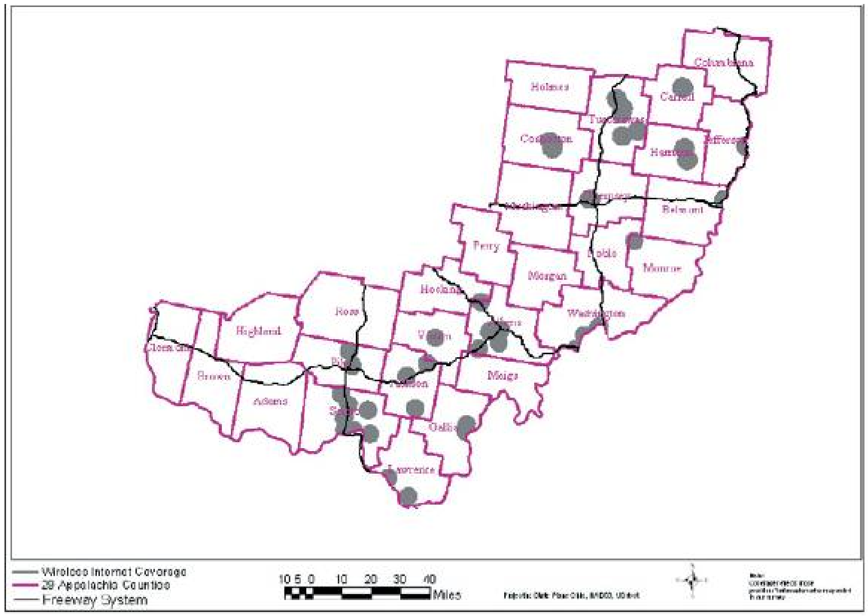
The Appalachian Region includes all of West Virginia and counties in 12 other states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia. The Ohio region contains 29 counties with a population of over 10,000 in each county. Numerous telecommunications companies serve the Appalachian region and they provide telephone, cable, and high speed internet access. Certain areas within Appalachian Ohio have particularly poor telecommunications infrastructure, while other areas have excellent capabilities. In 2000, the Appalachian Regional Commission (ARC) conducted a study that measured the availability of these services. In a 2002 report, ARC found that Ohio was light in digital subscriber line (DSL) equipped central offices, only 47 percent of the Appalachian region's zip codes have one or more high speed service subscribers (compared to the nationwide average of 59 percent), and dialup was the preferred method of connecting to the internet in this region (Oden & Strover & Inagaki & Arosemena & Gustafson & Lucas, 2002).

Ecom-Ohio (2000) was a project attempting to measure Ohio's readiness for electronic commerce. Components of e-commerce are infrastructure and access. Infrastructure is the communication networks that connect users to the Internet. Access is the choices available by which users can connect to the public data network at the level they demand or need. Several of the ARIC committee members were asked to prepare a technical systems inventory. The most astonishing institutional assessment came from Health Recovery Services (HRS) a behavioral healthcare resource. Their main location, recently built and located in Athens, uses dialup connection to access the internet and organizational email. Frognet is HRS's internet and email service provider. Of the six locations 4 don't have internet connection at all, two connect to the internet by Frognet dialup and some even use the Windows 95 operating system. Some of reasons why facilities like HRS don't have access to broadband is lack of capital. Broadband in Southeast Ohio is expensive, and sparsely dispersed, so access points are dominated by dialup. Ecom-Ohio (2000) says that 28% of LANs and 14% of wide area networks (WAN) are used by Southeast Ohio businesses.

Access Appalachia, another initiative in 2001, was implemented to assess the level of supply of advanced telecommunication services in Appalachian Ohio. Access Appalachia project concluded that most counties in Appalachian Ohio are quite technologically advanced, however, regional wireless telecommunications access still lags significantly compared to more urban and suburban communities in Ohio (Access Appalachia, 2004). Access Appalachia found that wireless Internet broadband services exist in 16 of the 29 Appalachian Ohio counties. Figure 1.1, is a map that details the coverage area of wireless broadband services in the Appalachian region of Ohio. The grey dots represent a three mile coverage area around a wireless access point.

Figure 1.2

Wireless Coverage in Ohio's Appalachia Region



Source: Access Appalachia (2004)

Wireless broadband covers only a small area of broadband services in Appalachian Ohio. Those areas are usually centrally located within coffee shops, on university premises, and in a select few public venues.

2.3 *Real world concerns*

Telecommunications and information technology can provide increased opportunities for health care delivery and community development. Parker and Hudson (1992) demonstrated that telecommunications infrastructure investment enhances economic activity and growth at the national economic level. However advanced telecommunications infrastructure is not available for many rural areas. Even in those areas where the necessary transmission media are available, they may be prohibitively expensive. The Access Appalachia (2004) report revealed a disparity in rural area rates for various telecommunication transmissions. This is a serious situation, given that the most effective use of telemedicine would be in the rural areas. The list of factors limiting active deployment of telemedicine includes slow demand for integrated solutions; high costs of telemedicine services; inadequate telecommunication infrastructure; lack of profit potential; legal issues; insufficient publicity for telemedicine; and lack of private networks.

Universal service has been an important goal of policymakers since the first Communications Act of 1934 and the recent 1996 Telecommunications Act. Universal service mandates that telecommunication carriers provide services which “promote quality services at just, reasonable, and affordable rates; increase access to advanced telecommunications services throughout the nation; advance the availability of such services to all consumers, including those in low income, rural, insular, and high cost areas at rates that are reasonably comparable to those charged in urban areas” (FCC, 1996). The 1996 Telecommunication Act’s core basis was the development of competitive markets which could allow government to reduce its traditional role of overseeing the telecommunications industry and regulating its prices. In rural areas, where the availability of businesses doesn’t encourage competition, some telecommunication carriers believe the incentives for universal service delivery to support programs like telemedicine do not outweigh the costs to provide it. Many health care providers are discouraged from using telemedicine because telecommunications rates are sometimes several times the rates paid by their colleagues in urban areas. There are several government programs available that offer discounted rates for telecommunication services in health care. One program is universal service’s Rural

Health Care (RHC) division which provides reduced rates to rural Health Care Providers (HCP) for telecommunications and Internet services necessary for the provision of health care (Universal Service Administrative Company, 2003). According to former FCC Chairman Kennard "many of our grantees found that the program's discount rates were either non-existent or so small that it was not worth completing the complicated and multiple step application process. This problem with the discount rates was due in part to the way the benchmarks are calculated (OAT, 1999)." Consequently local exchange carriers (LEC) did not see any incentive to participate in filling out their section of the application because the lack of business available in rural markets did not support competition. An American Telemedicine Association (2003) presentation on RHC identified some of the problems former FCC Chairman Kennard argued four years earlier. Their solution was that the application process be simplified, time limits imposed on telecommunication firms, and HCP be reimbursed directly (ATA, 2003).

Federal and state grant programs are important sources of funds for telemedicine investments. An academic hospital in close proximity to rural hospitals increases the chance of funding by private and public donors (Emery, 1998). For instance between 1994 and 1997 the Appalachian Regional Commission had three telemedicine projects taking place and received a total of $831,381 in federal telemedicine funding (OAT, 1998). During this time Ohio University was awarded $325,837 from the USDA Rural Utilities Service. Rural Utilities Service (RUS) is a division of USDA that provides a loan program to support rural access to high speed technology. The Committee on Agriculture (2003) found that only 10 percent of the total investment has been in the form of loans. Some hospitals are prohibited from entering loan programs. FCC

Commissioner Michael Copps stated "We now understand that our Rural Health Care Program has not lived up to its potential. We set aside as much as $400 million annually, but in the first five years of the program, just over $30 million was disbursed to rural facilities (FCC, 2003)." RUS also is unable to get enough demand for their $190 million loans. Many programs sink or swim depending on the amount of funding they receive and grants are preferred rather than loans. The paradox is that while telemedicine offers a means to reach the isolated, there isn't always a means for cost recovery (Committee on Agriculture, 2003).

Chapter 4, section 4.5, will further discuss funding concerns surrounding wireless and RFID.

CHAPTER 3

THE BASICS OF SPECTRUM

Spectrum is used to provide a variety of wireless communication services, which are categorized as fixed or mobile voice/data services or broadcast services. Wireless communications includes cellular telephony, paging, personal communications services, federal government communication, radio and television broadcast, and satellite control. The radio frequency spectrum, a limited and valuable resource, is a part of the electromagnetic spectrum that is used for telecommunications services. Electromagnetic radiation spreads energy that travels through space in the form of radio waves (Kruger, 2002).

Section 2.1, gave a brief introduction to different types of broadband technologies available and their applications. This section also provided an FCC definition for broadband as an advanced telecommunication service. Broadband is a telecommunication service in which a large band of frequencies is available to transmit information. The information that is transmitted is sent on many different frequencies or channels within the band in tandem, allowing more information to be transmitted in a given amount of time. Broadband signals have a large bandwidth and can support many advanced telecommunications services such as high speed data and video transmission. According to the FCC broadband refers to a new generation of high-speed transmission services, which allows users to access the Internet and Internet-related services at significantly higher speeds than traditional modems. There are different types of broadband service, which include DSL, cable modem, wireless internet, satellite, and broadband over power lines (FCC, 2002). Bandwidth describes a range of limiting frequencies and will influence how fast data is transmitted or received through wires, air, or space. Bandwidth is the width of the range (or band) of frequencies. Signals are transmitted over a range of frequencies which determine the bandwidth of the signal. More information can be transmitted with greater bandwidth. Throughout most of the last century, wireless communication depended on “analog” signal transmission. An analog device receives modulated waves by tuning to their frequencies and converting them to images, sounds or commands. For example a pager is an analog device that sends an alphanumeric message. Advances in digital communications technology over the last decade have increased the usage of digital signal transmission. It is now possible to convert sounds, images and other data into electronic impulses that may be processed by computer chips. In this form, they can be transmitted and received via frequencies of the spectrum in greater volume, and with much more efficiency and precision than analog waves in some applications. Digitization makes possible a strengthened partnership between wireless and networking across different localities (Kruger, 2002).

3.1 *Wireless LAN*

A local area network (LAN) is a group of computers and associated devices that share a common communications line or wireless link and typically share the resources of a single processor or server within a small geographic area. Standard LAN protocols, such as Ethernet[2], can operate at fairly high speeds with inexpensive connection hardware, bringing digital networking to almost any computer. The evolution of LANs

[2] International standard networking technology for wired implementations. Basic 10BaseT networks offer a bandwidth of about 10 Mbps, fast ethernet (100 Mbps), and gigabit ethernet (1000 Mbps).

has allowed more people to communicate. Wireless technology has taken this a step further by changing the way personal and business relationships are conducted. Wireless signals transmit and receive data through the air with radio frequencies. A wireless local area network (WLAN) is a flexible data communications system implemented as an extension to or an alternative for a wired LAN. WLAN technology combines data connectivity (computers) with user mobility, and offers simple and flexible network installation with reduced cost of ownership and enhanced network scalability (Li, 2003). A standard, IEEE 802.11, represents the standard protocols for wireless LANs.
There are currently four specifications: 802.11, 802.11a, 802.11b, and 802.11g. Section 3.3.3 will go into further detail about these standards.

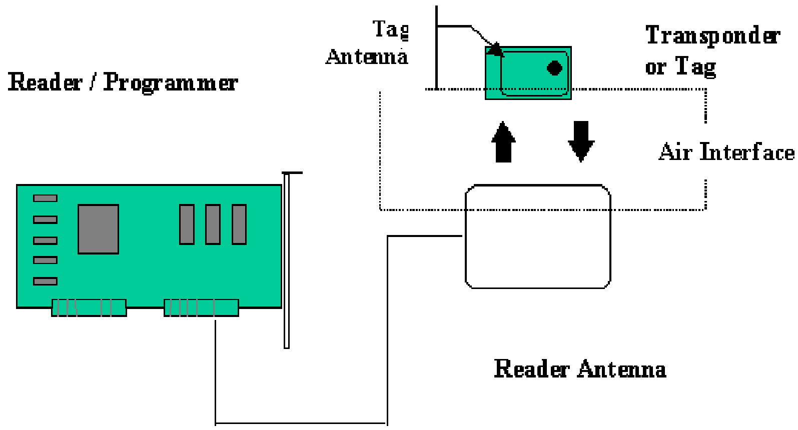
3.2 *Radio Frequency Identification*

The first examination of radio frequency identification (RFID) occurred during World War II. Britain used radio wave based navigation to identify whether an aircraft was a friend or enemy during night operations. More recently, commercial businesses began using RFID technology for specialized applications. For instance, in the 1980's the agricultural industry used tags, inserted beneath the skin, to track livestock. At the time the high cost of the technology was thought to be offset by the potential loss from lost, misplaced or stolen goods. Today RFID is less expensive. Regular consumers already have in their possession products like Mobil speed pass and OnStar, a form of RFID technology. The enormous impact of Wal-Mart and DOD purchasing power will dictate how and when consumer goods companies adopt RFID technology (Red Praire, 2003).

A basic RFID system, illustrated in Figure 1.2, consists of three components: an antenna or coil, a reader or transceiver (with decoder), and a transponder (RF tag) electronically programmed with unique information (Finkenzeller, 1999; AIM, 2003).

Figure 1.3

RFID system components

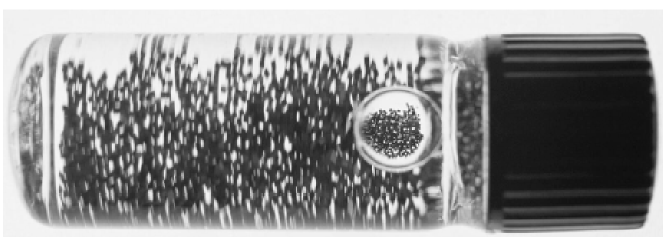


Source: AIM (2003)

RFID is essentially an extremely small and durable semiconductor chip that acts as a digital license plate that stores and transmits information about a product or device through electromagnetic waves in the radio frequency spectrum. Figure 1.3 shows a vial filled with thousands of RFID microchips in a liquid solution.

Figure 1.4

Vial of RFID chips



Source: Weis (2003)

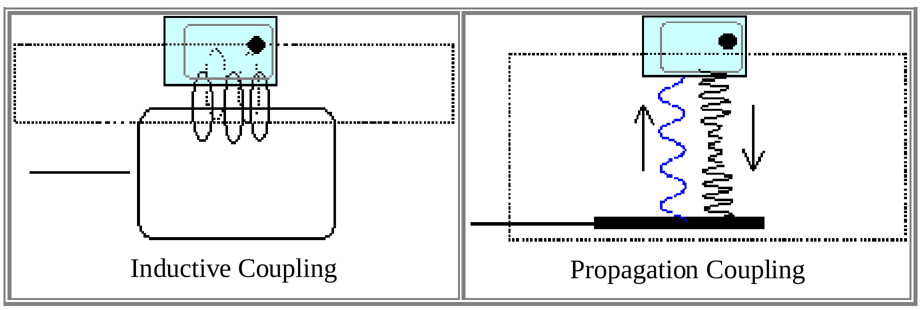
The transponder or RFID tag is the actual data carrying device which consists of a coupling element (antenna) and a tiny silicon microchip. Antennas are the conduits between the tag and the transceiver, which controls the system's data acquisition and communication (AIM, 2003). An RFID transceiver transmits a radio frequency (RF) signal, which is detected by the tag through its antenna. Sometimes antennas are packaged with a transceiver and decoder to become a reader (or interrogator), which can be configured either as a handheld or a fixed-mount device (AIM, 2003). The reader (or interrogator) receives the backscattered signal and decodes the data or electronic product code (EPC). When an RFID tag is within the electromagnetic zone the transponder is activated when it detects the reader's signal (Finkenzeller, 1999). The tag reflects the RF signal and reads and writes data to it. The reader decodes the data encoded in the tag's silicon chip and the data is passed to the host computer for processing (AIM, 2003).

It is important to understand the many different aspects of RFID if it is to be integrated into a healthcare setting. Tags' capabilities are based on their intended use as specified by a particular manufacturer. RFID tags have different designs and are categorized as either active or passive. Active RFID tags are powered by an internal battery and are typically read/write. Read/write capabilities allow tag data to be rewritten and/or modified. The memory of active tags varies among different applications; however, storage capacity is usually up to 1MB of memory. The power supplied by the active tag's battery gives it a longer read range. The trade off is greater size, greater cost, and a shorter operational life which may yield a maximum of 10 years, depending upon operating temperatures and battery type (AIM, 2003). Unlike active RFID tags, passive

RFID tags obtain operating power from the radio frequency waves of the reader, not from an internal battery. This is termed inductive coupling which is based upon close proximity to electromagnetic waves. Propagating coupling is based on far proximity to electromagnetic waves. Figure 1.3 represents two methods that distinguish and categorize RFID systems. Coupling via 'antenna' structures forms an integral feature in both tags and readers.

Figure 1.5

Electrical Coupling



Source: AIM (2003)

Passive tags are consequently much easier to produce thereby making them lighter than active tags, less expensive, and with a longer operational life, which makes them well suited for asset identification. Passive tags thereby have shorter read ranges and require a higher-powered reader. Table 1.1, gives a breakdown of the different characteristics of active and passive tags.

Table 1.1

Characteristics of Active and Passive Tags

CHARACTERISTIC	ACTIVE	PASSIVE
Power Source	Battery	Inductive
Memory	up to 288 kb	up to 288 kb
Read Range	$\leq$ 1,500 feet (500 meters)	$\leq$ 15 to 30 feet (10 meters)
Class	0 (read only) 3 (write once, read many) 4 (multi read / write)	0 (read only)
Frequency	Low (125, 134 KHz) High (13.56 MHz) Ultra High (868 to 930 MHz) Microwave (2.4 GHz)	Not applicable 303, 433 MHz
Risk of Interference	High	Low to medium
Data Transfer Rate	Variable	Variable

Source: Red Prairie (2003)

Tag types are unique in their ability to read and/or write. Table 1.2 identifies tags by their class designation and explains programming features. The simplest, and least expensive, tags are read only, meaning the data on the tag cannot be changed. The data is encoded during production by the distributor. Read-only tags most often operate as a license plate into a database, in the same way as linear barcodes reference a database containing modifiable product-specific information (AIM, 2003). Read only tags cannot be reused. However tags that are read/write are programmable and reusable. The data stored on them can be encoded, augmented or changed at any time. This can be an important security, quality control, and theft deterrence feature; section 4.3 will discuss security and privacy issues in greater deal.

Table 1.2

Types of Tags by Class Designation

Tag Class		Class Designation	Programming
Class 0	=	Passive, Read Only	Programmed in manufacturing process
Class 1	=	Passive, Write Once, Read Many	Programmed once by the customer then locked
Class 2	=	Passive, Multi Write / Read	
Class 3	=	Active, Multi Write / Read	Can be reprogrammed many times
Class 4	=	Active, Networking Tags	

Source: Red Prairie (2003)

Currently, depending on the type of RFID tag, the read range of the signal is typically between 3 feet and up to 150 feet. Passive tags have a shorter read range than active tags, currently 25 feet or less. Because of the short range, the use of passive tags is limited to applications where readers are in close proximity to objects being identified. Active tags' read range can vary from a few feet all the way to satellite-based applications (Red Prairie, 2003). Active tags have a greater advantage because having a longer range means that fewer readers are needed to identify products across a given area at a lower cost. If there are a number of readers and/or tags in a small confined area it is possible for multiple signals to overlap causing errors in the data. Time division multiple access (TDMA) offsets the trouble associated with collisions by initiating readers to send or receive information at different times. The ISO 15693 standard for RFID supports a slotted Aloha mode of anti-collision which is similar to TDMA (Weis, 2003).

Earlier in the chapter we discussed the relationship between signal and frequency. The power of an RFID read range is determined by the level of frequency being utilized. Three frequency ranges are generally distinguished for RFID systems: low, intermediate (medium) and high. The Table 1.3 summarizes these three frequency ranges, along with the typical system characteristics and examples of major areas of application.

Table 1.3

Frequency Bands and Applications

Frequency Band	Characteristics	Typical Applications
Low 100 - 500 kHz	Short to medium read range Inexpensive low reading speed	Access control Animal identification Inventory control Car immobilizer
Intermediate 10 - 15 MHz	Short to medium read range potentially inexpensive medium reading speed	Access control Smart cards
High 850 - 950 MHz 2.4 - 5.8 GHz	Long read range(greater than 90 feet) High reading speed Line of sight required Expensive	Railroad car monitoring Toll collection systems

Source: AIM (2003)

Because there are so many different types of tags, this paper will categorize types of tags and their most common usage within health care facilities in chapter 4, section 4.1.1.

3.2.1 *Organization and management*

RFID technology can be used for three purposes: tracking, inventory management, and validation. Each of these characteristics could provide benefits that could yield cost savings and improved productivity.

<u>Tracking</u>

RFID is used to follow a product through the supply chain and clinical workflow. It can be used to track a product to a particular patient and identify the clinician who used said product with a patient. RFID reduces the amount of time involved in locating or tracking, thereby making the process less cumbersome.

Inventory Management

Inventory management is the most important aspect of managing an organization. It enables managers to monitor usage patterns throughout their organization. It is a complex process that asks what (what is in stock), how (how much is it), who (who has it), where (where is it), and when (when to reorder). RFID helps manage patient inventories so that the right assets are available when and where they are needed.

Validation

Validation assures that an action has taken place or that the desired item is on hand. Like tracking, the ability to validate through RFID technology can reduce medical errors, check productivity, and help construct necessary documentation for administrative and audit purposes. The validation is an effective method of ensuring quality in a healthcare setting. The most important validating function is to verify that the patient being treated is, in fact, the right patient and that the treatment that is about to occur is appropriate (HIMSS, 2003).

3.2.2 *Benefits of RFID*

A broader way of looking at RFID is viewing it as a tool for managing information and inventory. Health care managers and workers who have accurate data available to them are able to make decisions based on valid information. The accuracy of RFID tracking can provide up-to-date information about inventory levels which can improve productivity, reduce wasted time by staff, and thereby increasing cash flow into a hospital instead of out.

The advantages of RFID are (AIM, 2003):

- *Accuracy:* increases accuracy by reducing the likelihood of human errors.

- *Ease of use:* easy to use as long as the appropriate hardware and software components are in place to maximize the process of automatic data collection. For example, all RFID systems are advantageous because it is a non line of sight technology. Tags can be read through a variety of surfaces such as snow, fog, ice, paint, and other visually and environmentally challenging conditions.
- *Timely feedback:* promotes timely feedback of data captured in real time, enabling decisions to be made from current information. For example, RFID tags can also be read in challenging circumstances at remarkable speeds, in most cases responding in less than 100 milliseconds.
- *Improved productivity:* improve productivity in that many manual activities and tasks become automated, enabling resources to be utilized in other ways to increase efficiencies. For example, the read/write capability of an active RFID system is also a significant advantage in interactive applications such as work-in-process or maintenance tracking.

3.2.3 *RFID vs. barcode*

RFID technology and barcode technology are two different technologies. Often times people refer to RFID tags as "smart" barcode tags. There are situations where barcode technology will be the better technology to use. Barcode is already widely used by many industries and it has well established standards. Barcodes cost far less than RFID tags. It is unlikely that RFID will replace barcode, however, both are indispensable for a wide range of identification applications, even though RFID is more expensive. Placing an RFID tag on an inexpensive item like a 55 cent candy bar would not be cost efficient. Barcode technology uses line-of-sight technology which means that a scanner must be lined up with the barcode in order to read it. RFID does not have this problem because it uses radio waves to transmit signals. RFID tags can be read through objects and read in real time. RFID tags are unique in that each is a unique identifier while barcodes for a particular item are typically the same. RFID is advantageous in this instance because it carries more data, enabling individual items to be identified not just by their unique identification, but also distributor, manufacturer, expiration data, and so on. For example RFID tags can store information about a medical product being shipped like date of the shipment, date received, and other miscellaneous information. RFID can also interface with digital data sources to store information. Table 1.4 cites some clear differences between RFID and barcode technology.

Table 1.4

Main Differences between RFID and Barcode

System	Barcode	RFID
Data Transmission	Optical	Electromagnetic
Typical Data Volume	1-100 Bytes	128-8K Bytes
Data Modification	Not possible	Possible
Position of Data Carrier for Read/Write	Visual contact	No line of sight
Reading Distance	Several meters (line of sight)	From centimeters to meters (depending on the frequency and tags)
Access Security	Little	High
Environmental Susceptibility	Dirt	Very small
Anti-collision	Not possible	Tags can be read simultaneously

Source: Accenture (2001)

3.3 *Government Use and Regulation*

RFID is a wireless service that makes use of the spectrum. The federal government manages the spectrum in order to maximize efficiency and to prevent interference among spectrum users. The need for government to regulate use of the spectrum arose when analog technologies became susceptible to interference because much of the radiofrequency spectrum is shared among two or more wireless services. Transmissions on the same frequency confused the receiver and caused noise. The government decided to set aside different areas of the spectrum for different uses by granting licenses to spectrum users. The government also retained patches of unallocated “white space” between broadcast frequencies to avoid interference. A small portion of the spectrum is for unlicensed uses such as amateur radio, walkie talkies, global positioning satellite devices, and wireless networking.

3.3.1 *Federal regulatory agencies*

The National Telecommunications and Information Administration (NTIA) manages all spectrum used by the federal government and the Federal Communication Commission (FCC) manages all non-federal spectrum used by state and local governments and the commercial sector. The FCC is an independent regulatory agency that is responsible for the regulation of all RF devices. Individuals or companies wanting to use a slice of the spectrum apply for an FCC license, which authorizes the holder to use a particular frequency for a specific purpose in a particular location. There are services that do not necessitate the need to obtain a license. These services will be discussed in further detail in section 3.3.2.

3.3.2 *Part 15*

Title 47 of the Code of Federal Regulations (CFR) are the FCC rules which stipulate that any device which radiates radio frequency energy is to be tested for compliance. Part 15 of Title 47 is the section of the CFR that deals with devices that emit radio frequency energy and are to be operated without an individual license. Within the radio frequency spectrum are certain bands available for "unlicensed" operation and Part 15 administers these bands. Part 15 governs a broad range of the radio spectrum ranging from .009 MHz to above 38.6 GHz. A few of the "free" or unlicensed bands open for public use include 902 MHz to 928 MHz, 5.7 GHz, and 2.4 GHz band. Wireless, unlicensed medical devices in health care facilities operate in 470-668 MHz as well as

174-216 MHz. RFID operating frequencies have been reserved specifically for industrial, scientific or medical applications or for short range devices.

The FCC stipulates that RFID devices in the United States operate at ultra high frequencies (UHF) and in the ISM bands[3] (Industrial, Scientific and Medical) under conditions defined in FCC Part 15 rules, Section 15.247. UHF has a frequency range from 300 MHz to 1 GHz. Section 15.247 covers operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz. The 902-928 MHz band offers optimum range of operation. Table 1.5, provides an extended list of frequency ranges for RFID systems.

Table 1.5

Frequency Ranges for RFID Systems

Frequency Range	Application and Comments
Less than 135 kHz	low frequency, animal tagging, access control, track and traceability
6.765, 6.795 MHz	medium frequency (ISM)
Approx. 13, 13.56 MHz	medium frequency (13.56 MHz, ISM)
26.957, 27.283 MHz	medium frequency (ISM), special applications only
433 - 460 MHz	UHF (ISM), rarely used for RFID
902 - 916 MHz	UHF (ISM)
2.400, 2.483 GHz	SHF (ISM)
5.725, 5.875 GHz	SHF (ISM), rarely used for RFID

Source: AIM (2003)

Part 15 compliant RFID systems typically utilize a frequency hopping spread spectrum modulation technique in order to benefit from maximum reader transmitted power allowances. Section 15.247 further stipulates that the RFID carrier frequency must

[3] ISM bands are designated by the International Telecommunication Union (ITU)

"hop" from channel to channel within the 902 MHz to 928 MHz bandwidth. The regulation specifies 50 channels, and the RFID interrogator may not dwell on any channel for more than 4 tenths of a second before switching to another channel. Part 15 compliant UHF readers can operate at a maximum transmitted power of 1 watt, or up to 4 watts with a directional antenna, if they hop across a minimum of 50 channels.

3.3.3 *Standards Organizations*

There are several standards and regulatory considerations in place that apply to RFID. However there aren't uniform standards in place at the national and international level. RFID manufacturers are particularly concerned because the price of RFID chips has decreased and has been sparking the interest of buyers thereby increasing the demand for this product. Homogeneous RFID standards would enable more widespread adoption and use of the technology. Bodies like the Institute of Electrical and Electronic Engineers' (IEEE), EPCglobal (EPCG), International Organization of Standards (ISO), and Department of Defense (DOD) all have input on the standardization of RFID.

3.3.3.1 *IEEE's "Wi-Fi"*

IEEE first introduced an internationally recognized standard for WLANs in June 1997; it is known as IEEE 802.11 or "Wi-Fi" (wireless fidelity). Its purpose was to establish standards for vendor-to-vendor interoperability. IEEE 802.11 recognizes 2.4 GHz, as acceptable for radio frequency communication (AIM, 2003). IEEE 802.11 specifies the physical layer and media access control (MAC) layer within a WLAN scheme. The MAC protocol is a scheme called carrier sense multiple access collision avoidance (CSMA/CA). Later 802.11 became composed of several standards operating in different radio frequencies. Table 1.6 provides a list of those standards as well as others.

In 1999, IEEE 802.11 WLAN working group introduced the 802.11b standard. The 802.11b standard is the most affordable and established wireless LAN technology. 802.11 allows wireless connections up to 400 feet in an enclosed space, up to 1200 feet in open space, and can easily be added to existing wired networks. Its performance is comparable to a standard wired Ethernet network with a speed up to 11 Mbps[4]. The 802.11a standard provides a bigger medium for data and supports more simultaneous users. The reason is 802.11a operates at radio frequencies between 5 GHz and 6 GHz. It is ideal for deployments where speed and bandwidth are important. The 802.11a networks can run at up to 54 megabits per second (Mbps) and support more users per access point than a Wi-Fi. The 802.11g standard provides wireless transmission over reasonably short distances at up to 54 Mbps compared with the 11 Mbps of the 802.11b standard. The 802.11b and 802.11g standards operate in the 2.4 GHz range and are compatible with each other. Devices that use the 802.11a standard do not talk to 802.11b devices, but there are certain access points (usually called dual access points) that enable the use of both types of networks simultaneously. There are other well accepted standards like Bluetooth and Home RF that have strengths as well as weaknesses over WiFi but for now Wi-Fi is the established leader.

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[4] Mbps (megabits per second) which is the rate of speed data is transferred (e.g., 1 Mbps equals 1 million bits per second).

Table 1.6

Performance Metrics for Select Wireless Networking Standards

System Type	Channel Bandwidth	Channel Capacity	Typical Data Rate to Customer	Range
802.11b	22 MHz (2.4 GHz band)	11 Mbps	5.5 Mbps**	250’
802.11a	40 MHz (5.7 GHz band)	54 Mbps	32 Mbps**	75’
802.11g	40 MHz (2.4 GHz band)	54 Mbps	32 Mbps**	150’
Bluetooth	1 MHz (2.4 GHz band)	1 Mbps	721 kbs**	30’
HomeRF	1-5 MHz (2.4 GHz band)	10 Mbps	***	150’

**If WEP (Wireless Equivalent Privacy) security protocol is activated, it may use an additional 10% of the channel capacity.

Source: Carter, K. R. & Lahjouji, A. & McNeil, N. (2003).

3.3.3.2 *EPCglobal and RFID*

EPCglobal (EPCG) provides the industry's need for RFID network standards with its electronic product code (EPC) network. The Hardware Action Group (HAG) a group within EPCglobal, develops specifications for key hardware components of the EPC Network, including tags and readers. The EPC system defines several classes of products Table 1.3 demonstrates class designation. Generation 2, in the planning process, is going to be newest and most advanced of EPCglobal's RFID specifications in the UHF band (Roberti, 2004). Generation 2 specification defines the air interface and communications protocol used by tags and readers to exchange information. Generation 2 will resolve all of the shortcomings of the two older specifications, Class 0 and Class 1 of Generation 1, by improving global compliance, tag throughput, rewritability, security, privacy and robustness in high density reader environments (EPCglobal, 2003). Generation 2 will have an open standard and a worldwide compliance that meets the requirements of high-volume supply chain users.

3.3.3.3 *ISO and RFID*

International Organization of Standards (ISO) assures users their RFID systems are interoperable for worldwide use. The ISO 18000 series of standards are the most appropriate item identification standards for RFID, however, there are other ISO RFID standards in use like ISO 15693, 90001, and etc. ISO 18000 parts 1, 2, 3, and 4 cover the generic parameters for the air interfaces at all major frequencies, as well as specific air interfaces for tags operating at 135 KHz, 13.56 MHz and 2.45 GHz. ISO 18000 parts 5 and 6 are two standards for RFID tags used to track items that cover “air interface.” ISO 18000-6 covers the air interface for RFID tags operating at ultra high frequency (860 – 930 MHz). ISO 18000-6A and 18000-6B are incompatible with each other and with the EPC standards (Impinji, 2003). ISO 18000-5 covers the air interface for tags operating at 5.8 GHz. ISO 18000 parts 1, 2, 3, 4, 6 were accepted and 18000-5 was rejected.

3.3.3.4 *DOD and RFID*

U.S. Department of Defense (DOD) mandates Unique Identification (UID) policy for asset management. DOD states that UID is a set of data for tangible assets that is globally unique and unambiguous, ensures data integrity and data quality throughout life, and supports multi-faceted business applications and users (OSD, 2004). UID will be compatible with ISO RFID standard. The Department of Defense says, “the military plans to… eventually deploy Class 1, V2, or Class 2 (read-write) EPC tags,” and “the DOD [is] working with the ISO and EPCglobal to ensure that RFID standards meet its needs” (Impinji, 2003).

There are many other committees, working groups, and national standard organizations involved with RFID. Like ISO some of these standards are voluntary although, as with all voluntary standards, marketplace pressure usually mandates compliance.

CHAPTER 4

WIRELESS PATIENT MONITORING NETWORK

Telecommunication technology has changed the way data is gathered and transmitted. Technologies like computers and local area networks have revolutionized the way business is conducted especially in health care settings. Wireless systems have made healthcare transactions even more effective and efficient. New wireless networking technologies operate on different frequencies that minimize inference with medical equipment, unlike cellular phones. Many health organizations incorporate wireless into their infrastructure because information flow is seen as being effortless under a wireless system because there isn't much worry about wiring. Health professionals are able to monitor their patient through uses of devices like a wireless handheld personal digital assistant (PDA) or tablet PCs which combine computing, Internet and other networking features. The decision to develop a wireless patient monitoring network should not be taken lightly by any institution especially a health care facility. However the benefits are far reaching, i.e., wireless technology allows healthcare practitioners to assess patient data instantaneously.

Emerging technologies like wireless have joined a growing number of conventional patient monitors that have been enhanced with RFID transmitters and receivers that establish wireless links to hospital information systems. By using a wireless LAN, patient information can be transferred to an electronic patient management system, further eliminating manual reentering of data at a central computer terminal

(PDC, 2003). Health care institutions could significantly benefit from technology that offer features such as these. This approach to the technology could reduce medical errors and improve productivity thereby increase savings to a hospital.

A wireless patient network isn't very complex. Antennas, positioned at key points on a hospital's floor, receive signals transmitted by sensors and their associated components, and pass the received data on to the wireless network. Wireless systems like this are being used for patient identification, infant abduction prevention, and patient wandering. The Navy is among the few organizations using RFID technology to interface with their EMR system. The system is referred to as Tactical Medical Coordination System or TacMedCS. Within this system each patient admitted to the Navy's hospital is fitted with a RFID-enabled wristband and medical personnel use the handheld scanner to confirm the identity of the patient being treated (PDC, 2003). The wristband helps to eliminate human error in entering medical data and ensures accurate patient information.

The adoption strategies and issues described in this chapter were taken from multiple RFID projects. This chapter also presents some of the hard lessons learned including the impact on workflow, an overview of issues to consider when selecting hardware and software, a list of vendors, and RFID to patient wristbands application.

4.1 *Patient Point of Care*

Point of Care (POC) is an important term in medicine; it means near the patient and its objective is to generate a result quickly so that appropriate treatment can be implemented which can lead to an improved outcome. As discussed in previous chapters, RFID can tremendously improve productivity. Rewritable RFID tags can capture data electronically at the point of service. In healthcare delivery such capabilities of RFID tags could not only enhance productivity, it could improve safety and quality of care. Verifying patient information with an RFID reader prior to treatment can alert caregivers to potential errors before they occur, thereby avoiding patient harm and liability to the hospital. RFID in hospitals is a type of decision support system that can verify what are commonly called the “Rights” (HIMSS, 2003):

- Right Patient
- Right Treatment (Drug, Dose, Route)
- Right Time

4.1.1 *Patient wristband*

There are emerging applications of RFID in the healthcare setting (Collins, 2004). There are several applications on the market that enable healthcare facilities to integrate RFID enabled devices with patient registration system. One type is in the form of wristbands. In general, hospitals require that patient’s wear wristbands at all times for identification purposes while they are being treated because the importance of positive patient identification can not be underestimated. Too often, caregivers who are rushed or distracted fail to perform the basic task of checking the patient’s ID, instead they rely on their memory or a verbal response from a patient who may be confused or on medication. As many as 98,000 people die in the United States each year due to medical error. According to the Institute of Medicine (1999) the leading cause of death is due to medical error caused by patient, specimen, or medication misidentification.

Figure 1.6

RFID Wristband

Source: Precision Dynamics Corporation (2004)

An RFID patient wristband is a great tool for decreasing medical mishaps. An RFID wristband is an inexpensive, non-transferable, and positive patient identification mechanism that can be used to track, validate, and provide inventory information to determine that the appropriate care is being provided to the right patient. An RFID patient wristband would be placed on the patient at the point of registration (when a patient first enters a hospital). The RFID wristband system acts as a portable dynamic database that carries patient information and is able to be updated during the patient's stay. The increased memory capacity of the RFID microchip won't just hold patient identification information but other useful information that can determine whether the accurate amount of medication is being administered, past diagnostic procedures, and even alert clinician whether a patient is ready to be moved to another branch of the hospital.

Precision Dynamics Corporation (PDC) and Exavera Technologies are the only two companies in the United States that manufacture RFID enabled patient wristbands. Health organizations that have purchased their product use class 1 or 2 designation because they are passive tags and they are rewritable. Some great characteristics of passive tags, as discussed in section 3.2, is they're easy to produce, light, and inexpensive. The tags and readers used from Alien Technology by PDC operate at 2.45 GHz (Collins, 2004). This UHF frequency band is used because 2.45 GHz and 5.8 GHz have long range and they are more secure (Johansen, 2004). An RFID wristband can be programmed and printed on demand by direct thermal or thermal transfer printer/programmers (PDC, 2003). Section 4.2.3 will discuss tagging requirements and Appendix A provides a contact list of RFID printer manufacturers.

4.2 *Communication infrastructure*

Wireless communication infrastructure consists of a wireless radio frequency LAN and mobile devices which can be plugged into a wireless modem, or into a mobile device using a Personal Computer Memory Card Industry Association (PCMCIA) slot or a wireless modem-to-modem connection can be made to the host or server computer. There are changes that are required to the local area network in order to facilitate a smooth transition to automated patient identification. The first is making sure the appropriate LAN system is in place. Having a wired Ethernet and other connected systems in place makes an easy transition to a wireless LAN system because then it is just a matter of expanding and reconfiguring. ARIC's EMR system will most likely have this minimum infrastructure in place to support such a transition. Second is selecting the appropriate wireless product. Research must be conducted by the IT department to determine what is the most effective way of bringing wireless networking technology into an organization, the best wireless configuration, the most cost-effective LAN configuration, where to place wireless access points[5], and what software and hardware should be used.

Important features to consider are that the products are easy to manage, flexible, expandable and secure. For instance IT managers will look mostly at 802.11X standard and compliant products. Currently, most health care providers are deploying 802.11b. The reason is it is well established, fast, and cost efficient. Exavera Technologies designs RFID systems for patient monitoring purposes. Exavera's information system is unique in that it combines RFID with Wi-Fi wireless LAN and voice over IP (VoIP)[6] to deliver a single system to track patients, staff and hospital assets. The company's system uses a Wi-Fi (802.11a/b/g) network router, which connects to the hospital's LAN via an Ethernet port. Exavera's unit includes an RFID transceiver to read RFID tags placed on patient bracelets, staff ID badges, and hospital equipment. The tag attaches to a patient's wrist with a disposable plastic wristband. Hospital staff are equipped with Wi-Fi enabled PDA's or tablet PCs. The PDA acts as the communication device and individual identifier. Whenever the RFID transceiver[7] detects the proximity of a hospital staff member to a patient, the Wi-Fi network will deliver the patient's records on the caretaker's handheld device (Collins, 2004).

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[5] A wireless LAN transceiver or "base station" that can connect a wired LAN to one or many wireless devices. Access points can also bridge to each other. A bridge is a product that connects a local area network to another local area network that uses the same protocol (for example, wireless, Ethernet or token ring). Wireless bridges are commonly used to link buildings.

[6] VOIP is a system that enables telephone calls over the high speed network.

[7] The number of transceivers installed is dependent upon the size of the facility to support the RFID WLAN system.

4.2.1 *Data integration*

It is important to know about data integration because it could either be economical or costly in the long run. The beneficial thing about wireless is it does not place any additional data integration requirements on the health care organization. Most organizations are looking at single vendors to provide end-to-end software solutions so adding and upgrading is easier in the future. A single vendor could cause problems for the user. If the vendor goes out of business, the organization could be locked-in to products which no longer have support. To protect RFID equipment investment, hospitals should insist on guarantees from their software and hardware vendors that the equipment they purchase will follow with training to relevant personnel and will be easily upgradeable to support innovations.

4.2.2 *Software application*

There are other areas of the IT infrastructure that may need to be extended to support RFID operations. One such area is RFID middleware that allows for a faster link into the proprietary existing electronic health records systems. Middleware is connectivity software between the network and applications. This software provides services such as identification, authentication, authorization, directories, and security. There are middleware applications available that specifically support RFID systems some are offered from enterprise resource planning (ERP) software providers.

4.2.3 *Tagging requirement*

RFID will need to be applied to the current management system in order to meet tagging requirements. Tagging requirements means there is a plan in place for tag encoding, RFID media selection, label placement and software changes. Requirements are set by the purchasing organization. Printer programs allow the RFID tag to be coded before it is printed and embedded in a smart label. Thermal printers and labeling software are used to complete this process of smart labeling. “Most smart label printers use rolls of media with RFID inlays in the label stock. It is important that printers support all the required media and procedures are established to prevent different smart label media from being used interchangeably” (Zebra, 2004). An RFID compliance tagging system can be a very manageable once there is a clear understanding of requirements and options.

4.3 *Privacy and security issues*

The only comprehensive legislation solely addressing privacy is the Privacy Act of 1974. Technology has drastically changed since then and legislation needs to keep up with such changes. When the caregiver scans a patient’s RFID enabled wristband, the caregiver has real time access to the patient’s information and can view what currently needs to be done for the patient. Security becomes a major concern when accessing real-time information through wireless networks. Secure wireless networks can include firewall, virtual private networks, and intrusion detection (Greengard, 2003). There are several things that need to be taken into consideration when devising a means to secure an organization’s wireless LAN: 802.1X authentication standards, Wireless Equivalent Privacy (WEP) key management, user and session authentication, access point authentication, detection of rogue access points, unicast key management, client session accounting records, mitigation of network attacks, WLAN management, operating system support.

A well designed security policy must be in place before a wireless system is implemented. A security policy provides employees within an organization a roadmap to follow. A security policy must also clearly detail which security features must be configured. For instance, if there is "widespread use of WLAN technology....it should be clearly mandated that all access points must have encryption enabled, and Wired Equivalent Privacy (WEP) keys" (Regan, 2003). WEP keys are used as a means of securing the link layer. The link layer controls access to local networks which thereby controls access to other networks. Network and application layer security should be included within the security policy to guard against harm to features that support the network. Authentication is another important term which is the verification of the identity of a person or process. An organization will decide whether it will allow for open or shared authentication. Open authentication is when anyone associated with access points can get onto the network and shared authentication is when certain individuals have access to the network. Not only is it important for network administrators to turn to solutions that increase the security of wireless networks but also the mobile devices that interoperate with them. More and more manufacturers' systems include more advanced security features in wireless routers and access points.

Wireless LAN also introduces a new challenge in terms of privacy. When discussing patient's EMRs, it's essential to have the proper protection in place to prevent inappropriate access or corruption of that information. The Health Insurance Portability and Accountability Act (HIPAA) of 1996 required the Department of Health and Human Services (HHS) to establish uniform standards for data exchange and protection and confidentially of a patient's medical information. Title II of HIPPA requires the establishment of national standards for electronic health care transactions and national identifiers for providers, health plans, and employers. HIPAA requires safe electronic data exchange of medical records. CFR Title 45 Part 164 of HIPAA regulations address the security and privacy of health data. There are two other medical regulatory groups that have a say in medical standards: Joint Commission on Accreditation of Healthcare Organizations (JCAHO) for positive patient identification and American Hospital Association (AHA) guidelines, calling for a tamperproof non-transferable wristband that minimizes the risk of lost or transferred data.

In order to track patients with RFID, active transponders with long range operating frequencies in the GHz must be used within a given area. Higher frequency bands are required because they enable higher data rates which prevent personal information from being exposed to outsiders. Encryption may also be required to improve security. “For improved security tags should contain a unique number to be mapped into a personal file by the host computer” (Johansen, 2004). Currently there aren’t any federal laws enforcing privacy rules for RFID. The only section of Part 15 that mirrors some semblance of that is section 15.9[8] but it is indirectly related in this instance. Though the rules are not in place for RFID devices compliant with HIPAA, a representative in a health care organization must be apart of an RFID project implementation to develop and implement security policies and procedures.

Weis (2003) said due to implementation costs, manufacturers will resist including security and privacy features on tags unless pressured by consumers or legal obligation.

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[8] 15.9 Prohibition against eavesdropping: Except for the operations of law enforcement officers conducted under lawful authority, no person shall use, either directly or indirectly, a device operated pursuant to the provisions of this part for the purpose of overhearing or recording the private conversations of others unless such use is authorized by all of the parties engaging in the conversation.

Consumer groups as well as HIPAA lobbyists are making their presence and opinion known regarding their concern and reluctance to adopt RFID.

4.4 *Technical Support*

Accessible technical support is an issue confronting some parts of the Appalachian Ohio region. An ever-present factor that could cause problems is the availability of technicians to support an RFID-based patient ID system and the solicitation of physicians to be part of this new infrastructure. Physician retention is a serious problem; many doctors who aren't from the area may be reluctant to settle in a rural community. However infrastructure changes like incorporation of an EMR system into Appalachian Ohio may invite physicians. They will welcome being in an environment in which technological innovation is celebrated. Phillips (2004) said doctors whose practice uses a sophisticated EMR system can receive malpractice deductions. Research has shown that medical professionals are open to new innovations and are willing to learn new ideas (Aspden, 2002; Cain and Mittman, 2002). The future is unknown on whether RFID-based patient ID will be the next hot application and the outcome can not be addressed at this time.

4.4 *Pilot projects*

Pre-deployment testing in preparation for deploying an RFID wireless patient monitoring network is essential because it could reveal any interference, quality, or performance problems that need to be resolved before deployment. Internal operations may bring about interference so health organizations should work with their vendor to assess potential interference and resolve with solutions. "Interference can be avoided or mitigated by using different styles and sizes of RFID antennas and tags, and experimenting with different frequencies, power output levels and tag mounting options, all within the scope defined by the application requirements" (Zebra, 2004).

The labeling system will require the media and adhesive to withstand all the environmental and usage conditions the label will be exposed to. As with the RFID system, testing is very important so the organization can determine the best possible environment to guarantee proper performance. Testing should also be conducted to determine if the smart labeling system can keep up with labeling volume requirements during normal and peak conditions. "Smart labels take a little longer to produce than non-RFID shipping labels, and in a high-speed, automated labeling environment, this must be taken into account to ensure adequate throughput capacity" (Zebra, 2004).

Zebra Technologies (2004) recommends that there can never be enough testing with RFID because there are so many variables to test and contingencies to look out for. They suggest that planning can overcome some hurdles that may come about.

4.5 *Limitations*

There are various things to consider before deploying such a technology. The biggest obstacles include building the wireless infrastructure that handles the medical data, integrating RFID, making use of the system, and training staff and maintaining support. A SWOT analysis was used to asses the limitations of RFID and WLAN.

<u>Strengths</u>

Recently Appalachian Ohio has been viewed as a forward focused region with regard to technological advances. Access Appalachia (2004) found that there is significantly more access to all forms of broadband services today than in their 2002 report. For the availability of DSL as doubled, in 2002, "DSL was virtually nonexistent in 14 Appalachian counties in Ohio. Today, DSL is available in all the Appalachian counties in Ohio with the exception of Morgan" (Access Appalachia, 2004). Wireless broadband coverage is increasing steadily.

The ARIC planning project hopes of establishing an EMR system used by all of the 29 counties in the Ohio will include a uniform high speed LAN system. Once this infrastructure is in place, including the purchase and utilization of an electronic system, health care organizations will be able to enhance their network to a WLAN and RFID system. Deployment and configuration of WLANs is much easier than LAN. WLANs are also easier to maintain, cover a wider area range, and IEEE 802.11b operates as open standard. Implementing RFID will improve specific processes within a health organization. Also the price of RFID tags will be significantly less than it is today when this region decides RFID patient monitoring is appropriate.

U.S. national policy addressing the acceleration of broadband deployment came with the introduction of the Tauzin-Dingell bill. It has been acclaimed as a rural broadband deployment bill because it wanted to break through the digital divide (Strover, 2003). Legislation in 2004 has been aimed at wireless broadband operations in the 3650-3700 MHz band and broadband over power lines to promote broadband service to underserved areas. Also with the President's State of the Union address ordered an EMR system implementation deadline of 2014. Rural areas like Appalachian Ohio may receive future benefits from legislation aimed at helping rural America.

Weaknesses

The process of building infrastructures will take a long time. It will require increased capital, network systems, and adequate storage and bandwidth needed for large data. WLANs are slower approximately 11 Mbps to 22 Mbps compared with 10 Mbps to 100 Mbps of a wired Ethernet LAN. Signal interference can often cause connection disturbance. The risk of interference with other applications could be higher when using RFID in high UHF bands. As discussed in Section 3.3.3, 802.11a and 802.11b are not interoperable. So system requirements must be clearly defined by the purchasing organization before choosing a vendor.

One of the main reasons cited for lack of adoption of wireless RFID patient tracking systems is fear over the reliability of the hardware and potential radio interference with other devices (Ewalt, 2003). Such fear is associated with lack of knowledge. Attewell (1992) says only when knowledge barriers have been sufficiently lowered can organizations accept and adopt new technologies. WLANs will need to be carefully installed and configured to secure an organizations' infrastructure. "A good authentication framework is vital, and will form the heart of a secure WLAN. There are inherent weaknesses in WEP, but with dynamic key rotation and the forthcoming IEEE 802.11X enhancements, that will change is the coming years, weaknesses will and can be overcome" (Regan, 2003). Also, as the technology evolves software applications, set in place at an earlier time, will need to be modified or developed to take advantage of RFID capabilities. ABI Research reports (2004), that "RFID software and services are, ultimately, more important and expensive than the RFID hardware costs. RFID software adds significant value by networking various services and data together. Software is an essential piece of the puzzle and one that will likely be extremely competitive as the RFID industry continues to grow."

<u>Opportunities</u>

Looking further into the future, RFID could possibly replace barcode technology used in hospitals. The RFID technology allows for the storage of more detailed patient tracking information than the traditional barcode. A significant new opportunity that can aid in lowered costs is the implementation of RFID for equipment purposes. Some Appalachian health organizations may choose this approach first rather than patient tracking. Appalachia has much to gain from this new but old innovation.

Although the initial cost of purchasing RFID could be significantly high, the long term cost savings are dramatically lower. Health care organization may have to seek out different methods of funding to utilize RFID. Recently the Robert Woods Johnson Foundation, which gives grants to health care facilities, funded a trial RFID patient system within trauma emergency department (Collins, 2004). On July 21, 2004, Tommy Thompson, Secretary of Health and Human Services, and David Brailer, National Coordinator for Health Information Technology, put together a strategic action plan for the President on how funding should come about for improving health care in rural communities through technology; the document said “the government could help define a common set of practices by incorporating minimal performance requirements into its contracts with, or grants to, communities” (Thompson & Brailer, 2004). Once individuals notice the success of the ARIC project and grasp the benefits of RFID, Appalachian Ohio could receive funding from numerous sources.

WiMAX, 802.16, is the next generation in WiFi. WiMAX is a standard being developed which enables the delivery of last mile wireless broadband access as an alternative to cable and DSL. WiMAX will serve multiple market segments to include fixed and portable service applications. It offers a service range of up to 30 miles, allowing users to obtain broadband connectivity wirelessly (WiMax Forum, 2004). WiMAX could change the future of RFID systems. For instance, WiMAX would operate under different 802.11 standards than WiFi which could be higher security.

Threats

The strengths associated with implementing such advanced technologies also have drawbacks, some of which include the need to retrain health and technical professionals as well as restructuring business processes to meet new technology demands. Continual change and updates to wireless technologies have the potential to result in loss of investment caused by restructuring done to meet current demands.

Legislation needs to be more forthcoming about how to handle privacy, security, and standards issues associated with RFID. There is a need for uniform stands for RFID manufacturers to follow. Once consumers are made aware of the possibilities of this technology, they could influence how RFID policies are made. Some consumers may be afraid that RFID will be a kind of surveillance which treads on their right to privacy.

CHAPTER 5

CONCLUSION

Telecommunication is seen as an engine for economic development. There are a growing number of studies that demonstrate the positive correlation between telecommunications and economic development (Parker & et.al., 1992). Parker stressed the need for rural communities to be provided with all the information required to build a new economic and community vision. American consumers demand convenience, timeliness and cost-effectiveness from any service provider – rural health care providers are no different. Rural hospitals' reasoning for using telemedicine is much stronger than urban hospital's, in fact Emery (1998) says that urban hospitals adopt telemedicine more as a marketing ploy for hiring top physicians as attracting consumers. A wireless RFID patient monitoring system would have a tremendous impact on healthcare service distribution. It could attract physician and well as consumers. Some people choose not to use health care facilities in Appalachian Ohio. The reputation isn't as highly regarded as those in urban centers and some people choose to go elsewhere to receive medical care.

Telecommunication isn't a complete solution for rural development and desired improvements will be limited for a fraction of rural areas (Malecki, 2003). Building a rural area's telecommunication infrastructure does assist development by creating more jobs and establishing better service. It isn't a complete fix because sparsely populated are more subjected to higher prices and sometimes can support additional infrastructure changes whether it is lack of capital or unstable local policies. Currently 10 different counties are represented in the ARIC project. The goal is to use an EMR in each of the 29 counties in Appalachian Ohio. Committee members hope that as the project develops local legislators and hospitals will recognize the need to participate in ARIC. It was a combination of government programs and private sector initiatives that, over the course of a single decade, resulted in the creation of opportunities for some rural areas to take advantage of telemedicine programs through radio, television, telephone, and/or the Internet. Only time will tell if universal service, rural development, and local policies and funds will allow Appalachian Ohio to utilize RFID. The solution being offered to use RFID as a patient tracking system in the end must appear to address a hospital's criteria and must offer a sense of assurance for improving productivity.

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APPENDIX A

RFID VENDORS PROFILE

The following is a condensed list of RFID vendors who have been active in healthcare application. An additional designation of H, LP, SI, or W will be given to firms that have an added specialization. Hardware Vendors will be given the designation of (H). Label and Printer Vendors will be given the designation of (LP). Software and Integration Vendors will be given the designation of (SI). Wristband Vendors will be given the designation of (W).

Accenture Ltd
http://www.accenture.com - SI

Alien Technology Corporation
http://www.alientechnology.com/

AMTSystems, Inc.
http://www.amtsystems.com

Automated Systems, LLC
www.amtsystems.com

Avery Dennison
http://www.averydennison.com - LP

Axcess Inc
http://www.axsi.com - H

Crosslink
http://www.crosslinkinc.com/ - H, SI

Exavera
http://www.id-systems.com/ - W

Escort Memory Systems
http://www.ems-rfid.com/

ID Systems Inc
http://www.id-systems.com/ - SI

Identec Solutions AG
http://www.identec.com – H, SI

Intermec Technologies Corporation
http://www.intermec.com – H, SI

Motorola
http://www.motorola.com

Omron Corporation
http://www.omron.com – H

OatSystems
http://www.oatsystems.com - SI

Philips Semiconductors
http://www.semiconductors.philips.com/identification

Pinpoint
http://www.pinpointco.com - SI

Precision Dynamics Corporation
http://www.pdcorp.com/ - W

RedPrairie
http://www.redprairie.com

RFID DataCorp
http://www.rfiddatacorp.com

Samsys Technologies Inc
http://www.samsys.com

Savi Technology
http://www.savi.com

Texas Instruments
http://www.ti.com/tiris/default.htm

Wherenet Corporation
http://www.wherenet.com

Zebra Technologies Corporation
http://www.zebra.com/ - LP