

# **Medical Device Networking for Smarter Healthcare: Part 3**

*Next-Generation WLAN  
Deployments in Hospitals*

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# Contents

Introduction.....	3
Wireless Roll-outs.....	5
Medical Device Connectivity / Mobile Carts .....	5
Handheld Devices.....	6
Computer-based Physician Order Entry (CPOE).....	7
Next-Generation Wireless Applications .....	7
Location-based Services .....	7
Voice-over-WLAN .....	8
Internet/Intranet Access .....	9
Wireless Technologies.....	9
WLAN/802.11 .....	9
Bluetooth .....	10
Zigbee .....	10
Barriers to Wireless Technology.....	10
Security and Intrusion .....	10
Interference.....	11
Bandwidth Availability.....	11
Quality-of-Service (QoS).....	11

## Introduction

The need for greater efficiency and patient mobility is fueling the rapid growth of wireless technologies and applications being deployed in the health care industry, particularly in hospitals and medical centers. Wireless technologies are expected to significantly reduce hospital costs and medical errors, as well as improve patient safety.

As an example, heart failure patients who used an interactive telehealth system with motivational support at home spent less time in the hospital and felt their quality of life improved, according to the Catalan Remote Management Evaluation (CARME) study conducted by Philips Electronics. The study revealed a decrease of 68 percent in heart failure-related hospitalizations and a 73 percent reduction of days spent in the hospital.

Wireless technologies enable hospitals to streamline communications, and health care practitioners to access critical care information from patient monitoring devices, as well as lab test results and radiology reports from anywhere in the hospital, while smart phones connect doctors and nurses to patient information in both ambulatory and in-patient environments.

Nearly all respondents to a Healthcare Information and Management Systems Society (HIMSS) 2010 Analytics study indicated that the primary reason for interfacing medical equipment to an electronic medical record (EMR) is to automatically chart the data in order to reduce medical errors, improve workflow, and potentially gain additional data analytics. The HIMSS 2010 study also reveals that most connections are achieved through wired local-area networking (LAN) (50 percent), while 28 percent of respondents say they use a combination of wired LAN and wireless connections. Eight percent of respondents only use wireless.

The study also finds that the two likely device candidates for wireless connections are interactive infusion pumps and electrocardiographs (See table).

Device	Number Deployed	Wired and Wireless LAN Connection	Wired LAN Connection	Wireless LAN Connection	Not Specified
Cardiac Output Monitor	29	27.60%	55.20%	0.00%	17.20%
Defibrillator	4	50.00%	50.00%	0.00%	0.00%
Electrocardiograph	120	11.70%	35.00%	28.30%	25.00%
Fetal Monitor	112	8.90%	61.60%	0.90%	28.60%
Infant Incubator	15	33.30%	6.70%	0.00%	60.00%
Infusion Pump	18	22.20%	5.60%	16.70%	55.60%
Intelligent Medical Devices Hub	66	16.70%	62.10%	7.60%	13.60%
Interactive Infusion Pump	28	32.10%	14.30%	28.60%	25.00%
Physiologic Monitors	194	13.90%	66.00%	6.70%	13.40%
Ventilators	70	20.00%	64.30%	2.90%	12.90%
Vital Signs Monitors	53	18.90%	43.40%	15.10%	22.60%

Source: 2010 HIMSS Analytics white paper, Medical Devices Landscape: Current and Future Adoption, Integration with EMRs and Connectivity

### Next-Generation WLAN Deployments in Hospitals

The study points out that the majority of hospitals are interfacing their medical devices with the EMR via a wired LAN connection. However, most often they will choose wireless interfaces when both wired and wireless options are available.

Wireless technologies provide major benefits, particularly in applications where an intelligent medical device is being used in an area that does not have wired LAN connection ports or when a device needs to remain connected to a patient during transport within the hospital. Wireless technology can also assist doctors in outpatient clinics and portable screening labs by providing access to magnetic resonance imaging (MRI), ultrasound and computed tomography results from remote laboratories and hospitals.

Wireless devices offer an advantage over wired solutions because they must conform to existing authentication frameworks and provisioning for hospital networks.

Wired networks in hospitals typically do not have a way to identify an attached device, and there is no authentication mechanism that is widely deployed for wired networks. As a result, access control/authentication of devices that are attached to the wired Ethernet network in the hospital is tricky and difficult, and thus it is often not deployed. On the other hand, since wireless is inherently insecure, authentication and security frameworks are always deployed. This enables the hospital IT staff to assign identities to wireless devices, as well as authenticate their connectivity based on defined policies using standardized mechanisms available in wireless network deployments.

Wireless technologies available today include Wi-Fi, Bluetooth, cellular and Zigbee, which are used across several application areas such as wireless LAN (WLAN), personal area networking (PAN) and telepresence. New standards such as IEEE 802.11n with extended bandwidth and range is expected to fuel widespread adoption of wireless applications in hospitals.

Although the Federal Communications Commission (FCC) has allocated a separate WMTS band for wireless medical telemetry, medical device vendors and providers have been moving away from this special frequency due to limitations caused by interference issues in hospital environments and associated costs. In addition, the IEEE 802.11 standard is well understood by hospital IT departments.

Since large institutional health care facilities are dominated by networking giants like Cisco, large hospitals are mandated to use Enterprise Wireless in the 802.11 spectrum using Enterprise Authentication such as EAP or EAP-FAST. There will also be private networks integrated into the general infrastructure network at these large health care facilities.

This paper will show how 802.11 WLAN is driving the adoption of new applications including voice communications, mobile carts, handheld devices and location-based services in hospital environments to remotely access patient records and laboratory results as well as to track assets and inventory. The benefits include improved patient care and safety, streamlined communications, reduced costs and fewer medical errors.

## Wireless Roll-Outs

Hospitals are starting to take advantage of many opportunities to employ wireless access, ranging from mobile carts to computer-based physician order entry (CPOE). By installing IEEE 802.11 WLAN in all patient areas, patient care teams can have immediate access to a patient's EMR at any time to check test results, order medications and document care during rounds. The key benefits cited by most hospital administrators include increased productivity and reduced errors.

A 2009 Motorola report, "State of Mobility in Healthcare," finds that mobility applications have reduced errors by 31 percent and increased productivity by 39 minutes per day. The report also finds that about 80 percent of IT decision makers in the health care industry believe mobile technologies are more important today than in 2008, citing key applications such as electronic health records (EHR), CPOE and medication administration, and asset/inventory management.

The U.S. Department of Health & Human Services recently announced the final rules to support "meaningful use" of EHRs under the Health Information Technology for Economic and Clinical Health (HITECH) Act 2009. The completion of the regulations ensures that EHR system vendors meet the required capabilities by providing the standards and criteria for the certification of EHR technology. (<http://healthit.hhs.gov/standardsandcertification>)

Another factor driving adoption is patient care. According to the Annual 2010 HIMSS Leadership Survey of healthcare CIOs, the top business objective cited by 29 percent of respondents is improving patient care, up from 24 percent in 2009. Healthcare CIOs also believe that information technology (IT) can have the biggest impact on improving quality outcomes (37 percent) and reducing medical errors (28 percent).

Here we take a look at three key application areas that are adopting WLAN technology, which are expected to help reduce medical errors, improve patient care and safety, and, ultimately, reduce operational costs.

### ***Medical Device Connectivity/Mobile Carts***

Hospitals use mobile carts to transport medical equipment to and from patient rooms and in operating rooms (ORs). Equipment is also transferred alongside patients' beds as they are wheeled from one location to another to undergo tests. If the equipment is wirelessly enabled, the data collected by the medical device can be accessed from any computer in the hospital. In addition, a lot of a nurse's time is spent gathering data, monitoring a patient's health status and ensuring that a patient's medication dosage is administered correctly. With a connected system, the equipment can perform the reporting duty and provide information on a patient's status even if the patient isn't in the room and has been taken to radiology, for example, for x-rays or an MRI.

Connecting medical devices including IV pumps and vital sign monitors to a hospital's network also will lead to greater productivity and improved care. For example, Welch Allyn, a leading manufacturer of medical products and solutions, has said that adding wireless capabilities to vital sign devices significantly reduces the amount of time it takes to document vital signs, giving providers more time with their patients. It's also expected to reduce data logging errors.

#### ***Next-Generation WLAN Deployments in Hospitals***

Twenty-three percent of vital sign documentation via paper and EHR manual entry is inaccurate with transcription mistakes and workarounds leading to errors, according to an article titled, "Comparison of Quality and Timeliness of Vital Signs Data Using Three Different Data-Entry Devices," *Computers Informatics Nursing (CIN)*, July/August 2010.

A major part of a nurse's routine is making rounds and spending time logging data from patient monitoring equipment into the patient's chart and then re-entering the data at the nurse's station into the patient's electronic medical record. By networking monitoring equipment to the hospital's IT infrastructure, which enables the data to be displayed at the nurse's station and updated directly to the patient's record, it eliminates the nurse's non-productive activity such as logging data, while providing immediate information about a patient's health status. It also gives doctors access to real-time patient information – in some cases, the uploaded data can be used to develop patient protocols. For example, if a patient is on a ventilator, the raw data uploaded to the hospital's server can be run against the manufacturer's software algorithms to return accurate recommendations to help wean the patient off the ventilator.

Most of the technology needed to enable these automated tasks is readily available today. There are networking equipment devices that attach to existing medical equipment to provide the online connection as well as new equipment that have the connectivity already built-in. The medical equipment market is transitioning away from standalone devices designed to just display data by the patient's bedside to those that are able to "echo" the information at the nurse's station. While the manufacturers' first priority is data communications, there is no reason why they can't leverage this connectivity to add other features such as location-based services.

Connectivity could also be used in voice and video recording applications. As an example, hospital emergency rooms (ERs) have long used voice and video recording for both procedural teaching and legal purposes, but they haven't been able to gather all the data from monitoring equipment to reconstruct all the data points for a particular patient case. If all the equipment is recording the data, they can recreate that environment in complete detail.

### ***Handheld Devices***

Doctors and nurses also will be able to take advantage of handheld or tablet devices to input and access medical data including test results during their patient rounds. This allows the patient data to be automatically uploaded to the patient's EHR instead of being logged into a paper chart, and later transcribed into the computer.

Most likely, a nurse's clipboard will not be replaced with an iPad but rather with a Kindle-like \$100 to \$200 electronic pad with an electronic pen that provides personalized handwriting recognition. This new tool also is expected to help with drug interactions and medication orders. As an example, if the software doesn't recognize what the doctor wrote it will return a list of possible choices. This will minimize mistakes, which ultimately reduces cost due to medication errors and/or wrong procedures that could lead to patient re-admittance. It also doesn't require any new infrastructure or new equipment in the hospital just Internet and Intranet access.

These portable devices also will play a bigger role in CPOE, which brings us to the next application.

## ***CPOE***

CPOE and bar-code scanning for medications is expected to be widely adopted over the next few years, fueled by wireless communications networks. The average percentage of medication orders entered electronically is on the rise, according to the Hospitals & Health Networks' Most Wired Survey 2010. The report finds that 51 percent of physicians in "most wired hospitals" order meds electronically, up from 27 percent in 2004. The number of physicians at hospitals overall also increased, from 12 percent in 2004 to 29 percent in 2010.

The 2010 most wired hospitals also are making use of real-time reporting alerts for allergies, drug interactions and drug formularies. For example, the report cites that 83 percent of nurses, 90 percent of pharmacists and 78 percent of physicians are currently using allergy alerts. According to the Healthleaders Media Industry 2010 Survey of Quality Leaders, nearly 34 percent of respondents said using technology such as EMRs and electronic prescribing, or e-prescribing, will be a "strongly effective" measure in improving physicians' quality of care. Another 39 percent said this measure would be "moderately effective." Less than 3 percent believe there would be no benefit.

Case in point: Mount Auburn Hospital has implemented a CPOE system, which is designed to catch medication errors at the time of order entry. According to the hospital, the e-prescribing system eliminates several steps thus reducing the chance of errors, while providing all patient information including lab tests, medications the patient currently takes or is allergic to, which further reduce the chance of error (*Source: Mount Auburn Hospital – Health Connection 2010*).

The CPOE system also is continually updated with the latest information in evidence-based medicine, which both streamlines the process while providing the most effective course of treatment, says the hospital. As part of the process, the system also "knows" which medications require lab work and it will automatically order the lab tests, further automating the process, says the hospital. The medication is then available in automated dispensing machines around the hospital at the time they've been ordered for, adding another safety measure. Mount Auburn Hospital's CPOE system allows doctors to order lab tests, CT scans or any other test.

## **Next-Generation Wireless Applications**

### ***Location-Based Services***

Location-based services, also known as active RFID or active real-time location services (RTLS) are typically used by biomedical and clinical engineers who need to know where all their equipment is being used. In some cases, the technology can be used to locate nurses and/or patients. By using RFID to locate equipment, hospitals find they can reduce leasing costs because they can now find devices sitting unused in closets or other areas.

Wi-Fi adoption in the health care industry has increased more than 60 percent over the past year, driven in part by RTLS and WLAN deployments, according to a recent research report from ABI Research. However, WLAN-based RTLS suffers from a lack of granularity. This means in order to get a more fine-grained lock on the location of a patient or a piece of equipment within a few feet or few meters, it must be combined with other RFID technologies.

In some cases, hospitals are implementing these location-based services using Zigbee Mesh or even Bluetooth because of their advantages in more accurate location-based positioning and tracking at much lower power requirements. As an example, Texoma Medical Center in Denison, Texas, recently implemented Skytron's ([www.skytron.us](http://www.skytron.us)) RTLS, powered by Awarepoint, to automatically track and manage more than 200 hospital assets, including IV pumps, telemetry packs and wound vacs as well as to monitor all visiting vendor sales representatives in the hospital facility. The 100-percent wireless ZigBee-based RTLS infrastructure from Awarepoint ([www.awarepoint.com](http://www.awarepoint.com)) enabled quick installation in about one month.

The primary reasons cited by the medical center for the implementation were to locate and use their assets more efficiently, and to provide improved patient and staff safety. The system also provides wireless temperature tracking of all refrigerators, freezers, drug cabinets, blood bank, warming cabinets and cold rooms.

So far, the key benefits cited by the medical center include increased visibility into actual equipment utilization including rental devices to reduce capital equipment purchases and rental expenses, reduced staff search time for missing equipment, improved hospital staff satisfaction, and speedier biomedical scheduled preventative maintenance.

Some of the most innovative hospitals are using RFID patient bracelets and disposable med containers with barcodes as a way to reduce medication errors and improve patient safety. This technology is currently being rolled out first in neonatal wards, which have a big incentive to keep babies safe.

With new medical initiatives, re-admittance has a high penalty. A hospital will not be reimbursed when a patient is re-admitted for the same issues or complications. They also will be penalized on preventable mistakes including wrong medications, wrong procedures, and serious drug interactions, which along with financial penalties will also lower a hospital's rating.

### ***Voice over IP***

Hospital care givers and administrators are transitioning from pager systems to voice over IP-based systems. One of the primary reasons for the shift is the lack of two-way communications with most pager systems, which require medical practitioners (physicians, nurses or therapists) to find the nearest central station to return the call, often resulting in "telephone tag."



Voice over IP allows nurses and doctors to easily communicate with each other via mobile phones while roaming throughout the hospital. They can respond immediately to calls instead of heading back to a central nurses' station to either provide or receive critical care data about a patient. This is one area that is expected to grow significantly in the future. In addition to offering two-way text messaging and integrated alarm capabilities, voice over IP boasts an added benefit in that the number of handsets available for a given department doesn't have to increase with the number of employees. They can share the devices because they are based on log-in credentials unlike pager systems.

In addition, IT departments can leverage their investments in their WLAN infrastructure to support a communications network and not have to overlay a separate pager network or a two-way communications network. It's all running over the infrastructure that they've already deployed.

### ***Internet/Intranet Access***

WLAN can also provide guest Internet access to both visitors and patients, who are increasingly demanding access to the Internet as more mobile phones become Wi-Fi enabled. It could become as prevalent as providing a TV in each patient room.

Part of the push is work-related. People can't afford to be away from work for long periods of time, and doctors need to be connected to their practices, while making hospital rounds. Other drivers include patients who want to communicate with family and friends over the Internet via social networking sites or e-mail. Internet access also could serve as an entertainment option in the room.

With advances in tablets, netbooks and cell phones with browsers, health care providers now can get data on-the-go via the hospital's Intranet. This includes patient information, case histories, test results, x-rays as well as research such as for drug interactions. This is becoming more important as time spent with patients is getting shorter due to costs and the increasingly lower number of care-takers versus patients ratio.

## **Wireless Technologies**

The health care industry was one of the first commercial adopters to take advantage of wireless technology through WLAN. WiFi is based on the IEEE 802.11 standard and supported by the WiFi Alliance. In comparison, wireless personal area network (WPAN) technologies such as Bluetooth and Zigbee will play important roles in transitioning hospital patients to outpatient care as well as in the homecare market. This will be a topic for future discussions.

### ***WLAN/802.11***

The first industry supported WiFi version was IEEE 802.11b standard, which was quickly followed by several upgrades -- 802.11a, 802.11g and 802.11n -- with higher performance specifications including higher data rates and throughputs. Although the health care industry appears to favor the 802.11a standard because of the less congested 5-GHz frequency, 802.11n offers several benefits including higher data rate and throughput and an extended range.

## ***Bluetooth***

Designed as a low-cost, short-range wireless technology, Bluetooth is based on frequency-hopping spread spectrum and can connect and exchange data between devices through a secure ISM 2-GHz radio frequency bandwidth.

## ***Zigbee***

Zigbee, based on IEEE 802.15.4, operates at 868 MHz, 902 to 928 MHz and 2.4 GHz. The technology is said to be lower cost than other WPANs such as Bluetooth.

## **Barriers to Wireless Technology**

Achieving a high quality wireless network design that can meet the performance and reliability goals of the various applications running on the WLAN requires a complete understanding of the network. This includes the expected use of the network, the bandwidth (data rate) and latency requirements for the various devices on the network, security requirements, user/device density in each area, the types of building materials and interference sources as well as the ability to provide and maintain a stable RF environment.

IT departments typically face deployment issues centered on four key areas: security, interference, bandwidth availability, and quality of service (QoS).

## ***Security and Intrusion***

Protecting sensitive patient data that travels over the wireless network is crucial as well as mandatory for HIPAA compliance. Both data integrity and transmission security (encryption) are essential. Each device on a wireless network needs to be validated to ensure privacy of patient information.

Wireless networks, based on IEEE 802.11, transmit data over radio frequencies ranging from 2.4 GHz to 5 GHz, which means that any wireless device that communicates over the same RF can also receive transmissions.

After problems were discovered using the Wired Equivalent Privacy (WEP) protocol to protect and encrypt wireless data, the Wi-Fi Alliance developed WiFi Protected Access (WPA), which uses a pre-shared key (PSK) and Temporal Key Integrity Protocol (TKIP) encryption with 64-bit message integrity.

IT departments need to ensure that the latest and most secure standards in wireless security, namely 802.11i and 802.1X, are adopted and supported by all devices on the wireless network. They also need to provide the ability for continuous analysis of the wireless environment for threats such as wireless intrusions and security violations.

## ***Interference***

The quality of wireless transmission is impacted by several key interference issues including number of access points, density of mobile devices, types and number of walls and other medical and non-medical equipment. As a result, the IT staff will need to take into consideration several design and use factors including interference from nearby equipment.

For example, the higher density of devices including medical equipment and non-medical equipment such as steel carts and microwave ovens can potentially distort RF coverage. Wireless devices also can cause interference and require extensive network planning and implementation. IT staff also need to take into consideration shielded rooms such as x-ray and MRI areas that can create coverage "shadows."

RF interference can impact both the range and quality of the wireless link. As an example, in a noisy environment, WLAN radios will slow the transmission speed to achieve better receiver sensitivity, but it could slow data throughput significantly. This is why it's important that IT staff estimate a worst-case scenario for the RF environment as well as the tolerable level of interference.

## ***Bandwidth Availability***

All wireless applications mentioned earlier require different levels of bandwidth and throughput requirements. This includes both usage – hospital-wide access, wireless tablets at the patient's bedside, wireless monitoring equipment and patient/asset tracking – and the different kinds of equipment in the WLAN such as laptop computers, tablets and voice handsets. IT staff will need to determine the number of access points required to ensure the right level of granularity and bandwidth for each wireless application. This will result in better management of bandwidth as well as reduce downtime. In addition, the maximum data throughput depends on several factors including the host processor speed and wireless technology selected. There also are tradeoffs between data response time versus amount of data packets being sent or received, again depending on the application requirements.

## ***Quality of Service (QoS)***

QoS enables latency-sensitive wireless applications such as voice and video over wireless to coexist with other data applications. Support for prioritization and queuing in the context of 802.11 WLANs can also enable medical device data traffic to receive higher priority on the hospital network if so desired.

Managing QoS guarantees on a shared medium like wireless is a difficult task that not only requires significant investments in wireless infrastructure but also careful planning and continuous monitoring of the deployed wireless network. Ultimately, the IT staff has to consider the benefits of deploying a unified wireless communications infrastructure versus the resources available for wireless deployment.