Case Study

Deployment of an Enterprise Wireless Infusion Pump Management System

Richard Swim, CLES, MCSE

Wireless technologies hold huge promise to improve efficiency and streamline patient care. Yet, there are many challenges and risks inherent in this technology. Wireless communication makes sense for portable devices, such as infusion pumps and electrocardiogram (EKG) carts that are constantly moved from room to room. But, wireless is not always the best choice for networking all medical devices. Hard-wired networking should be used when a device will be staying in one physical location, as wired networking is less vulnerable to interference and security issues.

This article reports on an initiative undertaken at Baylor Health Care System in Dallas, TX, to deploy approximately 2,500 wireless smart pumps.

Why Wireless Smart Pumps?

Infusion pumps are a beneficial tool for the nurse to use in intravenous (IV) therapy administration, but the use of conventional infusion pumps may also contribute to medication errors when the pump delivery is incorrectly programmed. It is possible to leave out a decimal point or add a zero and dramatically alter the pump's desired infusion rate.

A "smart pump" enables a nurse to program the correct medication dose based on drug libraries, greatly reducing the possibility of medication errors. The drug libraries developed by the hospital's pharmaceutical team provide recommended medication parameters, such as dose, dosing unit, rate, or concentration. While someday these drug libraries and smart pumps may work in concert with a computer physician order entry (CPOE) system, it will likely be several years before the infusion pump management system at Baylor communicates with the CPOE.

When a smart pump is used, the nurse will select the administered drug from a library and then program the pump for delivery. If a delivery rate or dose is selected outside of the drug library recommendations, the pump will either refuse to deliver at the programmed rate (hard limit), or display a warning message that may be overridden (soft limit). Smart pumps log these types of programming limits as well as other infusion information such as time, date, drug, concentration, rate, volume infused and key presses. This information may be transmitted to a central pump management server for reporting.

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> —*Richard Swim*

It is possible to load a drug library onto a pump and then use the pump without further communication to a pump management server. However, there are many benefits to using constant network communication with infusion pumps. Such constant communication allows continuous data log transmission, drug library transfer, and pump location capabilities. Wireless communication allows two-way communication to occur 24x7 so data may be easily retrieved when desired. For instance, error logs wirelessly transmitted from the pumps back to the server can be used for quality assurance and performance improvement initiatives. In the past, a pump would have to be physically located and hard-wire interfaced to a computer to obtain this data. Considering the portable nature of an infusion pump and the benefits of continuous communication, the obvious architecture of choice for this application is wireless networking.

Project Planning

Baylor Health Care System selected a wireless smart pump technology in 2005, and planned implementation for early 2006. Soon after the selection decision, planning for deployment started with the Baylor Information Services network and server teams. Many meetings took place with the vendor and Baylor teams to work out the

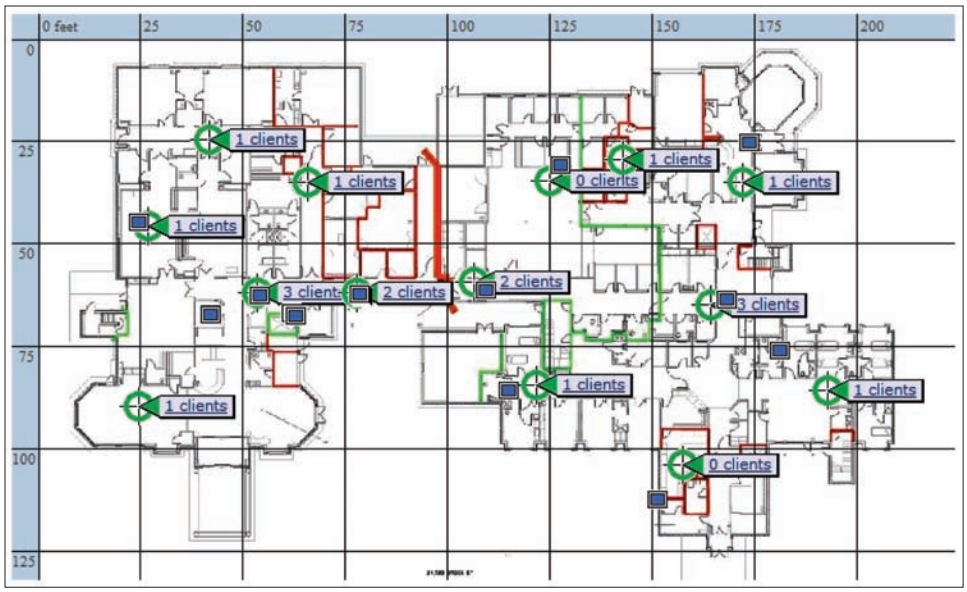

Figure 1. Wireless Control System access point and client map. The location of an access point is shown by the green circular icons. The blue square icons are clients—infusion pumps or other wireless devices operating in the 802.11x band.

logistics. The smart pumps depended on a network connection to a hosting server for data collection and drug library distribution. Servers were specified, ordered, and installed in the system data center. The pump management application/database was installed by the vendor for each server. The network design was a point of focus for security and bandwidth utilization considerations that are beyond the scope of this article.

A service set identifier, or SSID, is a name used to identify a specific 802.11x wireless local area network (WLAN) through which a device will communicate. A separate SSID for pump communication is desirable to increase network security. A new medical device SSID was designed and implemented to provide the capabilities for limiting network communication to only the pumps and their hosting servers. Deploying a new SSID for the pumps was at one time a tedious task requiring a command-line telnet session to each of the hundreds of wireless access points (AP). But with the use of a wireless control system, new configurations may be distributed to all access points with relative ease. The wireless control system manages all access points throughout the healthcare system.

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Besides the added benefits of monitoring access points and deploying configurations, a graphical real-time client location map may be displayed. We are working with the infusion pump vendor to leverage a radiofrequency identification (RFID) tag location technology within our pump management application in the near future which will describe a pump's location with greater precision within a pre-defined clinical area.

Location Capabilities

The WLAN was designed so that a pump will continue to communicate on the network as it moves with a patient throughout a single hospital. This is accomplished by utilizing a single dynamically issued IP address for the medical device SSID WLAN anywhere in the pump's "home" facility. But pumps can wind up in other Baylor facilities. Baylor is a multi-hospital system where it is possible (but hopefully rare) for a pump to be transferred with a patient to another facility. With this in mind, the medical device wireless SSID WLAN was developed such that a pump will eventually communicate with the enterprise network from any facility and its location be shown in the pump's management application. This system-wide pump location capability helps us return pumps to their home facility.

For the pump management application location capabilities to properly perform, each AP must be mapped to a physical location name. When this project first started, the documentation for AP locations was sporadic and sometimes not available at all. Some facilities were mapped by walking around with computers or handheld devices to identify AP locations. After the introduction of an enterprise wireless control system, the location of a new access point is easily identified as an icon on a hospital floor plan, as demonstrated by the green circular icons in Figure 1. The blue square icons in this figure are clients—infusion pumps or other wireless devices operating in the 802.11x band. The clients

and access points may be identified by their media access control (MAC) addresses in the wireless control system. A MAC address is a unique identifier for a device's network adapter.

Once an AP location is identified on a floor plan, it is translated to a common department name or physical location description within the pump management application. We are currently working with the infusion pump vendor to improve the location capabilities regardless of a pump's power and use state. This RFID technology will enable pumps that are powered down and out of sight to be located and put back into use, which will ultimately reduce total infusion pump capital requirements.

Figure 2. The initial configuration and staging area for Baylor's smart pumps. Inset: The Plum A+® Infusion System with Hospira MedNet™ Software.

Pump Configuration

The first time a pump is configured, it requires a physical connection in order to load the network information into the wireless interface card. A separate server for data management is required at each facility due to pump management application design, so each pump has to be configured to communicate with its facility server hostname. Part of this initial configuration specifies the SSID and security key to the pump's wireless network card.

After the initial configuration, the pump is turned on to validate wireless communication, and its first drug library is pushed after it appears in the pump management application. It is possible to perform the initial configuration and transfer a drug library to a pump via a wired network and then deploy the pump for use with the assumption that it will communicate wirelessly in the clinical setting. But, it is important to validate wireless communication prior to the pump leaving the configuration area. This will ensure that the pump will transfer infusion data, receive future new drug libraries, and be located when that need arises.

It was decided to use a central physical location to configure the approximately 2,500 pumps for the healthcare system. When access point radio congestion complicated that approach, additional temporary access points were provided by the network team. The initial configuration workflow improved, but slowed once again as new pumps refused to connect wirelessly.

It was then discovered that the dynamic IP addressing pool was filled up due to the large number of pumps being configured. As more pumps were connecting for the initial library push, IP addresses were being used up, even though the pumps were turned off after receiving their new library. This issue was resolved by decreasing the lease time of the IP address down to a very short duration (hours vs. days) in order to free up previously used addresses. After the initial system pump inventory configuration was completed, the IP lease time was extended.

Expanding Capabilities

Baylor has recently had to take action to expand the scope of the medical device WLAN to accommodate more pumps that have been purchased at our largest facility. We have found that it is important to plan for growth of the inventory of connected wireless medical devices, and to design the network to allow enough IP addresses for future needs.

We are also introducing other wireless medical devices such as EKG carts that communicate over our enterprise network. Using wireless communications with our EKG carts enables the tech to transmit a study where desired in the hospital rather than locating a telephone line. This flexibility makes the patient studies available to the physician sooner. We foresee other medical devices utilizing wireless networking in the near future. An example is a handheld device which will communicate with noninvasive blood pressure monitors for transmission of patient vital signs to electronic medical records. Using the handheld wireless device as the go-between to the enterprise network allows the non-invasive blood pressure (NIBP) with serial data output to transmit data efficiently.

We will be expanding the use of wireless communication as we introduce additional patient care safeguards, such as the five "rights" of medication administration—giving the right drug to the right patient by the right route in the right dose at the right time. This will require real-time wireless data transmission as the nurse bar-code scans the medication to be given, the patient's ID band, and the nurse's ID badge. In the future, the nurse could scan the infusion pump, which would then be automatically programmed and ready for infusion therapy after the setting validation.

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Collaboration Critical to Success

The synergy of biomed and information technology networking/server teams was critical to the success of this project, and is critical to the success of improved patient care delivery in all healthcare facilities. As Michael Fink from Baylor's network team states, "the level of collaboration between the biomed and IT services teams here at Baylor is very good. I have seen other healthcare facilities where the two areas exist as silos that do not involve each other in the planning and implementation stages of a project like this. Unfortunately those situations usually result in last-minute fire fights and project failures. It makes me proud to be a member of an organization that has such a high level of intra-organizational communication. The end result of our efforts and use of technology is the ability to provide great patient care." Improved patient safety and simplified equipment management have been the ultimate results of this successful collaboration. ■

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