Confronting the Network Challenge

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Many biomedical engineering service teams are witnessing a new world of connected medical devices that exchange data with information systems. Even though patient monitors have been connected via networks for central display and other remote viewing functions for a while now, medical device connectivity use is changing rapidly.

With the expanding use of electronic medical records (EMR) or electronic health records (EHR), physiological monitors are populating patient records with data. Historically, a clinician recorded patient vitals with ink on paper. This practice is changing quickly to where the clinician is now charting patient vitals with a computer. The connected medical device feeding the EMR is a natural progression to gain efficiency in patient charting and reduce transcription errors. The downside is an increase in potential problems—very little can go wrong with a pen, but biomeds are increasingly being called in to troubleshoot network problems that involve medical devices.

Network Overview

Examples of connected medical devices today include physiological monitors; infusion pumps; 12-lead electrocardiogram (EKG) carts; pulse oximeters; and point-of-care devices such as glucometers and multi-parameter analyzers. While there may be network-trained staff on a hospital's information services teams, there are many reasons for the biomedical equipment technician to understand network design and troubleshooting. Some medical equipment networks are physically segmented from the hospital enterprise network and are the responsibility of biomed teams and medical equipment vendors for ongoing support. Others have a connection to the hospital enterprise network for data transmission, and the biomed team can benefit from understanding network design to help make connection implementation and support happen efficiently.

A physically segmented clinical network means that devices on that network can communicate with each other, but not with other networks without the use of a bridge, router, or protocol gateway. Even within a segmented clinical network, it is a common design to use network switches dedicated to one nursing unit so that central patient monitoring within that unit may continue if the connection to other nursing units fails.

Many patient monitoring networks use Ethernet over copper twisted-pair cabling and optical fibers to transmit waveform and parameters to central monitors and information systems. Twisted-pair cabling is typically limited to 100 meters in length; fibers are used to connect nursing units over greater distances. There are two typical communication protocols used: user datagram protocol (UDP) and transmission control protocol (TCP). Waveform data typically use the real-time UDP protocol, which means if there is a network disconnect or congestion, the data that make up a physiological waveform are lost, which results in a waveform gap or dropout. The fact that streaming waveform data are so critical and sensitive to packet loss is the reason that many patient monitoring networks were designed on their own physical segments to control data traffic congestion. The other typical data protocol is TCP, referred to as guaranteed delivery. If TCP data are interrupted, then the transmitting and receiving devices reconstruct the lost data to complete the information.

All devices that transmit information over networks use internet protocol (IP) addresses to identify a connected device, known as a node. An IP address must be unique within a hospital network and comprises four octets of numbers between 0 and 255, such as 172.16.24.204. The subnet mask indicates a subset of the total network where nodes may communicate with each other and limits unnecessary traffic across the entire network. For example, a subnet mask of 255.255.255.0 for the IP address above will allow devices addressed between 172.16.24.1 and 172.15.24.254 to readily communicate with each other. In this case, 172.16.24.0 indicates the network and 172.16.24.255 is a broadcast address to all devices within the subnet. A device within this subnet may communi-

cate with devices in other subnets through the use of a router or bridge. If the clinical network is connected to the hospital network with a router, a default gateway address is configured on the medical device in order for data to be sent through the router that interconnects the two networks.

Troubleshooting Connections

When a patient monitor or other medical device is not communicating with other devices, there are network troubleshooting tools available to the biomed to diagnose the issue.

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The most common software tool to confirm network communication is the Ping command, which is available on most patient monitoring central systems through a service menu. A computer that is addressed to communicate on the network subnet may also be used to troubleshoot network connectivity issues. Using a recent release of the Microsoft operating system as an example, one may launch a command prompt window by the Start/Run menu by typing in "cmd". Once the command prompt window has launched, one may type "ping 172.16.24.204" (using our sample IP address) and then watch for a series of replies or timeouts to indicate either a successful test or a failure. If a timeout results, and a router or bridge is present between your medical device and the destination, then the address of the interconnecting device should be pinged from each side of the device to determine where in the network an issue may be present. Another useful command is "ping –t" followed by the IP address to do a continuous ping test while diagnosing intermittent failures.

Most network connection ports on both the medical device and its network switch will have a status light-emitting diode (LED) that indicates a network communications link. A quick check of the link indicator can indicate either a good network connection or a possible faulty patch cable, port, or other cabling. There are also relatively inexpensive network cable test tools that may be used to determine wiring issues and cable paths, such as a tone generator. Fibers that interconnect network physical segments may be tested by either their link status indicators on network switches or with optical test tools to confirm fiber integrity.

Wireless communication introduces a whole different set of issues to be aware of with medical devices. Most large hospitals will have installed a wireless infrastructure, which typically communicates at 2.4GHz. Wireless access points communicate on channels within this 2.4GHz band. Some wireless patient monitors utilize this same band for connectivity, and may operate without issues if the biomed and hospital network teams plan for co-existence. These wireless monitors must be deployed with caution after working with your hospital's network team members. There is only so much air space available for the access point channels. Even though the patient data traffic size may not be substantial, there are few channels available for the access points to operate on within the 2.4GHz band. The key thing to remember about wireless patient monitoring is to use it only where necessary. Other than possible radio frequency issues, troubleshooting wireless network connectivity is very similar to wired networks utilizing the same diagnostic commands.

I hope that this basic information will benefit you in understanding network use with medical devices. There are many sources available on the Internet for further learning, along with your local library or bookstore. Rather than listing individual websites in this article for further reference, I suggest using your favorite search engine with the term "network basics" to find a multitude of potentially valuable sites that may be explored. For the biomed technician and engineer, networking knowledge is another tool for supporting clinicians in their mission of providing the best possible patient care. ■

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Need More Information?

For more on managing the integration between medical devices and clinical information systems, see IT World in this issue of *BI&T*.