

Wired and wireless networking in healthcare computer networks

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Abstract

In the health care area, electronic medical records (EMRs) became the most important method for documents. More medical equipment for patients is wireless. Some medical treatments are required to keep wireless connectivity. Information technology is widely expanded to desktops, electronic medical records, and clinical care system.

From the earlier time, the information technology was simple and easy. For example, the screen showed lab test results. Right now the network can carry electronic medical records, clinical data, and store them in a computer. The wireless network can send the readings of a wireless blood pressure cuffs to a doctor's iPad. Wired networks connect hospital and data center, and handle large image files from radiology. The infrastructure of a network can transfer EMRs among hospitals, nursing homes, and doctors' offices. Doctors can updates patients records through the wireless network. It is impossible to access a patient's records from several locations without wireless networks.

However, the cost of infrastructure is high. Old hospitals did not have network equipment. Doctors still have to install hardware and software in their hospital because they have to use a computer to see lab results and tests. Delay of information will affect the work being done efficiently. Wired and wireless networks are important in the healthcare area.

The contents of the paper will include wireless standard, wireless and wired network challenges in bigger, urban hospitals, and the solutions for the challenges. Small, rural hospitals have network challenges, and they adopt wireless network to improve their healthcare quality. The remote healthcare network can use, SNMP, simple network management protocol to improve healthcare communications.

Introduction

The mobility of Wireless devices improves the effectiveness of healthcare. More employees will bring their own wireless devices, such as tablets, to their work places. Almost every doctor and administrator will bring iPads and used them to check emails and take notes. More and more healthcare employees will use wireless devices. Many hospitals and healthcare facilities choose cloud computing for their connectivity. Because hospitals and facilities will install software and services to employees' devices, the connectivity of cloud computing will make the maintenance job easier. More doctors will choose cloud computing for convenience. However, something is still to be improved. For example, some mobile devices only are for outpatient services. Inpatient services are not included. Some physicians use software in the virtual desktop. However, the software does not fit some computers. These situations should be improved.

Even though there are weak places, the current medical wireless devices still help to increase effectiveness. When nurses take vital signs for patients, they push the start button, which is on the blood pressure cuff. The results will be sent to the patient's records. One example is the use of barcodes. Each patient has a wristband. Nurses can use barcode reader to read the wristband and to verify the identification, medication, and the instructions on how to use the drug. These patients' records are part of EMRs. To provide more services, information technology technicians check the patients' charts frequently and make analysis, because more people bring their wireless devices to the healthcare facility and want to connect to the healthcare networks. For visitors, they can use the guest network, which has a firewall between guest network and the facility's network. Because many people used guest networks, hospitals began to use 802.11a standard, which is the same as that of clinical charts.

The Institute of Electrical and Electronics Engineers, IEEE, developed WLAN standard, which was called, 802.11, in 1997. However, the network bandwidth was 2 Mbps. This speed was not fast enough for devices to use it. Therefore, products which adopted the standard were not produced any more. In July 1999, IEEE developed 802.11b. The maximum bandwidth could be 11 Mbps. 802.11b still used unregulated radio frequency 2.4 GHz (Nee et al., 1999), which was the same as 802.11. The good part of the unregulated frequency is lower cost. The not good part is that the frequency will interfere with other frequencies, such as microwave ovens, cordless phones, and any devices using 2.4 GHz. Fortunately, if these devices have some distance, their frequencies will not interfere with each other.

Almost at the same time IEEE developed 802.11a. The maximum bandwidth is 54 Mbps. The signals are regulated frequency around 5.12 to 5.35GHz (Aslett, 2002). The range of higher frequency is shorter than 802.11b. The higher frequency has more difficulty going through walls and solid objects. The cost is higher than 802.11b. Because the 802.11b and 802.11a have different advantages and disadvantages, in 2002, another WLAN standard was developed, and it was called 802.11g.

802.11g combines 802.11a and 802.11b. Its bandwidth is 54 Mbps and the frequency is 2.4 GHz, which has wider range. If the access point is 802.11g, then it will accept a network adapter, which has 802.11b. Analysis is the following.

- The advantages: The speed is faster than 802.11b. The signals are better than 802.11a at going through walls.
- The disadvantages: The cost is higher than 802.11b. The signals might interfere with unregulated frequencies.

In 2009, 802.11n was developed to improve 802.11g to handle antennas and wireless signals. The access point of 802.11n will accept 802.11b and 802.11g. The bandwidth is up to 300 Mbps. 802.11n has advantages and disadvantages.

- Advantages: The speed is faster than 802.11g. The range is greater. It has better resistance to interference with microwave ovens or cordless phones.
- Disadvantages: The cost is higher than 802.11g. Antennas and wireless signals that use 802.11n might interfere with 802.11b and 802.11g.

802.11ac is the improved standard. It is dual band wireless. That means it can transmit signals on 2.4GHz and 5GHz at the same time. It is compatible with 802.11b, 802.11g, and 802.11n. On 2.4 GHz, the maximum bandwidth is 450 Mbps. On 5 GHz, the maximum bandwidth is 1300 Mbps (Mitchell, 2015).

Clinical charts use a different band from the regular network so the other traffic will not bother the traffic of clinical charts. The newest standard, 802.11ac, might help the clinical charts to differentiate from the other band and provide the best performs. Even with the high demand for wireless devices, healthcare still needs wired networks. In remote locations, people could only have one telecommunication method. Hospitals can use wide area network to connect servers and data centers. Redundant connections can use fiber networks to connect hospitals, data center, and clinical places. In some areas the redundant is not ready yet. Radiology image files have large size, so these images are transmitted through wired networks. Doctors will put the priority of the image files higher than the other files. The concerns of images are not only size, but also speed. The speed of transmitting an image is different from that of transmitting a regular file. From now on, doctors do not use paper and a pencil to take care of patients. They use computers (O'Connor, 2012).

Challenges in Wired and Wireless Connections

According to the Healthcare Information and Management Systems Society, HIMSS, Analytics, two thirds of hospitals in U.S. used wireless technology in their healthcare organizations. HIMSS Analytics wanted to know about any issues and challenges around wireless networks. They had a survey, in which there were two groups of senior information technology managers, who used wireless networks. They were from different hospitals. Some were large hospitals, which had 1,000 beds. Some were small hospitals, which had 100 beds.

From this survey, all of them agreed wireless technology was the trend in healthcare, helped to improve the effectiveness and quality of healthcare and the productivity of hospitals. The applications in healthcare include electronic medical records, EMRs, medical devices, clinical documents, emergency departments, and

picture archiving and communications systems, PACS. Some users enrolled to use the systems. Some logged into housekeeping systems. Some registered to use financial systems. The devices of users included computers on workstations, cell phones, tablet computers, desktop computers, and electronic bandages. Wireless technology is used in ambulatory care, ambulances, home health care, and mobile clinics. From this survey, HIMSS Analytics found five challenges. The problems are in hardware, technology, user needs, security management, and network systems.

The first problem is hardware connections in hospitals, and users having a problem accessing networks. The main difficulties include that wireless signals cannot reach the older buildings, the basements, and the lower part of buildings. Some new buildings have glazed windows, which would block wireless signals. When it is not proper for cables to go through brick walls, a wireless connection is the option. Wireless technology will help distance healthcare services. However, mountain areas are another challenge to transmitting wireless signals to doctors, and home health care providers. Solutions for remote areas are to install wireless repeaters, which will increase wireless signals. A distributed antenna system can work as a repeater in a building. Survival remote gateways can help to increase internal and external wireless communication ("Avaya Survivable Remote Gateway 50 6.0 Configuration Guide," 2011).

The second problem is technology. The bandwidth of a wireless network will affect users accessing EMRs. PACS, picture archiving and communications systems, and videos need enough bandwidth to transmit properly. The benefits of PACS is that the healthcare staff can view medical images in their tablets or laptop in anywhere with the network connection. This is better than paper records and helps make healthcare more efficient (De Leonardis et al., 2002). Some IT managers increase more access points, and then users have enough bandwidth to access the information. Some use the segments of network to let users access the patients' records. Some guest networks are controlled to reduce bandwidth problems. The download of streaming videos will need large bandwidth. The network policy and management can arrange the priority of applications to control access to the network. Compressed files can reduce the size, and can help the wireless network to perform efficiently. Each area has different hardware or devices, which do not match or work well that will slow down the connection speed. The solution to the variety of technology is to upgrade devices to the consistent 802.11 versions.

The third problem is user needs. Users are in hospitals, ambulatory care, home health care, and emergency services. Some devices are wired and some are wireless. Users need the connections to be fast and reliable. The important concern is that users do not need to be IT experts, but they know how to use wireless connections. Another concern is that the wireless connection is reliable. Some doctors want to access patients' information, and buy devices, such as cell phones and access points. However, these devices are not compatible to the patient information connections. To establish policy for the devices, the IT department should be able to support doctors and their equipment. Patients' information is not only available to healthcare employees but also patients and families. They can use the guest network. Some doctors and healthcare employees are in remote areas and want to access medical records. Some hospitals charge them. These healthcare employees cancel their account in IT department and save their money. They can go through guest network to access medical records.

However, some healthcare organizations control the bandwidth of guest networks. Thus users of guest networks only can access smaller records. The access of healthcare employees is limited to some information. The users in an ambulance need to use a wireless connection. IT people can put an access point on the ambulance. The information will be send back to the hospital through a virtual private network. Some patients and families need to use the guest network to know the conditions and results of their treatments. Patients and families can enroll for a temporary account and get a special service set identifier, SSID, during the treatment period.

The fourth problem is security management. Healthcare employees usually are the users of the healthcare networks. However, some employees do not behave properly when they access the networks. Some unauthorized users want to access the networks. To prevent users' mistakes and unauthorized users' access, it is necessary to put security applications in networks. For security concerns, many healthcare organizations use virtual private networks. According to Health Insurance Portability and Accountability Act of 1996, healthcare organizations have to protect patient records and information. Some portable devices can be stolen or lost. Some organizations have security control centers, which have software to perform access control, and stop access when devices are lost or stolen. Another concern about security is that patients and families use their own devices to access a guest network. Hospitals use different segments for the guest network and their network. The purpose of the segments is to provide different security levels for patient information.

The fifth problem is the network system. To make sure the availability of the network, IT employees supervise the network system daily. Reliability is the basic requirement for a network. Some organizations still have to solve the problem. However, some have stable networks. An IT department has a help desk. When the help desk gets many calls to get help, this shows that the network is not stable or reliable. If the help desk does not get many calls to get help, the network might be stable and better. Some people may think that if they bring their equipment to make their own system, then they can manage their problems. For the IT department, this way will not decrease problems in the network. One solution is to provide a survey to users. From the feedback, IT employees can know where there are problems and improve them. Reports from different devices offer the issues of each device, and then the IT department can monitor the device that shows more problems. One more option is to use virtual private network software, which can detect problems and provide alerts to administrators. IT managers can set the range for devices, servers, and users, and get notifications through email, simple network management protocol (SNMP), and audit logs. Managers can correct the problems soon to prevent the problems getting worse. SNMP is an application to work for network management, and it can communicate with network system, servers, network printers, and routers (Case, Davin, Fedor, & Schoffstall, 1989).

Wireless connection is not going out of popularity, and is becoming to the main technology to get information. Some healthcare organizations want to upgrade to 802.11n standard. Some will add more access points in new areas. Some IT managers want to apply new applications to their devices, and replace old devices with new and smaller devices in their work places. IT departments will find solutions to reduce the problems, and challenges. IT professionals will improve the technology to increase the

productivity of healthcare organizations. According to the American Recovery and Reinvestment Act of 2009, ARRA, the federal government funded \$20 billion to help healthcare organizations to use health information technology, HIT, and electronic health records, EHRs. The American Recovery and Reinvestment Act do not mention that the technology is wireless technology. However, wireless technology can help to manage digital data. Healthcare providers can share information with wireless technology, which will become the important technology (Horowitz, 2009).

Small, Rural Hospitals

1. Background

The Health Information Technology for Economic and Clinical Health, HITECH, Act is Title XIII of the American Recovery and Reinvestment Act of 2009, and it funded hospitals to use electronic health records. Even though small, rural hospitals have funds to help them to use electronic health records, they still do not have enough money to improve their technology. However, small, rural hospitals still need to share information with larger, urban hospitals. Therefore, they have to handle these challenges. Small, rural hospitals usually have less than 50 beds. The reason for using electronic health records is that hospitals need to share, use, and transform healthcare information. Hospitals can help rural communities to learn about disease prevention, and healthcare education.

2. Products

In small, rural hospitals, technology is used in financial and human resources areas. They have a problem get nursing and IT staff. When they do not have knowledge of information technology, they have a problem selecting products. Wireless technology has different standards. It is expensive to switch from an old system to a new system. When the administrators of hospitals want to choose products, they make a decision by price and other hospitals' suggestions. Different devices have different interfaces. When they buy the devices, they may not consider the difference. When they do not have anything to connect two different interfaces, they only can use paper to send and receive information. Privacy and security are required when small, rural hospitals use wired and wireless technology. Especially, if employees are used to using smart cell phones and tablet devices, they will hope they can use their devices to connect to the network. The hospital is challenged to develop policy to handle privacy and security in the wireless network. It is difficult to build an infrastructure system because small, rural hospitals might have no Internet, hardware maybe out of date, and there may be no security and privacy policy. Even if they have the Internet, the bandwidth and speed may not be enough to access the wireless network and exchange healthcare information. Another challenge is that IT employees have to build a list for drug, dictionary, and template for every product. However, they usually do not have enough information from the product suppliers. These problems are not easy to know ahead.

Choosing a product is a tough decision. Hospitals cannot trust vendors because the information from vendors is not necessarily correct in any situation. The product must be useful for a long time. Each application will increase the cost, so it should be used for health information. Other hospitals' experience and information on products are good references. The review of the product from other users is a good resource too. Hospitals will know after the product is installed, the interface will be different based

on the system. If a product is the newest version, it may be useful for longer. When hospitals want to buy products, they should know how many products they need. If the entire system is from one vendor, they can avoid paying money for different interfaces.

When hospitals work with vendors, and some staff in the vendors are new and do not have knowledge on electronic medical records, some problems cannot be solved soon. Hospitals will be disappointed with these vendors. Vendors sell products to hospitals. They are supposed to install and configure products. Later they have to give training to health employees about how to use the products. However, hospitals and vendors may not have contracts to state what vendors should provide. Administrators of hospitals and employees will be frustrated because they do not get enough support from vendors. For legal rights, hospitals should have contracts with vendors. The contacts can include employees' training, and support to the interface. Hospitals should tell each vendor what they need and get support as much as possible. Hospitals have to make the products fit the healthcare workflow, and know that problems could happen and delay progress.

3. Cost

To buy products for electric medical records is an internal cost of hospitals. They hope the cost will improve the care to patients, and do not expect to get money back from taking care of patients. The cost of electric medical records is an annual cost. To determine the cost of electric medical records is difficult. Vendors offer cost estimates. However, hospitals do not have enough knowledge to estimate the budget for training. Therefore, expenditure is underestimated. The five-year average cost is \$1.5 million.

5 Year Average Cost	
Electronic Medical Records Operating Budget	\$429,332
Electronic Medical Records Capital Budget	\$1,148,377
Total Electronic Medical Records Budget	\$1,577,709

Table 1 displays the cost.

Small, rural hospitals need to have investment in electronic medical records. However, it is not easy to estimate the cost. If a hospital gets a conventional loan for electronic medical records devices, they might have a problem paying back the loan. The investment of electronic medical records is a large part of a small hospital. Every year the maintenance fee for electronic medical records includes software, hardware, upgrade devices. It is a burden for hospitals to support the maintenance. Some small, rural hospitals do not have enough patients to get incentive payments from Medicaid. Small, rural hospitals are not allowed to depreciate the cost of EMRs from the incentive payments of Medicare, which only can pay the current cost of EMRs. Incentive payments are not allowed to cover the cost of staff training. The federal government will give different reimbursements to each hospital based on diverse cases.

Because it is not easy to know the expenditure ahead, hospitals need to have a plan to estimate the budget. The plan will include maintenance of software and hardware, and upgrades for system and network. Vendors, other hospitals, and consultants can help to estimate the cost of EMRs. When a hospital wants to have a contract with vendors, they should predict the cost when the amount of reimbursement cannot cover the cost. Despite this small, rural hospitals want to invest money for EMRs.

If their credit report is not good, they cannot get a conventional loan. Even if they get conventional loan, when they do not meet meaningful use criteria, they cannot get incentive payments, and then may not be able to pay the loan. Hospitals have several ways to reduce the cost of EMRs. They have to continue using EMRs, and then meet meaningful use criteria to get incentive payments, which will come soon. They can increase their services to increase their revenue.

One challenge is to accept healthcare employees' devices and new systems in the original system and network. Employees will become frustrated when the wireless communication does not show the results that they expect. Even if the staff can communicate well and transmit EMRs effectively. Each hospital will have a different culture.

Rural hospitals do not have enough staff that has IT knowledge. It is difficult to give training to implement a big system. The number of IT employees is not enough. Each IT employee has to handle multiple jobs. This reason will affect their performance. Many staff are part time, so they do not have enough time to be familiar with the health system. Hospitals need to give training to employees. Vendors usually can offer three days training. However, some employees need more days of training. Hospitals cannot afford providing too long training. Meetings and discussion can help staff to accept EMRs and work with them properly. Project managers can develop a project and work with the IT manager to implement the health care information technology successfully ("Overcoming Challenges to Health IT Adoption in Small, Rural Hospitals," 2012).

SNMP

Home health care is one of the health services. More people need this service because some people have chronic diseases and some are disabled. The development of e-health can decrease health cost and the time that patients wait in a hospital. Patients can be more independent. The home health care network architecture has two places. One is at home. The other is at the health care place. Patients check their vital signs daily. A medical device will collect the vital signs, and then transfer them to a computer, which will transfer the vital signs to the health care site. One central server will manage the data from different homes. One important thing is technology that is able to transfer and analyze data. The management of the technology is to make sure the networks work well and to improve any problems. SNMP, simple network management protocol, can provide communication between multiple manager computers and multiple agent computers. SNMP version 3 has three major functions, which are access control, encryption, and authentication. Its structure has two models. One is the interaction model. The other is the value model. In the interaction model, the agent of SNMP will answer any request and send alert concerning the important changes. In the value model, the management information base (MIB) function will handle the data. When the data is not in the normal range, the function will provide an alert. SNMP can help to perform the good e-health (Lasierra, Alesanco, & García, 2012).

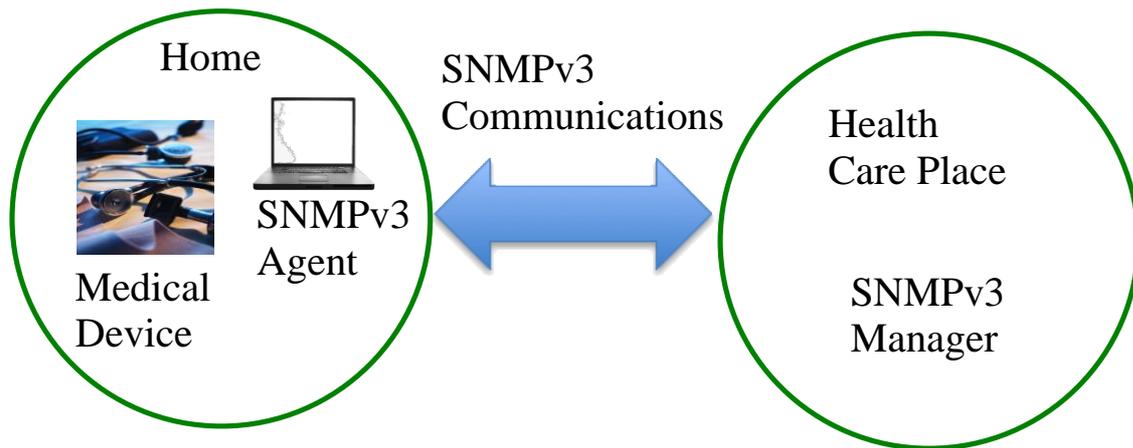


Figure 1 shows the SNMPv3 communications.

Conclusion

The federal government funded hospitals to adopt technology to improve healthcare services. Wired and wireless networks can help doctors to access patients' information effectively. Patients can access their own information to know the details. IT professionals will improve the technology to satisfy the users' needs. Because technology is not cheap, the Federal government did a good job making the e-health better.

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