Pervasive Healthcare

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The US healthcare industry is confronting a number of challenges, including skyrocketing costs, a growing incidence of medical errors, inadequate staffing, and lack of coverage in rural and underserved urban areas. Healthcare workers are under increasing pressure to provide better services to more people using limited financial and human resources.

One proposed solution to the current crisis is *pervasive healthcare*. The widescale deployment of wireless networks will improve communication among patients, physicians, and other healthcare workers as well as enable the delivery of accurate medical information anytime anywhere, thereby reducing errors and improving access. At the same time, advances in wireless technologies—such as intelligent mobile devices and wearable networks—have made possible a wide range of efficient and powerful medical applications.

Pervasive healthcare has the potential to reduce long-term costs and improve quality of service, but it also faces many technical and administrative obstacles.

APPLICATIONS AND SERVICES

Figure 1 illustrates one possible scenario for a pervasive healthcare system that integrates the unique capabilities of current and emerging mobile devices, wireless networks, and middleware. These technologies can support a wide range of applications and services including mobile telemedicine, patient monitoring, location-based medical services, emergency response and management, pervasive access to medical data, personalized monitoring, and lifestyle incentive management.

Wireless technologies can reduce medical costs and improve quality of service.

Mobile telemedicine

Many medical errors result from a lack of correct and complete data at the time of service, which can lead to wrong diagnoses and drug interaction problems. This is especially true in emergency situations in remote locations where quick action is needed but those attending a victim lack expertise or are unfamiliar with the patient's health history. The ability to transmit critical information about victims to a hospital before they arrive, or to let specialists diagnose and recommend treatment from a distance, can make the difference between life and death.

Wireless technology enables ambulance personnel to send real-time data about a patient's condition to a hospital while en route. This gives the hospital staff a head start in evaluating the patient and preparing treatment. In some cases, paramedics can electronically retrieve the patient's medical records, including known allergies or preexisting conditions, from the hospital database.

In medical facilities equipped with wireless local area networks (LANs), doctors and staff can review and update a patient's medical records from any location using a handheld device. Entering diagnostic information and taking notes electronically eliminates the need for time-consuming manual dictation and errors associated with handwritten instructions. In addition, physicians can generate and wirelessly transmit prescriptions to a pharmacy, which also saves time and increases accuracy.

Patient monitoring

Wireless LANs and personal area networks make it possible to continually monitor patients almost anywhere and immediately notify healthcare workers, the nearest hospital, or an emergency service of any critical change in status. Such networks can quickly route biomedical and environmental data from sensors deployed on the body, in a room, or throughout a building to a central computer system for processing. Building in context awareness would help to avoid false-positive alerts in the future.

With remote monitoring, patients undergoing postoperative care who are no longer in acute danger but are still subject to a relapse or other complications can be safely transferred earlier to other units within a hospital. Many can move to less costly assisted care facilities or even return home more

quickly. In addition, doctors and staff can focus on urgent care and spend less time "making the rounds."

Location-based services

Healthcare providers can use location-based tracking services to supervise elderly patients or those with mental illnesses who are ambulatory but restricted to a certain area. For example, an assisted care facility could use network sensors and radio-frequency ID badges to alert staff members when patients leave a designated safety zone.

Network or satellite positioning technology also can be used to quickly and accurately locate wireless subscribers in an emergency and communicate information about their location. Proximity information services can direct mobile users to a nearby healthcare facility; voice-activated systems could provide such instructions to blind persons. Location-based health information services can help find people with matching blood types, organ donors, and so on.

Intelligent emergency response and management

An intelligent emergency response and management system could use location-tracking technology to filter emergency calls by matching different reports of the same event. This would reduce the overload on emergency systems that routinely receive hundreds of cell-phone calls for the same incident. It would also prevent dispatching multiple vehicles to the same emergency, which is wasteful and can delay responses to other calls.

In addition, the system could obtain real-time traffic information from wireless networks to efficiently route emergency vehicles to victims and then to the closest hospital where the needed care and space are available. This would make it possible to handle many more emergency cases with a limited budget and fewer personnel as well as improve overall quality of service.

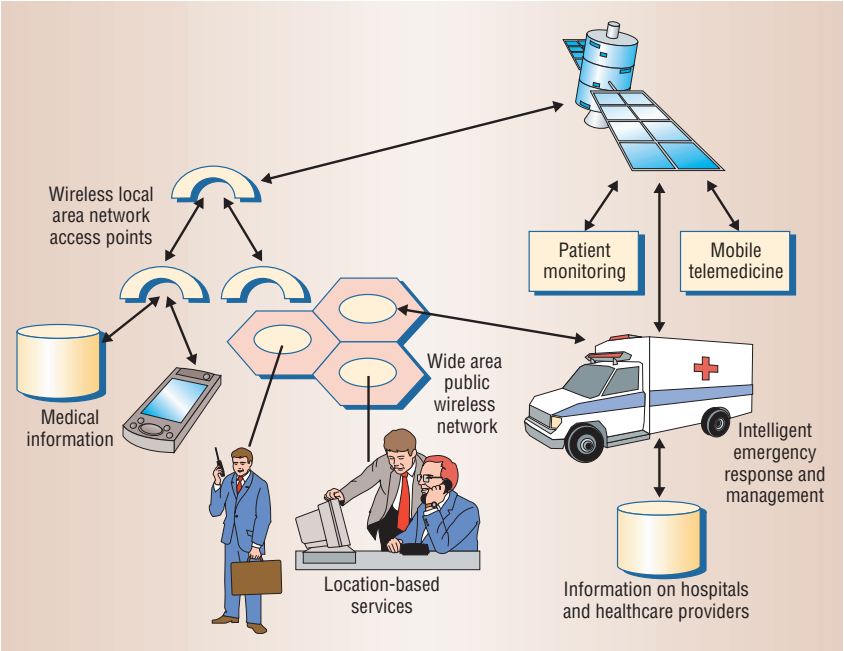

Figure 1. Pervasive healthcare scenario. Wireless network intelligence and advances in pervasive technologies can increase healthcare quality and access.

Pervasive access to medical data

Both patients and healthcare providers would benefit from pervasive access to lifetime clinical records. During a check-up, for example, patients could use a handheld device to upload their personal medical history and insurance data into their healthcare provider's database, reducing the effort required to enter such detailed information manually. Alternatively, such information could be downloaded from a Web-based health information system with proper authentication.

Both options decrease the chance of either the patient or receptionist entering incorrect data, thereby reducing the number of medical errors, as well as minimize the stress associated with administrative paperwork. In addition, giving doctors browser-based access to certain information, such as lab-test results, would enable anxious patients to receive such information more quickly.

Patients could likewise use mobile devices to update their personal and family medical information and physician contacts, receive alerts to take prescribed medications, check for drug interactions, or dynamically change restrictions on who can access their health data. Wireless service providers or healthcare providers could use opt-in and opt-out capabilities to make any information they store sharable only with the user's consent.

Health-aware mobile devices

Numerous portable devices are available that can detect certain medical conditions—pulse rate, blood pressure, breath alcohol level, and so on—from a user's touch. Many such capabilities could be integrated into a handheld wireless device that also contains the user's medical history. It may even be possible to detect certain contextual information, such as the user's level of anxiety, based on keystroke patterns. After analyzing data input, the device could transmit an alert message to a healthcare provider, the nearest hospital, or an emergency system if appropriate.

Lifestyle incentive management

Those who exercise or eat nutritious

meals could be rewarded for their healthy behavior with mobile micropayments that they could then use to pay wireless monthly charges, donate to a charity of choice, or pay medical expenses. This may be a more effective incentive than the proposed "fat tax" on fast-food items to help recover the healthcare costs arising from obesity. The wide-scale deployment of wireless LANs supporting mobile payments would facilitate such programs.

CHALLENGES

The healthcare industry has introduced wireless technologies on a limited scale for many simple tasks. However, researchers and advocates must overcome many challenges before a truly pervasive healthcare environment can become a reality.

First, most existing implementations do not interoperate well, resulting in segmented solutions. Moving to a fully pervasive system would be a complex transition requiring several steps and incremental budgetary increases to create the necessary infrastructure. This process should not interfere with the basic functioning of the current system.

In addition, due to limited available resources, multiple players must become stakeholders in the system. Providers and insurers must believe that investing in wireless technologies will make healthcare more efficient and safer, thereby reducing operating costs. Consumers must be convinced that paying higher premiums now will lower their healthcare bills and increase access to services later. Employers and government entities must be persuaded that pervasive healthcare will ensure a healthier workforce and reduce long-term spending.

Privacy and security are also potential problems. Healthcare data should be available anytime anywhere, but only to authorized persons. Pervasive healthcare information could be abused by corporations in deciding who should be promoted, by insurance companies in refusing coverage for people with poor health, and by spouses and their attorneys in divorce cases. There must be clear guidelines on who can access such data.

The usability of pervasive healthcare solutions is another challenge, at least in the near future. Those who are less technically savvy are generally willing to use intelligent mobile devices if these devices enrich their lives, give them more independence, and offer intuitive interfaces. Training healthcare professionals as well as patients to use such devices will become less problematic as handhelds and other wireless products become commonplace in society.

Finally, the large-scale introduction of wireless technology in healthcare has legal and regulatory implications. For example, insurance companies might not pay or might pay differently for treatment via mobile devices. Further, it is unclear how to ensure that wireless technologies can comply with the 1996 Health Insurance Portability and Accountability Act, designed to protect patient information.

Pervasive healthcare would improve the productivity of healthcare practitioners and greatly facilitate the delivery of a wider range of medical services. The rapidly increasing use of handheld devices and the deployment of wireless-based solutions should accelerate the development of such services, especially in areas where a wireline infrastructure is minimal or impractical. Faster and more accurate communication would result in substantial savings that could be used to expand basic healthcare to everyone, thereby reducing costs in the long run. ■

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