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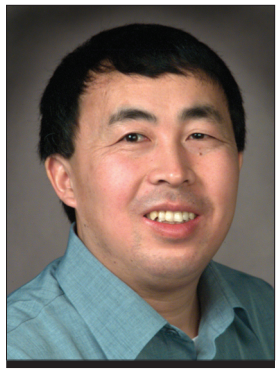
EDITOR'S NOTE

Emerging Technologies for e-Healthcare



Xuemin (Sherman) Shen

Healthcare has been a daily concern of individuals, families, and governments in different countries throughout human history. Countries and jurisdictions have different policies and plans in relation to the personal and population-based healthcare goals within their societies. In addition, the healthcare industry has impact on every other industry as healthy employees are critical for a successful business. A recent study by professional services company Towers Watson shows that the average healthcare cost per person over the world increased by 9.8 percent in 2011 and is projected to rise at a similar level in 2012. According to the World Health Organization (WHO), the United States spent $7146 on healthcare per capita and 15.2 percent of its GDP on healthcare budget. The federal finance minister of Canada also indicated that national funding for healthcare will grow from $27 billion in 2011–2012 to a minimum $38 billion in 2018–2019. With these huge monetary/labor investments, healthcare has evolved rapidly as an advanced technology over the past decades, and it can be delivered in a fast and safe way with high quality. The evolution of healthcare changes our way of living and forms a significant part of a country's economy. However, healthcare is still far from satisfactory in many aspects. For example, people increase their expectation for healthcare services while the aging population makes healthcare shortage even worse. The shortage of healthcare practitioners and inefficient use of healthcare resources are serious problems in the world. A public opinion research report reveals that Canadians are frustrated about the lack of action on reducing medical waiting times, the shortage of doctors and nurses, and cutbacks in medical services, despite many promises by political leaders.

On the other hand, state-of-the-art information and networking technologies have significantly changed our working and living habits. The communication and information services via mobile applications over the Internet or wireless networks are of high efficiency and reliability. As a result, healthcare has been renovated to an extended e-Healthcare via integrating powerful wireless networking and sensing technologies. e-Healthcare enables a shift from the traditional hospital-based setting with geographical restrictions to the patient-centric setting with pervasive and real-time information access. The e-Healthcare system mainly consists of three domains: body area, communication and networking, and service. The body area domain is defined by a number of wireless body area networks (WBANs), each corresponding to a user. A WBAN is composed of a number of sensors and a gateway. The body sensors are placed in, on, or around a user's body to continuously monitor the user's physiological conditions such as heart rate and body temperature. They transmit sensory data to the gateway via WiFi or Bluetooth technologies. The major functionality of the communication and networking domain is to bridge the body area and service domains. Advanced wireless communications technologies (e.g., cellular networks, WiFi, and WiMAX) link WBAN gateways to the Internet and enable efficient mutual data communication between two WBANs. In the service domain, a trusted authority maintains an online server that is responsible for receiving, recording, and analyzing user health-related information. In summary, e-Healthcare can reduce human operations and enable automation in information exchange. This brings great convenience to both healthcare practitioners and patients, and will definitely make our way of living better at low cost. However, e-Healthcare still faces many technical challenges, including patient privacy, energy efficiency in communication, and reliable information collection. In what follows, I briefly discuss some challenging issues in the emerging technologies for e-Healthcare.

e-Healthcare Via Social Networks

Social networking helps people to actively maintain and strengthen their social relations. Social media sites (e.g., Facebook, LinkedIn, and Twitter) have moved beyond the novelty stage and entered the mainstream. They have become effective and pervasive tools within the corporate setting as well. A study in 2009 examined media usage by nurses and found that 77 percent of the 292 nurses surveyed have visited Facebook, a quarter of them have visited LinkedIn, and 11 percent of them reported using Twitter. Facebook is also popular with women in the 45 to 65 age group who are the decision makers in their families on where to seek medical treatment. If you see your Facebook friends posting compliments on a hospital's business page, you are likely to go to that hospital next time when you need a medical procedure.

Undoubtedly, social media sites can be a great way for healthcare practitioners and patients to network with colleagues and friends and share health information. There are also popular online communities exclusively for them (See PatientLikeMe). However, there are drawbacks such as privacy violation and unauthorized use of medical information. Numerous legal issues can potentially arise when healthcare providers use social media. As a result, caution is required in using social media for e-Healthcare applications. New user privacy preservation and information security solutions are needed. The term of using e-Healthcare via social networks must be elaborately defined and accepted by users.

Reliable Health Information Collection Under Network Dynamics

Patients in general prefer their health information to be continuously monitored in order to receive fast and reliable healthcare services on time. In an e-Healthcare system, to collect real-time health information from anyone anywhere anytime is a challenging task. Different network settings pose difficulties in the quality assurance of real-time information collection. For example, some patients may require their health information to be collected continuously no matter where they are; some may have an emergency and need fast healthcare; others may require healthcare when they are driving on the highway or live in a remote rural area. The variations of network settings due to scenario changes lead to many challenges. First, the network dynamics make it difficult to ensure reliability in health information collection. When a user changes her body postures (e.g., from sitting to walking), the channel conditions of the WBAN exhibit diverse characteristics. When a user drives from his home to a shopping mall, the network access point from the WBAN gateway to the service provider also change accordingly. Therefore, the information collection methods must be automated to adapt to the real-time networking environment so as to provide a consistent and reliable end-to-end connection. Second, the quality of information collection may degrade due to radio interference among nearby WBANs. In a crowded place such as a hospital or medical clinic, health information collection from a large number of patients must be well coordinated to share the limited radio bandwidth. Wireless information transmission for a medical emergency should be given high priority, in order to guarantee reliable delivery of delay-sensitive information. It is well known that the throughput of a WiFi decreases significantly when the traffic load is high due to the contention based channel access. When a large number of users connect simultaneously to a WiFi hotspot, quality of service (QoS) cannot be guaranteed. Existing cellular infrastructures (e.g., 3G and LTE) provide QoS guaranteed communication links. However, they may not guarantee the high reliability required for e-Healthcare because the bandwidth may be occupied by other video streaming and web browsing applications. In addition, solutions to achieve QoS guarantee over the TCP/IP-based Internet need to be developed to ensure accurate, reliable, and on-time end-to-end information delivery. Overall, priority-based resource reservation strategies are required for e-Healthcare applications in both the wireless and wireline networking domains.

Integration with Cloud Computing

E-Healthcare systems can establish a profile for each individual. As the population grows, a huge amount of data will be collected and stored on trusted e-Healthcare servers. At the same time, the servers must facilitate efficient and secure access from system users so that they can monitor and manage their own health information. Therefore, reliable and robust data servers with large storage capacity and strong computing capability are required to store, process, and distribute health information. The emerging cloud computing concept fits well in this scenario. Cloud computing is an evolving paradigm that enables ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction. However, the adoption of cloud computing in e-Healthcare faces many challenges. One is potential data breaches, which can occur when someone either purposely or inadvertently does not secure information left on a laptop or tablet. In 2011, data breaches cost healthcare organizations $214 per patient, and the U.S. healthcare industry over $6 billion. When huge amounts of health-related information have been stored into cloud servers, data breaches become worse because the servers are more likely to be targeted and attacked. Service reliability is another concern of cloud-based e-Healthcare. Due to the importance of health information, it is necessary for geographically distributed clouds to guarantee the integrity and security of health information. In case of a power failure or system failure, backup cloud servers must be invoked and the healthcare services uninterrupted. In addition, when cloud servers are employed, the information access delay may be enlarged due to the potential long geographical distance between the cloud servers and the users, and the overloaded access systems from a larger number of users to the servers. From an energy efficiency point of view, e-Healthcare allows users to perform information access by themselves and thus requires the cloud servers to provide such access all the time. According to the U.S. Environmental Protection Agency ENERGY STAR Program, the electricity consumed by Internet data centers (IDCs) was about 3 percent of total U.S. electricity consumption in 2011. The electricity consumption by IDCs will significantly increase if the cloud servers are built for e-Healthcare among countries. Novel cloud server architecture to meet the security, reliability, and energy efficiency requirements for e-Healthcare requires joint efforts of academia, industry, and government agencies.

In conclusion, by applying advanced communication networking and sensing technologies to healthcare, e-Healthcare can improve our living standard at low cost. This note presents several changeling issues to be resolved for advancing e-Healthcare systems. I hope you enjoy reading this issue of the magazine.