INTERNET2 AND MEDICINE: OPPORTUNITIES AND ISSUES

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ABSTRACT

In recent years the area of Telemedicine has become an alternative in bring medical experts to distant and remote patient locations. This has mainly been accomplished through the support of Internet1, which in many regards has facilitated the application of the Internet for medical purposes, but at the same time has limited the capabilities of its use. In this paper we focus on the opportunities and issues associated with the use of Internet2 to support Telemedicine. A major concern beyond the technological foundation of future systems is the acceptance of the technology by physicians, technicians, and patients. The actual impact of Internet2 will stem from Quality-of-Service that users can anticipate will be available in supporting mission critical applications that mandate these capabilities.

Keywords: Internet2, Telemedicine, Quality-of-Service

INTRODUCTION

Telemedicine is a technological innovation that has excited researchers and practitioners worldwide. While one may believe the idea is new, it is not. In a sense, telemedicine has been around for more than three decades, pioneered by the space programs of the former Soviet Union and United States to allow medical teams on earth to monitor the physical conditions of astronauts in space. Telemedicine ("medicine from a distance") has been defined as the use of telecommunications technology to provide diagnostic and therapeutic medical information between patient and doctor without either of them having to travel. Patients who previously could not travel to a physician's office or who live in a rural or remote area can now contact their physician for both advice and care using telemedicine. For physicians, telemedicine allows them to transform the current office-based practice by allowing them to care for patients from their homes via computer-based communication. Medically, telemedicine permits primary care providers to deliver comprehensive care without geographic and situational limitations.

Most telemedicine systems include a base unit that is in the physician's office and a portable unit that can be transported to a patient's home. The system consists of a computer processor, monitor, and video camera used to transmit images between the physician and patient. Different monitors can be added to the system, depending on the functions to be observed. A telemedicine system typically combines computer, video, and network communication technologies, enabling efficient cost-effective quality care to persons at some distance from the provider. The system includes diagnostic instruments that are designed to provide information for digital transmission and reproduction. Some of these instruments are variations of the cameras already used by surgeons during laparoscopic surgeries; adapters allow these cameras to be used for examination of any part of the body. An interactive video component allows the doctor and patient to communicate interactively.

Currently, several computer-based systems are available. These systems are capable of monitoring a number of physiologic variables (blood pressure, weight, oxygen, temperature, pulse) as well as electrocardiography (ECG) monitoring, and most have an electronic stethoscope. Consumers (patients and physicians) may select the monitoring they wish to have and add or subtract various functions offered by the system. Medical information is transmitted over a telephone connection between the patient and physician. There are several types of telephone transmission lines being used, including the standard telephone wire, ISDN-BRI (integrated services data network-basic rate interface) lines, T-1 (terrestrial transmission lines), and the newer ADSL (asymmetric digital subscriber line). Fiber optic cable lines are also being used in telemedicine communication transmission. Color, full motion video is critical for telemedicine. Anything short of full duplex color telecommunications is viewed as suboptimal for the health professional user.

In the future, physicians may care for patients who have personal computers equipped with the appropriate hardware and software that would permit patients to record vital signs and test results (blood pressure, pulse, respirations, temperature, weight, blood oxygenation, glucose monitoring, peak expiratory flow, and remote electrocardiography [ECG] monitoring) and would permit auscultation of heart and lung sounds and examination of the pharynx and tympanic membrane. Through videoconference, the physician can also assist a patient with the proper placement of ECG leads. Some systems would allow an examiner to photograph and store important physical findings (e.g.: rashes) and to compare subsequent photographs to follow resolution of the condition. Real-time transmission of X-rays, MRI's, CT scans, pathology samples and other diagnostic tests are also possible, and the system can be configured to transfer and store these images on the physician's computer for later references. The patient may be able to contact a physician or nurse 24 hours a day, 7 days a week, therefore ensuring access to care, which is a common concern among health care consumers.

INTERNET2 CAPABILITIES

Internet2 is a consortium of over 180 Universities working with the IT industry and governments to develop new applications for tomorrow's Internet. It is designed to also be backward compatible with the old version of the IPv4 Internet. Despite Internet2's promises, however, the medical field will need to reorganize itself and adapt to new changes in order take advantage of its capabilities. The most noticeable difference between Internet2 and Internet1 is the speed. Internet2's backbone is supposed to be at least thousand-fold faster than Internet1's speed. Another difference is IP Addressing, in which Internet2 uses 6 bytes instead of 4 bytes. Known as IPv6, it supports multicasting and guarantees delivery and performance, delivering high Quality of Service (QoS). This means data can be theoretically sent to a destination computer in real time. In medicine, this allows an exam to be performed on a patient whose physician is in a distant location. Each frame of the video arrives on time and no frames are lost.

Another feature of Internet2 is the concept of a gigapop, which stands for "gigabit capacity point of presence", which are high-capacity, interconnection points between Internet2 participants. In this setup, geographic locations connect to a gigapop. The advantage is that high bandwidth networks are built when the network is connected to the gigapop. This eliminates the need for a network to build its own high-bandwidth network. The cost is primarily connecting to the gigapop.

Quality-of-Service

Current Internet standards allow for video streaming, but do not allow for near synchronous communication. At times, there can be at least a 2-minute delay (1). Also, the detail obtained from videoconferencing over Internet1 can be less than desired, which is a problem for remote surgery. Current technologies allow for streaming and/or videoconferencing, but not both at the same time. The term Quality-of-Service (QoS) denotes quality and reliability of transmission, when packets are guaranteed to make it to the destination in a time frame.

QBone is an initiative within Internet2 to provide a testbed for new IP QoS technologies. Some new applications that will be a part of Internet2 include instrument control, scientific collaboration and virtual classrooms. Initial implementation will be implementing differentiated services, in which bandwidth levels are allocated according to priority and need, etc. In May 1998, the Internet2 QoS Working Group developed criteria that need to be a part of the QoS approach. This includes a flexible framework in which a variety of advanced applications can be run. The approach must be highly scalable, pushing forward to the network edge. Finally, the design must be interoperable. Cloud-by-cloud QoS is emphasized instead of hop-by-hop QoS and per-hop forwarding behavior is emphasized. This allows for separately engineered and administered networks using different technologies to implements QoS. Networks can maintain their autonomy, but also participate in QoS features of Internet2

QBone's initiatives also include bandwidth brokers, which will automate the configuration of edge devices. At this current time, it is done manually (http://qbone.internet2.edu/faq.shtml). Another aspect of the QBone architecture will include measurement infrastructure to measure Differentiated service performance. Differentiated service works in primarily two components (http://www.rfc-editor.org/rfc/rfc2474.txt): packet forwarding and the differential treatment that a packet may receive as decided by queue service and management disciplines. A differentiated service field is defined in the new IP header in which a codepoint is used to determine the per-hop-behavior a packet will experience at each node. Each node can change the differentiated service field.

Although QoS functionality is included in Internet2, there are still complex criteria that must be met in order for QoS to be beneficial (2). Shifman et al describe issues with QoS approaches in telemedicine, specifically in real time image analysis. They describe several QoS techniques used. Of the several that were tested, Weight Fair Queuing and Weighted Random Early Detection were determined to be most useful in telemedical applications. Weight Fair Queuing looks to share bandwidth based on priority and relative size of traffic flow. Weighted Random Early Detection reduces network congestion by dropping lower priority traffic, which is built into TCP. Although these methods may be useful, there is a need to look carefully at restricting bandwidth and at what limits.

Abilene/VBN

Abilene provides the advanced backbone network that currently connects major universities that are working in the Internet2 project. The backbone runs at 2.5 Gigabits/sec and will be upgraded to 10Gigabits/sec by the end of 2003. Here, advanced applications, including QoS standards, multicasting, IPv6 and security/authentication protocols are in testing. Abilene connects major regional gigapops. VBN also serves as a backbone.

IPv6

IPv6 is the next "version" of the Internet Protocol to replace the current version on Internet1, IPv4. The first improvement in the new version is that is increases the number of IP addresses from about 4 billion to 340 trillion. The current IPv4 IP address is a 32-bit address. The IPv6 IP address is a 128-bit address. Other improvements include routing and network auto-configuration. Some new information in the IPv6 header includes top-level, next-level, and site-level aggregation identifier. The top-level aggregation identifier allows routers to route packets properly. Next-level aggregation identifier allows an address hierarchy within an organization. Site-level aggregation works within subnetworks.

Multicasting

The current Internet1 only supports unicasting, in which the data source must create separate copies of the data for each recipient. Multicasting allows for the creation of copies of the data closest to the recipient as possible. This allows for distance learning, digital libraries, and multicasting TV-quality video to thousands throughout the Internet2 region.

APPLICATION IN MEDICINE

Internet2 poses important potentials in the area of epidemiology and public and global health medicine.

Telemedicine

Academic consultation and referral (3) could be performed especially when acting remotely. While Internet2 can supply the technical infrastructure of telemedicine, there are, however, other hindrances to complete success, including licensing across political boundaries, lack of standards, issues dealing with patient confidentiality, cost of infrastructure, and the need for technical training of support staff. The Nation Library of Medicine's Unified Medical Language System (UMLS) could possibly provide standards.

Medical records can also be transmitted across Internet2, especially medical images at high speeds. There are many obstacles to this, however, including creation of methodology, standards, and the need for business process re-engineering (4). Unfortunately, each medical institution has separate needs and standards. Templates are a solution, in which organizations can add their own needed information.

Internet2 will also allow for global collaboration in for example HIV/AIDS research. A hindrance is the availability to all countries. The limiting speed will be the lower speed. This poses a problem when two researchers are in regions that have different Internet capabilities (5). The effects from Internet2 can become negligible.

Information Resources

Internet2 cannot only provide for the faster transmission of current media, but eventually to include other forms of media. Current media include health science libraries, clinical medical libraries, and other information retrieval services. This allows for easy access to information for epidemiological purposes. However, data must be protected in order to shield a person's data from being associated to them (4).

Medical Education

Medical Education potentially looks to benefit from Internet2, especially in areas of remote learning and simulation environments where anatomy and surgery may benefit (6). In an experiment on Internet1, network latency appeared ranged from 10ms to 350ms. 360ms could severely affect productive transmission. It is estimated that delays of 70-100ms could make slow movements in simulation unstable.

Videoconferencing/Education

Although Internet2 may be able to provide the framework for synchronous videoconferencing, personnel will still be needed to work with the technology to ensure that proper information is transmitted. Internet2 will also allow for higher resolution images to be transmitted at higher rates.

FUTURE DIRECTION

Despite the eventual advances in technology, there still exist issues within the organization of medicine itself. Ultimately, if medical organizations have the desire to collaborate, then there needs to be a merging of standards and a definition of the processes involved. Another issue is with compatibility with current medical devices. Are they capable of transmitting and receiving at such high rates promised by Internet2? Servers, software and devices may eventually become the bottleneck.

Database standards will need to be considered. Current database methodology is much decentralized. In order to take advantage of Internet2, a common framework must be decided. Despite the speed and reliability of Internet2, the lack of heterogeneous integration of data and databases between organizations becomes an issue (7) XML has been used and could be a possible framework (8).

In issues with standardization, McDonald et al. argue for creating an “Open Source” environment in telemedicine (9). As medical informatics becomes more industrial, “Open Source” would allow for lower development costs and more collaborative efforts in the medical field. The resources and infrastructure needed to implement Internet2 are also very expensive. While in first world countries the implementation of Internet2 may be a very short time, it may take at least five years to implement in second world countries.

Although technology will create the medium in which people work, Grimson mentions, “Complexity increases across this spectrum and consequently so does the task of reaching an agreement. This is not surprising since at the one end we are simply dealing with data and technology, whereas at the other we are dealing with knowledge and people.”(4)

CONCLUSION

The area of Telemedicine has the potential of evolving with the newer capabilities of the Internet2, but for this to happen, users must take advantage of these features. The implications are widespread from medical education to remote patient surgery. The QoS that can be expected from the Internet2 will provide the framework required to support these new applications in a manner that all involved depend on to accomplish many critical procedures. It is obvious that as the medical area evolves Telemedicine will become a standard practice supported through the functionality of Internet2 in order to lower cost and bring experts to locations previous prohibitive.

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