Cable Modem Access to Picture Archiving and Communication System Images Using a Web Browser Over the Internet

William F. Bennett, Dimitri G. Spigos, Kuldeep V. Vaswani, and James E. Terrell

This presentation describes our experiences using a web-based viewing software and a browser to view our picture archiving and communication system (PACS) images at a remote site with cable modem-internet communications. Our testing shows that using a cable modem to access our radiology webserver produces acceptable transmission speeds to remote sites. The average time-to-display (TTD) for 16 computed tomography (CT) images on the web-based intranet system in our hospital was 7 to 8 seconds. Using a cable modem and comparable equipment at a remote site, the average TTD is 16 seconds over the internet. The TTD does not significantly change during various hours of the day. Security for our hospital-based PACS is provided by a firewall. Access through the firewall is accomplished using virtual private network (VPN) software, a secure ID, and encryption. We have found that this is a viable method for after-hours subspecialty radiology consultation.

Copyright © 2000 by W.B. Saunders Company

WEB ACCESS TO picture archiving and communications system (PACS) images has proven useful at our institution. We showed the practicality of this system in a previous publication.¹ We are currently distributing images by web access to most sites within our hospital using the hospital intranet.

Access from remote sites is more difficult. Methods to access included telephone modems, integrated services digital network (ISDN) lines, and cable modems. This report describes our experiences using cable modem access to our radiology PACS.

MATERIALS AND METHODS

Testing was performed using our previously described system.¹ This consists of a commercially available PACS (Agfa, Ridgefield Park, NJ) and their web product, Web 1000. PACS images are accessed using a browser (Netscape 4.6, Netscape Communications, Mountain View, CA). The remote site consisted of a 450-MHz Pentium II computer with 256-MByte RAM. This computer was connected to a cable modem by a 3Com Ethernet card (3Com, Santa Clara, CA). The cable modem is Motorola CyberSURFR (Motorola, Schaumburg, IL), which is a two-way communications modem connected to the Internet using standard cable connections provided by Time-Warner Communications in our area. The route from the remote site computer to the hospital web server is shown in Fig 1.

Outside access to the hospital network is restricted by a firewall. Secure access through the firewall is provided using virtual private network (VPN) software (Checkpoint Software Technologies, Redwood City, CA) and a secure ID password

system. Once connected by VPN software, browsing the hospital network acts just as if it were taking place at the hospital. The web server can then be accessed using the browser.

A series of tests were performed over an 18-hour period (7 AM to midnight). A test of the hospital connection consisted of accessing three computed tomography (CT) scans (two head CTs and one abdominal CT), three computed radiograph (CR) images (five-view C-spine, portable chest, three-view acute abdominal series) and a magnetic resonance image (MRI) of the shoulder. The time-to-display (TTD) is the time from the moment the display button is selected to the time the display of the images is complete. The TTD for each case was noted. The CTs and MRIs were viewed on a 16-on-1 format and the CRs were on a 1-on-1 format. The memory was cleared after every test group. The images were stored on the web server with a lossless wavelet compression of 3-to-1. No postserver compression was used. In addition, general Intranet traffic was evaluated by accessing an Australian site to download a 3.7-MByte file, a California site to download a 25-MByte file, and a local site to display web page with graphics and text.

RESULTS

The Internet traffic is represented by download speeds of files relative to the time of day (Fig 2). The speeds of downloading the 25-MByte file ranged from 120 kByte/s (1:44 minutes) at 7 AM EST to 30 kByte/s (5:35 minutes) at 10 PM EST. International speeds were somewhat more uniform, ranging from 14 kByte/s to 9 kByte/s. This may reflect the slow server at the file transfer protocol (FTP) site, or it may be related to multiple transmission pathways and slowdowns along the way. The speed of viewing the local web page was difficult to assess because it was very rapid and a small data set. It ranged from 1.0 to 2.0 seconds, showing no trends relative to the time of day.

The TTDs for the radiologic study access from the hospital are plotted in Fig 3. There was a minor slowdown in access during the evening hours. The average TTDs early were approximately 14 seconds for 16 cross-sectional images and approximately 16 seconds later in the day. Cross-sectional

From The Ohio State University Medical Center, Columbus, OH.

Address reprint requests to William F. Bennett, MD, S-255 Rhodes Hall, 450 West 10th Ave, Columbus, OH 43210. E-mail: bennett-1@medctr.ohio-state.edu.

Copyright © 2000 by W.B. Saunders Company

0897-1889/00/1302-1021\$10.00/0

doi:10.1053/di.2000.6836

Fig 1. Diagram of the communications pathways from the remote site to the PACS in the hospital.

image TTDs ranged from a low of 12.2 seconds to a high of 18.9 seconds. The average TTDs for the CR images were approximately 17 seconds early and 23 seconds later, and ranged from 13.9 seconds to 33.8 seconds. The latter number may have been aberrant, as most of the other times were less than 25 seconds.

DISCUSSION

With the advent of PACS and the high-speed networks in hospitals, the distribution of images within the institution is becoming easier. We are

currently allowing access to PACS images in all areas of the hospital connected to the backbone using a web-server distribution of images. In a previous report, we showed that with a moderate-speed computer (at that time 200 MHz) and at least 128 MByte of RAM, the web access to images was a viable method of distribution. The challenge now becomes how to gain access to images from a remote site. As a department, we would like to provide subspecialty expertise after hours without the necessity of the subspecialist coming to the hospital for this service. Remote site viewing is desirable.

Fig 2. Chart showing the decrease in the speed of downloading files relative to the time of day. The California file is 25 MByte and the Australia file is 3.7 MByte.

Fig 3. Chart showing the slight increase of the TTD of image files from the PACS relative to the time of day. Data for cross-sectional and CR images are separated.

Phone lines with 28.8-kbps or 56-kbps modems are unacceptably slow. We previously showed that transmission times of 28.8 kbps were excessive. The average TTD for CR was 6.78 minutes without compression and 1.3 minutes with compression. The average TTD for cross-sectional images without compression was 9.8 minutes and with compression, 3.6 minutes. Viewing cases from home was tedious.

There is some improvement speed with an ISDN line running at 128 kbps, but it only reduces the transmission by a factor of four relative to a 28.8-kbps modem. The cost of the ISDN line is approximately \$50 per month. We do not have experience with this method of transmission.

The cable modem seems an excellent method of transmission. Theoretically, it can reach speeds up to 10 mbps or 1.25 MByte/s. Realistically, we have seen speeds of 2 mbps or 250 KByte/s, which is about 35 times faster than the optimal transmission speeds of a 56-kbps modem. The cost of cable modem access is approximately \$40 per month.

As shown by the data presented here, the overall average TTD is 14.9 seconds for 16 cross-sectional images and 19.7 seconds for CR. This compares favorably with 7.4 seconds and 6.7 seconds, respectively, for a comparable computer system connected directly to the network with an Ethernet connection. Some of the speeds realized in our situation are related to the connections that are available in our community. As shown in Fig 1, the cable modem at the remote site is connected directly to the main hub station, which is then, in

turn, connected by a high-speed connection (fiber-distributed data interface [FDDI] link, 100 mbps) to the university. This allows excellent transmission speeds at almost anytime.

Pundits have maintained that as Internet traffic increases late in the day, the speed of access to the hospital will decline dramatically. The data presented here suggest otherwise. There is only a 2- to 5-second increase in TTD during the hours when traffic is highest (evening). This may be explained by the optimal situation present at our institution. However, it does not account for the local traffic in the area surrounding the remote site (neighbors). Another factor may be the use of VPN software. This is mainly used for security, but has the added benefit of creating a pipeline through the Internet cloud from the remote site to the hospital. This pipeline allows for stable transmission speeds and provides a stable bandwidth for the connection.

One disadvantage of cable modem compared with direct telephone connections is security. While connected to the Internet, the remote computer is a node on a huge network, vulnerable to access by hackers. Information transmitted is also subject to eavesdropping. Information services (IS) departments will necessarily have concerns about security. Not only are the images of patients vulnerable, but the access through the hospital firewall can be compromised by an intruder riding piggyback through the firewall while the remote site is connected. This is accomplished by accessing the remote computer and hijacking the session. Al-

though the probability of this happening is low, the consequences are extremely serious.

Currently, the VPN software is our only security. Using this software as a conduit and a secure ID password system, the risk of passing through the firewall has been reduced. Unfortunately, the remote site computer is still vulnerable. Personal firewall programs that are available may solve this problem. On the horizon, our VPN software will be

able to determine if the signals coming through the conduit are originating with the remote computer, further protecting the connection.

Several members of our faculty are now using the cable modem for access to PACS from their homes. There have been instances where a consultation has been performed by the specialist at home after hours, providing additional quality of interpretation and benefitting our patients.

REFERENCES

1. Bennett WF, Spigos DG, Tzalonikou MT: Web-based viewing of picture archiving and communications systems images—Part I: Optimal personal computer configuration. *J Digit Imaging* 12:112-115, 1999 (suppl 1)