Distributing Digital Imaging and Communications in Medicine Data and Optimizing Access Over Satellite Networks

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To improve radiology access to full uncompressed Digital Imaging and Communications in Medicine (DICOM) data sets, we evaluated satellite access to a DICOM server. Radiologists' home computers were connected by satellite to a Medweb DICOM server (Medweb, San Francisco, CA). A 10.2-kb data set containing a 19-image head computed tomography (CT) scan was transferred using DirecPC (Hughes Electronics Corp, Arlington, VA) at three different times of the day; 6 AM, 3 PM, and 8 PM. The average transfer time for all 19 images from the DICOM server was 4 minutes and 17 seconds (257 seconds). The slowest transfer rate of 670 seconds (121 kbps) was obtained at 8 PM. The best transfer rate of 2 minutes, 54 seconds (467 kbps) was obtained at 6 AM. The full 16-bit DICOM images were viewed with bone, brain, and soft tissue windows. The Medweb plug-in viewer loaded the first image within 30 seconds of selecting the case for satellite transfer. In conclusion, satellite internet transfer of radiology studies is suitable for timely review of full DICOM data sets and can expand the range of teleradiology consultation.

WE PRESENT an evaluation of a commercially available satellite internet service, DirecPC (Hughes Electronics Corp, Arlington, VA), for transfer of medical images while retaining the full windowing and leveling that was available with the original images. DirecPC advertises a rate of 400+ kbps with surge rates of up to 700+ kbps. These rates are seven times faster than the standard 56-kbps modem, and three to five times faster than an Integrated Services Digital Network (ISDN) service.

METHODS

Images in Digital Imaging and Communications in Medicine (DICOM)-3 format were collected, compressed, and stored using Medweb (Medweb, San Francisco, CA) software. A 333-MHz Pentium (Intel Corp, Santa Clara, CA) processor with 128 MB of RAM using the Linux operating system (Linus Torvalds, University of Finland, Helsinki) was used for the Medweb server. Switched 10-Mbs internet service was used between all servers and workstations internal to the hospital. A T1 line provides 1.1-Mbs service to the internet. Images were viewed using the Medweb plug-in and a Netscape Web browser on a Pentium PC using the Windows 98 (Microsoft, Redmond, WA) operating system.

For home internet access, we purchased a DirecPC satellite system from a local electronics chain. The satellite network system uses the same type of minidish antenna typical of direct-broadcast television. The only major requirement is having a clear line of sight to the south to access the satellite signal at about 45 degrees above the horizon. Outgoing web requests use a modem and large downloads return through the 21-inch elliptical satellite dish.

Table 1. Transfer Rates in Seconds for 10.2-kb Data Set

Time	Thursday	Friday	Saturday	Mean
6 AM	185	182	174	180
3 PM	183	205	185	191
8 PM	670	305	232	402
Mean	346	231	197	257

Transfer rates were determined using a 10.2-kb 19-image head computed tomography (CT) test file that was transferred to the home personal computer (PC) from the Medweb server via the DirecPC system. Transfer rates were determined after a network connection had been established on the home PC. Transfer timing began when the examination was selected and ended when the final image appeared. Timing data was used only if the complete study was transferred; data from transfers that were interrupted or "timed out" were discarded. Test data was transferred at 6 AM, 3 PM, and 8 PM central time on Thursday through Saturday in the last week of August 1998.

RESULTS

Transfer rates to the home computer are shown in Table 1. Average transfer time for all 19 images from the Medweb server was 4 minutes and 17 seconds (257 seconds). This corresponds to a transfer rate of 316 kbps (10,162,176 bytes × 8-bits/byte/257 s). Note that this is a lower rate than the manufacturer's advertised 400 kbps. The full 16-bit DICOM images were viewed with bone, brain, and soft tissue windows. The Medweb plug-in viewer loaded the first image within 30 seconds of selecting the case for satellite transfer, allowing immediate review of the images.

Our mean rate of 316 kbps is less than the rate of 560 kbps reported for cable modems.[1] The slowest transfer rate of 11 minutes and 10 seconds (670

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Supported in part by Medweb, Inc, Maitland, FL.

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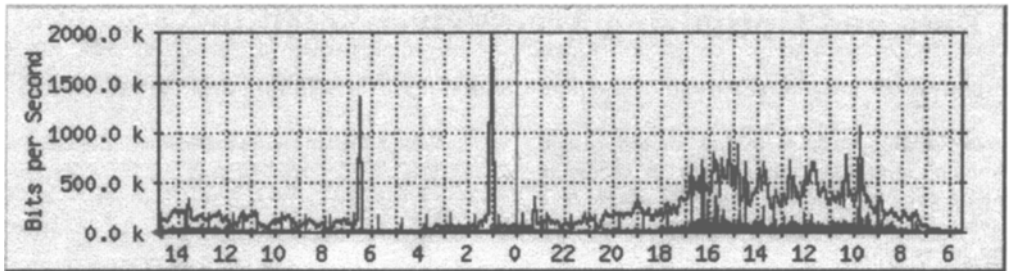

Fig 1. Daily graph (5-minute average) network traffic statistics for UT Houston Radiology Department from 6 AM Friday 8/28 to 2 PM Sat 8/29, 1998. Max in: 733.7 kbps (0.7%); average in: 71.1 kbps (0.1%); current in: 210.9 kbps (0.2%). Max Out: 1,963.7 kbps (2.0%); average out: 200.7 kbps (0.2%); current out: 147.9 kbps (0.1%); Lower line, incoming traffic in bits per second; upper line, outgoing traffic in bits per second.

seconds) was at 8 PM. The fastest file transfer performance was 2 minutes, 54 seconds (467 kbps). This time was attained at 6 AM on Saturday, when local internet traffic was minimal.

DISCUSSION

The satellite connection has three useful features when compared with other methods: simple configuration, relatively high data transfers rates, and relatively low costs. In our studies, we found that the transfer rate of the satellite system is more than adequate for small data sets such as head CT studies. We have also successfully transferred magnetic resonance images and digital angiography using the satellite connection. Our data suggest that the variations in transfer rates are a function of the time of day, being slower during periods of peak network usage and faster during "off-hours." In addition the T1 service line carries all network traffic between the hospital and the internet and may represent a significant rate-limiting factor for data transfer.

CONCLUSION

Our results demonstrate that satellite Internet access is a significant improvement compared to a modem using plain-old telephone services (POTS). The potential speed of satellite connections is limited by internet traffic especially during peak usage times. Satellite access offers an inexpensive method for connecting home or remote offices to the internet with a much improved transfer rate. The increased speed makes a larger range of teleradiology applications practical.

REFERENCE

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