Getting the Picture: When the Wide-Band Telecommunications Infrastructure Will Be Widely Available

Terry Miller

A SUBSTANTIAL number of papers presented at the 1997 SCAR meeting in Rochester dealt with the subject of file or data compression. Topics included the best compression and decompression methods, lossless file compression, the effects of compression on download times and storage, and FDA acceptance of compression. All of these topics were dealt with in considerable depth.

However, compression is rapidly becoming a non-issue. This paper deals with the recent advances in network design that render the subject of compression moot.

The heavy interest in file compression is based on the fact that until recently, it offered two important benefits that support PACS implementation:

1. Compressed files require less memory for storage. Because digital images require a tremendous amount of storage space, this helped address the problems inherent with maintaining a "filmless" radiology department.
2. Smaller files can be transmitted more quickly through data networks and telephone lines.

However, file compression has two major downsides:

1. Compression requires processor power and processing time, and
2. Any significant level of compression (greater than 3:1) causes loss of data, which essentially defeats the purpose of storing it.

The bottom line is, when files are compressed enough to reduce the amount of storage space or download time significantly enough to gain any real benefit, enough loss occurs to render the file of limited value.

Clearly, compression should be avoided if at all possible. The good news is that the reasons to

compress files—limited memory and reduced download time—are rapidly disappearing:

1. **Memory.** The cost of memory is decreasing at a rapid rate. The cost of RAM has decreased by 80% over the last five years, while hard drive memory cost has decreased over 90%. The cost of memory is simply decreasing faster than compression technology is being developed.
2. **Download Time.** File download times are decreasing as falling "bandwidth-per-dollar" costs make the deployment of faster networks and communications protocols financially feasible.

Faster networks and network services, which telephone companies around the world are currently rolling out, are eliminating the need for file compression.

THE CHALLENGE PACS PRESENTS TO A CONVENTIONAL NETWORK

Any discussion of PACS implementation today must include consideration of and legitimate concern over the impact PACS traffic will have on the facility's local area network (LAN) and wide area network (WAN). There is genuine cause for concern. Files for routine radiological studies are frequently 200 to 300 times larger than the size most networks are accustomed to carrying. A full PACS implementation—a true conversion to filmless imaging—can easily increase network traffic by a factor of 20 to 30 times above current levels.

Popular networking protocols—including 10 Mbps and 100 Mbps Ethernet, token ring, FDDI, and frame relay, even the emerging standard for "Gigabit-speed" Ethernet—all operate on the principle of shared bandwidth.

With shared bandwidth, a number of users are connected to and share the use of a common network. If the network is busy, the user waits for the network to be free before broadcasting information. If two users broadcast information at the same time, the information is lost, and both end up waiting for the network to be free. Such are the "rules of the road" that allow shared bandwidth networks to operate.

From Gene Burton and Associates, Franklin, TN.

Address reprint requests to M. Terry Miller, E.E., Vice President, Communications Planning, Gene Burton & Associates, 118 Seaboard Lane, Suite 100, Franklin, Tennessee 37067.

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Although shared bandwidth may not present a problem for routine data and text traffic, it becomes a bottleneck for files of the immense sizes that are routine for imaging traffic.

Increasingly, facilities contemplating PACS implementations are turning to ATM (Asynchronous Transfer Mode) switching to meet the extreme demands imaging traffic will place on their networks. Unlike protocols that operate on the principle of shared bandwidth, ATM is a switched environment. The shared bandwidth system broadcasts traffic through a shared network in hopes that the network is free. When the network is busy, the system detects the "collision" of files, and re-broadcasts later. In contrast, ATM provides a direct connection—free from other traffic—which remains open for the length of time it takes for complete transfer of the desired information.

Compare ATM to a modern telephone call. When you make a call, you dial another party and establish a private circuit for the duration of your conversation. Shared bandwidth networks are more similar to old-fashioned party lines, where callers waited for the line to be free and hoped no one else would pick up their phone and interrupt the conversation.

The vast majority of healthcare facilities today rely on 10 Mbs Ethernet as their primary LAN protocol. In most cases, 10 Mbs Ethernet is more than adequate for the routine data queries, orders, lab results, e-mail, spreadsheets, text files and other traffic which travels through them. But, a routine imaging study—a 32-Mb chest x-ray, for example—will transmit very slowly over 10 Mbs Ethernet.

To make matters worse, Ethernet is inherently inefficient. Overhead represents a minimum of 40% of each data packet. Collision detection, wait times, and rebroadcast times typically limit real Ethernet throughput to less than 20% of nominal network speed. Hence, the actual throughput for a 10 Mbs Ethernet is typically less than 2 Mbs.

Network traffic to remote facilities is typically routed over telephone company lines, such as 56 Kbs fractional T1 lines, full T1 circuits (ie, 1.54 Mbs), and various frame relay services. These smaller bandwidth circuits present additional bottlenecks for PACS traffic.

In many facilities, existing networks are so limited that PACS implementation has required construction of a second parallel network solely for the purpose of handling the imaging traffic. Con-

struction of a second parallel network requires additional investment and support, and generally is limited to serving as few workstation locations as possible, which severely limits the system's operational effectiveness.

THE SOLUTION: INEXPENSIVE WIDE-BAND COMMUNICATIONS

Clearly, any PACS implementation plan must include evaluation of the facility's network. And many—probably most—implementation plans will include either substantial network upgrades or complete network replacement.

ATM is the emerging standard for high-capacity PACS networks. ATM is a switched environment capable of providing multiple high-bandwidth private connections when and where needed without affecting throughput of other network traffic. During ATM network design, the amount of available bandwidth is tailored for the expected activities of each workstation. As a result, diagnostic PACS workstations are guaranteed adequate bandwidth to quickly access multiple images or studies, while less frequently used review workstations are provided with adequate (though perhaps slightly slower) download time.

ATM is also emerging as the worldwide standard for telecommunications. Conversion of AT&T's world-wide network to ATM was completed in 1997. Other long-distance and local telephone companies are starting to roll out local ATM service.

One additional benefit of the ATM protocol is the flexibility to handle real-time communications, including voice and video traffic. Although slight delays of fractions of a second might not be noticed with routine data or PACS traffic, these delays would be devastating to the continuity of a telephone conversation or video presentation. Because of its private switched connection nature and extreme bandwidth handling capacity, a single ATM network can support telephone and video as well as data and PACS.

POSTERS

- Sample Network Layouts for Multi-site PACS Implementations
- Comparative Download Times for PACS Traffic through Various Network Protocols
- Roll-Out Schedules for Switched ATM Services by Local Telephone Companies