# Managing Efficient Medical Image Transfers Over Public Network Connections

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Medical image transmission over Internet connections presents unique challenges for institutions in light of HIPAA requirements for maintaining the privacy of patients. The requirements of HIPAA make the unauthorized disclosure of patient health information (PHI) a criminal offense. This means the first concern of many medical institutions regarding moving medical images over the Internet has become security. This reaction is not in the spirit of HIPAA. Patient care must remain paramount. This paper will attempt to show several options for achieving high data transmission security without compromising patient care.

The simplest approach to moving data across unsecure connections is to send the information through DICOM via a Storage Service Class pair. This consists of a transmit side (Storage Service Class User, SSCU, usually a modality) and a receive side (Storage Service Class Provider, SSCP, usually a PACS server or WorkStation). Although this is the simplest approach, in most cases, it is not efficient or secure. Even though the DICOM standard includes both data compression and encryption, few modality manufactures have implemented these features. Older modalities are highly unlikely to have either feature. Unless both the SSCU and SSCP have encryption capabilities, this method could permit a violation of the confidentiality aspect of the HIPAA law.

Most institutions have overcome this problem by using Virtual Private Network (VPN) connections between sites to add a secure layer to the communications. This approach overcomes the encryption problem but it is at the cost of slower response times in critical situations. Since most modalities offer no compression options, images are transmitted with no compression. Even when lossless compression is available, the compression ratios are minimal because of the nature of medical image data. Most modalities, in particular the modalities that produce the major share of images (CT and MRI), produce 12-bit and higher bit-depth images. This data will typically only compress at a ratio of about 1.5:1. This means that a CT case containing 900 images will be about 460,800,000 bytes of data before compression. Over a T-1 connection (1.544 megabits per second or 193,000 bytes per second), the minimum data transmission time for uncompressed data will be approximately 2800 seconds or 46 minutes. This number includes some overhead (20%) for network transfers. If the data has lossless compression applied, the time can be reduced to about 31 minutes. This means the turn-around time to receive a report in an emergency situation is at best 31 minutes and at most 46 minutes plus the time needed for the radiologist to read and dictate the study. As an example, most of the after-hours reading services guarantee a report within 30 minutes, “AFTER ALL of the images are received”. The total turn-around time is then between 61 minutes and an hour and 16 minutes.

One of the major disadvantages of VPN connections is the need for higher levels of technical network expertise to create and support the connections. All of the modalities must be programmed for each destination. So, a change in after-hours reading service requires all modalities to be re-programmed. Also, when an institution changes Internet Service Providers or the reading service, the VPN connections must be reconfigured at both ends to accommodate the IP address change. If multiple VPNs are involved, the support problems are magnified.

A third approach to the problem of moving images over a public network is to use an intermediate system to add compression to the images before sending the data over the VPN connection. This approach also has the advantage of simplifying the network configuration requirements for the imaging modalities since the intermediate system, whether a workstation or a gateway, resides on the same local network as the modalities so no routing information has to be configured. This means that changes to the ISP or reading service don't require modality reconfiguration. In most instances, this is accomplished using a DICOM workstation or PACS server to receive the images from the modalities and adding a second procedural step of retransmitting the images from the workstation or server to the remote location over the secure connection. If this is done manually, much of the advantage of compression is wasted by the added procedural step. Even when this step is automated, there is still usually a delay while the workstation receives all the images before beginning the retransmission.

A relatively new method is the use of DICOM Routers to retransmit images from the modalities. These routers offer a range of features. Some are similar to the workstation approach without the need for user intervention or the requirement to have all the images before starting the retransmission. Others offer various levels of compression from lossless to varying types of lossy wavelet or JPEG2000 compression. Still others offer specialized features such as institution name aliasing, to replace the DICOM Institution Name tag with a consistent value in all images passing through the router. This simplifies the sorting of images on PACS servers and workstations at the receive end. Some also have encryption capabilities to preclude the need for VPNs.

Wavelet and JPEG2000 image compression offer compression ratios from lossless as mentioned above to lossy ratios up to 10:1 for CT images. The practical range of lossy ratios can vary depending on the modality and type of data in the image. Typically, a maximum useable ratio for CTs is between 7:1 and 8:1. If a ratio of only 6:1 is attained for the case above, the transmission time would be reduced from 2800 seconds to 460 seconds or 7.5 minutes (an 84% reduction). Adding the report guarantee above, the turn-around time goes from between 61 minutes and 1 hour 16 minutes, down to 37.5 minutes. If the reporting time is less than 30 minutes, the advantage is even greater. For a 5 minute report time the turn-around is reduced from as much as 51 minutes down to 12.5 minutes (a 75% reduction). Obviously, this is a huge reduction in time that could spell the difference between life and death for a patient.