Practical Considerations for Picture Archiving and Communications Systems Over the Enterprise Network

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GENE BURTON and Associates (GB&A) has been involved in picture archiving and communication systems (PACS) development and network planning since the inception of PACS. During the mid-1980s, GB&A consultants participated in early remote radiology network development projects with AT&T. A GB&A team developed a model for a remote radiology reading business during the early 1990s. Individually and as a group, GB&A's medical equipment and communications team has either worked on or completed more than 20 PACS, Minim-PACS, and PACS network projects during GB&A's 11 years in healthcare equipment consulting. Current PACS involvement is focused on coordinated medical equipment, communications, and network planning activities.

RECENT DEVELOPMENTS

Over the past several years, we have observed a near convergence of medical equipment, radiology, and computer technology. Within the past 10 years, medical and radiologic equipment has become computerized. Today's imaging systems are processor-based, software-controlled, digital, and interconnected.

Development of the Digital Imaging and Communications in Medicine (DICOM) standards and increased compliance by the manufacturers with industry standard communication protocols have resulted in PACS systems capable of "riding" on a hospital's computer network. However, few hospital networks can accommodate the immense traffic load presented by a PACS system.

We offer our observations—and some "tips from the trenches"—about the real-life challenges of implementing a PACS on a hospital computer network. In addition, we include strategies for planning and achieving long-term solutions to the issues that inevitably arise.

WHY PACS PLANNING SHOULD ALWAYS INCLUDE INFORMATION SYSTEMS

Information Systems should be a primary part of PACS planning from the start of the planning process through evaluation and selection, because a PACS is an enterprise-wide system. Although its nucleus may be the Radiology Department, its scope extends far beyond this department. In fact, the system's greatest financial benefits are experienced outside the Radiology Department, by the staffs of the clinical departments and medical units connected to the system, as well as any remote diagnostic and treatment centers, family practice clinics, and feeder hospitals that are also served by the PACS.

Once connected, all users—whether in the Critical Care, Surgery, or Emergency departments, or patient care units—have instant access to radiology images without having to request films and wait for their delivery. The PACS eliminates the need to travel to the Imaging Department to view images on proprietary workstations tied a single modality.

Remote clinics and feeder hospitals can share images with other facilities and send images to remote reading sites for primary and secondary over-read. Image mobility within the system permits the development of more specialties within a radiology group, as images can be referred to a specific specialist regardless of where his or her office is located. When a consultation is desired, neurologic studies can be routed to the neuroradiology specialist for interpretation, cardiac studies to the cardiology specialist, and so on.

Other advantages include on-call schedules, as radiologists at main facilities can easily cover for smaller departments in remote feeder hospitals during hours when the staff radiologist is off-duty.

To provide all of these operational advantages, the PACS must be connected throughout the delivery system. Healthcare delivery systems have two options: a separate PACS network can be extended to all departments and facilities, essentially duplicating the hospital's data network, or the hospital's existing data network can be upgraded to carry PACS traffic. The second option is much more economical.

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EQUIPMENT SELECTION AND LOCATION

Another important reason for including Information Systems in the PACS planning, evaluation, and selection process is that a PACS is composed of computer equipment.

A typical PACS system consists of the same file servers, workstations, mass storage devices, scanners and printers, and network hardware, operating systems, and applications software that comprise a computer system. No one in the hospital is more familiar with the administration and support of a computer system than the Information Systems staff. And no environment offers a better home base for the PACS equipment than the hospital's data center.

While operational administration of the PACS system may reside in the Radiology Department, system administration is always the domain of Information Systems.

PACS INSTALLATION AND NETWORK INTERFACES

To operate efficiently, the PACS system must interface with the hospital information system (HIS), radiology information system (RIS), and scheduling system. PACS vendors may offer to write the necessary interfaces, typically for an additional fee, but they often go only halfway. The HIS, RIS, and scheduling system require equally complex and costly interfaces to accommodate the PACS. To proceed with PACS implementation without a clear understanding of the interface requirements and related costs is risky at best.

TOOLS FOR PREDICTING PACS NETWORK TRAFFIC

Digital images create huge files. As a result, adding PACS to the hospital's network can easily increase overall network traffic by a multiple of hundreds or even thousands. To ensure the network can accommodate the dramatic increase in traffic, the Information Systems staff needs an accurate forecast of PACS network traffic and network design.

We recommend using the following tools to estimate network traffic based on the key factors affecting the traffic level:

- the hospital's operational model
- the imaging department caseload and workflow

- the number and size of the facilities served by the system
- the number and types of modalities connected
- vendors and equipment used
- projected growth over the system life.

Elements of the hospital's operational model include:

- services offered
- caseload
- strategic alliances
- competition
- relationships with group practices
- any other elements that might affect case load and case mix.

Imaging department caseload analysis includes:

- the types and quantities of studies
- the number of images typically included in each type of study
- image file size generated by each modality
- number of reference studies requested by the radiologist for each study type
- number of times each study will pass through the network from initial capture through final archive.

Imaging department workflow analysis involves determining the process flow and peak busy hours for each study type.

With this data, the PACS planner can predict peak network loads and when they will occur. Network elements can be properly sized to handle PACS traffic during peak times. Network segments can be properly sized to support traffic demands of each department and facility served. It is neither practical nor economical to design equally capable network segments serving a family practice clinic and a remote imaging center, for example. Traffic loads for these facilities will be dramatically different, and network design should take all of these variables into account.

ANALYSIS OF CURRENTLY AVAILABLE NETWORK PROTOCOLS

Because data files representing digital images are so large, a single study will typically contribute 300 to 400 MB of network traffic. Here's how:

A two-view chest study, for example, may generate a 32-MB file. This file may travel through the network five or six times as it travels from modality to review station, short-term archive, primary reading station, clinical review station, and finally to long-term archive. In addition, the radiologist will

typically access and review two or three archived studies for comparison, and may send all of these, along with the new study, for review by the clinician.

Many hospital networks do not see that much traffic in an hour. And most hospital networks currently deliver 10-MB Ethernet to the desktop personal computer (PC) workstation. For most applications, 10-MB Ethernet is more than adequate, but it is clearly not adequate for PACS traffic.

The clinical nature of PACS presents an added challenge for the network designer. Once PACS is implemented, the network becomes a clinical network carrying real-time clinical data. Tolerance for system faults decreases dramatically. The system simply must work, as its functioning is now an essential component of timely diagnosis and treatment.

The challenge for the network designer is to structure a single network capable of delivering PACS traffic and routine network traffic quickly, economically, efficiently, and fault-free. This is no small task.

Different network types and topologies vary significantly in capabilities. These differences include speed, but other key variables, such as flexibility, cost, and fault tolerance, are also important. Based on our experience, a full PACS implementation, except at the very smallest of facilities, requires an ATM backbone and ATM WAN.

An Ethernet network of any speed is simply too "flat." These networks offer too little flexibility to address either the traffic capacity or flexibility required once PACS is part of the network. Even switched Ethernet remains too much of a "one size fits all" approach to satisfy the variables encountered with PACS.

In contrast to Ethernet, ATM offers the opportunity to scale bandwidth and redundancy for each backbone segment and each workstation port, depending on the application.

INCORPORATING LEGACY NETWORKS AND EQUIPMENT

However, conversion to ATM (or "giga-speed" Ethernet) backbone does not necessarily require replacement of all computer hardware and cabling. Both are backbone topologies and can be structured

as hybrid systems, permitting continued use of existing 10-MB Ethernet workstation equipment and file servers. In fact, the Digital Imaging and Communications in Medicine (DICOM) standard actually calls for 10-MB Ethernet modality data output, necessitating a hybrid network approach.

And, even for a new system, the hybrid approach makes sense. The vast majority of network users will never require bandwidth faster than 10-MB Ethernet. There is simply no need to spend the money to provide faster connection everywhere.

MEETING TODAY'S NEEDS/PLANNING FOR THE FUTURE/STAYING ON BUDGET

One advantage of the ATM backbone strategy is its scalability. Inherent in the ATM architecture is the ability to share the load through multiple circuits. This is particularly valuable for seamless system growth. If data over a segment of the network increase as a result of increased case load or connection of additional modalities or workstations, additional parallel circuits can be installed, and the ATM operating system will automatically find the best routing pattern, using the new resource most efficiently. Similarly, if a segment or circuit fails, the ATM operating system automatically finds the most efficient alternate routing, and re-balances loads on related segments.

Load-sharing with ATM works equally well for WAN connections. Additional bandwidth requirements, which occur as remote facilities increase caseload or add modalities, can be satisfied by connecting additional T1, DS3, or larger circuits without the additional expense and complexity of reverse multiplexing.

REDUNDANCY, REDUNDANCY, REDUNDANCY

Once the network starts carrying PACS traffic, it becomes part of a clinical information system, with the heavy obligation of delivering fault-free operation. Redundancy thus becomes an essential part of clinical network planning. Designing alternate path routing within the facility involves both network hardware and cabling. Backbone cable segments should be protected in conduit, and alternate backbone pathways should be planned through other cable risers. Every network hub or closet should be connected to at least two other hubs or closets. In addition, network hardware should be designed

with automatic “fall back” to alternate routing if any cable segment or network hardware element fails.

Outside the hospital, connections to remote facilities should follow diverse routing through telephone company connections, depending on the type of traffic. The availability of “self-healing ring” services should be explored and evaluated. In many cases, grouping the voice, data, video, and other circuits hospitals typically use on a single self-healing ring will provide greater bandwidth and redundancy at a lower overall monthly cost. We have enabled several clients to achieve substantial savings simply by helping them to group and

purchase telephone and data connections more efficiently.

CONCLUSIONS

Network design is a vital element of any PACS implementation. The involvement of Information Systems in PACS planning and implementation is essential to the long-term success of the PACS’s implementation and operation.

Radiology equipment and PACS systems are now computer systems. Drawing on the capabilities of the staff in your organization who have computer expertise is essential to the long-term success of PACS implementation and operation.