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Planning for PACS
Imaging Upgrades Present Infrastructure Challenges

By Steve Wagner

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In recent years, the number of picture archiving and communication systems (PACS) installed at large medical centers, hospitals, clinics and other health facilities has grown dramatically. And why not? The ability to transfer both radiographic images and alphanumeric records between facilities and among clinicians also has changed dramatically.

No longer are records walked between departments, courier-delivered to referring physicians, or flown overnight to tertiary-care facilities. Instead, they're transmitted digitally and instantaneously via PACS. In an instant, in the time it takes to boot up a laptop or touch-control a handheld PC, diagnostic images can appear anywhere in a hospital or systemwide enterprise.

At new hospitals, PACS installations are seamless, initiated during design and completed during regular construction. At existing facilities, infrastructure changes ranging from modest to extensive are required. In both instances, the cost and inconvenience are justified by the end result: If planned correctly, PACS installations can pay for themselves within a few years.

To understand this phenomenon, PACS itself must be understood. A PACS is an integrated system of digital products and technology that enables the acquisition, storage, retrieval and display of radiographic images. The accelerating growth of PACS is largely due to the advancement of communication standards, decreased cost, open platforms and a phased implementation methodology.

Evolving since the early 1980s, PACS has grown to become a mainstream phenomenon. Primary-care facilities, including medical centers, large and small hospitals and other entities, are scrambling to hop on board. In fact, domestic PACS and teleradiology markets are expected to generate sales exceeding $1 billion in 2007, more than twice the total reported in 2000, according to health care analyst Frost & Sullivan.

"In the future, all health care organizations in the United States will have PACS," says D. Kirk Hamilton, a longtime architect and founding principal with Watkins Hamilton Ross Architects, Houston, which specializes in health care construction.

Today, the key components of PACS are modality (magnetic resonance imaging, computed tomography,

positron emission tomography, X-ray and nuclear medicine) interfaces, a network backbone, a database management system, an image management system, a long-term archive, and diagnostic and clinical workstations. Also, PACS must interface with the hospital information system and radiology information system. A capable Web server, which allows Internet access, is crucial.

Add it up and the bottom line is a change in health facility infrastructure that is precise, far-reaching and effectual.

More space, and everything else

"It's clearly easier to do a PACS installation if all the features of it can be built into a new project," Hamilton says. "It's much easier than trying to weave a system into a building that hasn't been designed for that in the first place."

According to Hamilton, a common misconception is that less space is needed in the hospital because PACS facilitates the digital rather than physical storage and transmission of images. The thinking goes that PACS will cause large storage rooms to disappear and, along with them, bulky film processors. Additionally, no longer will radiologists gather en masse in rooms filled with viewboxes. The maze of hallways where clinicians once bustled with images in tow can be whittled.

Quite the contrary. With PACS, reading rooms where viewboxes once lay flat against walls are now filled with workstations and large monitors, where
radiologists read in small groups to conveniently solicit opinions from colleagues. Hallways once clear of impediments are sprinkled with computer terminals. In some instances, data rooms must be expanded or beefed up to accommodate PACS servers.

Finally, during PACS phase-in, older film-based equipment often must be retained at least temporarily, resulting in even greater space constraints. After all, archived nondigital, or legacy, images cannot be read using state-of-the-art digital equipment.

However, while space issues are paramount in the eyes of architects, deeper infrastructure requirements also persist. These include:

- **Electrical.** To support the influx of PCs required to view images and read data, myriad electrical circuits and outlets must be installed. Usually, existing 110-volt power is sufficient. However, in data rooms, where 220-volt power is required, electrical capabilities must be strengthened to accommodate PACS and data server requirements.
- **Cable.** Because digital information is transmitted using cable, drops must be added wherever terminals are installed. In some instances, extensive recabling is required. Cable reconfiguration often can be achieved at the cable closets. Occasionally, however, recabling is required along ceilings. Category 5e cable has the bandwidth required to meet most PACS needs and is now the standard. However, category 6 cable is just becoming available and, as image file sizes grow, the

demand for category 6 cable should increase as well.

- **Cooling.** Computer monitors generate considerable heat. When scores or even hundreds of terminals are added to a health care facility, air conditioning systems often must be modified to keep rooms, departments and entire facilities comfortable.
- **Lighting.** Reading rooms are most acutely affected. Computer monitors have largely replaced wall-mounted viewboxes and can reflect glare from yet-to-be-replaced viewboxes, overhead lights and nearby monitors. The installation of workstations in circular arrangements helps eliminate this. Lighting should be incandescent, recessed and controlled by a dimmer.

Planning required

"If I'm a facility manager, these are some of the things I need to plan for," says Don McKahan of McKahan Planning Group, a Del Mar, Calif., facility planning firm.

One example of thorough planning is Tseung Kwan O Hospital, in Hong Kong, which opened in 2000. There, gigabit ethernet was used for both the hospital backbone and within the radiology department. For image distribution outside the department, 100 megabits per second fast ethernet was used.

The hospital is intraconnected via a Web server. An on-call radiologist is connected using an integrated services digital network service, adding a layer of security and little extra cost compared with widely used broadband virtual private network.

Closer to home, the PACS installation at Long Beach Memorial Medical Center (LBMMC) in Long Beach, Calif., evolved over time. The hospital installed a computed radiography (CR) system in its ICU in 1996, with a remote capability in radiology. Remote viewing was added at the Memorial Heart Institute two years later. CR technology was then added to both the ED and adult radiology. A year later, images from ultrasound were being transmitted to the neonatal ICU. Finally, a PACS selection team was formed in 2001 and a full-blown PACS installed in 2002.

"We really added our PACS system over time until the last few years, when a major portion was added," says Eric Aune, PACS administrator at LBMMC. That clearly made things easier.

"We already had the infrastructure in place by the time the new PACS system was installed," says Ron Morte, manager of technical services. "We set up a virtual local area network, but the cable plans, core switches and edge switches already were in place. The network backbone was there."

It's not always that easy. In a hypothetical walk-through, Henri "Rik" Primo, manager of marketing and strategic relationships for PACS vendor Siemens Medical Solutions, identified several areas within a hospital where infrastructure issues come into play.

"If you look around you'll see doctors and nurses who, instead of going to a lightbox, are holding films up to a ceiling light, the sun or whatever they can find," Primo says. "That's because there is no lightbox

where they want it. Static PCs are great, but it might be wise to look into making the infrastructure changes to accommodate a mobile computing platform, such as handheld PCs."

That requires network drops to mobile access points (MAPs), which are typically placed in the ceiling. Wiring must be carefully done so as not to interfere with wireless applications running on the same frequency. MAPs may be placed at least every 100 feet to maintain transmit rates.

Other infrastructure considerations, according to Primo:

- In surgery suites, wiring and other connectivity must adhere to special safety standards, as flammable gases often are used. Leakage cannot exceed 5 microamps, meaning PCs must be supported by isolation transformers (ITs). ITs often are installed in nearby power cabinets.
- In operating theaters, up to 25 PCs may be in play at once. With 10 or more theaters in some hospitals, the prospects for a power overload are significant. Scores of electrical circuits may need to be added.
- To accommodate the transfer of images, the hospital network must be upgraded to 100-megabit capacity. In some hospitals the backbone must be upgraded to gigabit technology. This can be done by adding cable circuits in the ceiling.
- A 600-watt PC can emit heat comparable to that discharged from a hair blower. Four-panel display stations emit 2,000 watts of heat. Multiply that by the 10 stations a typical hospital might have and the heat created is sufficient to warm a small house. If a hospital air conditioning system cannot handle the added load, it must be upgraded or replaced.
- PCs have cooling fans, which can be noisy. Sound isolation can minimize the noise created by a roomful of computers.
- Lighting should be dimmer-controlled to both minimize brightness for reader acuity while enabling custodial staff to see minute dirt, which can damage computers. Localized lighting should be provided at workstations.
- Telephone lines should be installed at each workstation, allowing radiologists to easily communicate with referring physicians.

Going fully digital

The definitive expert on PACS installation is Bill Rostenberg, vice president of SmithGroup, a prominent San Francisco-based architectural firm. Rostenberg, author of "The Architecture of Imaging," says PACS planning in new construction should not be overlooked.

In California, for instance, considerable new hospital construction is resulting from required seismic upgrades. Elsewhere, new construction is more modest--"New hospitals just don't come around very often," planner McKahan says.

"With a renovation project, the conversion to digital is probably going to be incremental," Rostenberg says. "With new construction, it really makes sense to go fully digital to some extent."

According to Rostenberg, the installation of PACS at new hospitals is usually cleaner than in retrofits. Construction is designed to meld space with infrastructure, ultimately providing an optimal information, staff and patient workflow. Telecommunication and data closets are stacked by floor in the original design rather than moved atop one another. The fiberoptic backbone is designed to function well into the future.

Additionally, all electrical, cable, telephone, lighting and other requirements are met from the get-go rather than through the back door. There is no need to plan for dark rooms, film processors, digitizers and image storage rooms.

At existing hospitals, visitors often see holes popped through ceiling tiles, symbolizing ongoing cable or electrical work. At newer hospitals that occurs less frequently, largely because the architects and engineers have planned futuristically.

"Today, a new building will have either cable trays or hangers--an oversized system that goes throughout the building to accommodate new data cabling into the future," Rostenberg says.

Where PACS is concerned, planning such as that is key to both new construction and retrofits. Just ask San Antonio Community Hospital in Upland, Calif.

The hospital installed a state-of-the-art PACS three years ago, including a reading room with circular workstation configuration where light and other potential reader distractions are nonexistent.

Not that there wasn't some backpedaling. Early on, San Antonio learned that T1 connections between the hospital and a remote facility provided insufficient bandwidth for transmitting certain images. To overcome that, the hospital installed a microwave communications system with transmitters and receivers atop the main hospital and sister facility, says Rob Frame, manager of client server networks.

The line-of-sight system has done the trick. "We now have ample bandwidth to more than meet the needs of today and tomorrow," Frame says.

Looking to the future

As medicine itself looks to the future with PACS, so must those who design and plan their installation. If they don't plan long range, a hospital enterprise will find its system overloaded early on, resulting in extensive and costly infrastructure changes later.

These days, that's a scenario few health care organizations would wish to chance.

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