Making PACS Work With Nuclear Medicine

Translating Color and Movement to Code

By David Surface

Editor's note: In our February 2 issue, the article "PACS & Nuclear Medicine: Are We There Yet?" addressed PACS's fairly limited ability to handle the imaging needs of nuclear medicine. Some people in the imaging industry claimed progress, but most acknowledged that the marketplace offered little in the way of a comprehensive PACS solution for nuclear medicine.

Soon after the article's publication, George Zubal, PhD, an associate professor of imaging at Yale University and a primary source in that article, contacted writer David Surface and told him Yale had just implemented a new system to better integrate nuclear medicine images with its PACS. Surface contacted the players to find out more.

"Why nuclear medicine is difficult in PACS goes back to the fact that PACS basically evolved for CT and MR," says Xiaoyi Wang, president of Thinking Systems Corporation, a small PACS company that specializes in working with nuclear medicine, PET, ultrasound, and cath lab images. "The whole PACS paradigm is based on the assumption that images are static, two-dimensional, and black and white. But for nuclear medicine, you have eight image types, four dimensions, motion, and color. Colors are extremely important; dynamic display is also. For the conventional PACS vendors to handle these things, they have to change their whole design because their existing design won't work."

Wang understands the historical realities behind the difficulties of integrating nuclear medicine and PACS. He has seen the effects of PACS in nuclear medicine departments evolving separately from other imaging modalities.

"There's a long history behind nuclear medicine," says Wang. "If you go to most facilities, nuclear medicine is not part of the radiology department. It's tucked away somewhere. It's so different from the rest of radiology—they don't understand it and they don't want to. The fact that nuclear medicine is not a big moneymaker, compared to CT and MR, does not help, either. The end result is that nuclear medicine people have to do whatever they can to keep their technology up-to-date."

A Failure to Communicate

While Wang admires the ingenuity of nuclear medicine departments that develop their own networking solutions, he also recognizes the problems these different proprietary technologies cause.

"The difference between CT and MR and nuclear medicine is that nuclear medicine is four-dimensional—three dimensions in space and one dimension in time and has very low image resolution," Wang says. "To overcome this and other challenges, vendors developed different proprietary technologies. The end result is that nobody can communicate with each other because each vendor has its own special format and the information that it needs. That has improved somewhat with DICOM, but you still have to use different protocols to acquire images for bone scans, for cardiac scans, for gallbladder scans, etc. Every organ has a different protocol, and it varies widely from vendor to vendor how images are acquired and processed. There is no place in DICOM for that kind of information.

"To develop a nuclear medicine PACS solution, you have to be able to handle all the proprietary information from all these different vendors," Wang continues. "We have special connectivity gateways to handle scanners that are not DICOM-compatible. We take the images in their native format and we convert them into DICOM 3.0 format, and we retain this proprietary information as private DICOM tags."

Wang and Thinking Systems do not replace proprietary networking systems but integrate them into the PACS network. "You have to understand all major vendors' special formats and preserve the proprietary information, and when you transfer images to other vendors' systems, you will have to know how to convert the images from DICOM into the other vendors' native formats," says Wang. "The PACS also has to understand all the different processing protocols. You will have to be able to do the things a dedicated nuclear medicine workstation can do in the PACS environment—preprocessing, processing, postprocessing, and quantitative analysis."

Successfully integrating nuclear medicine and PACS may not be so much a matter of technical innovation, George Zubal, PhD, an associate professor of imaging at Yale University, says, than a matter of having the willingness to perform the kind of painstaking work some larger companies won't do in a small segment of the imaging market.

"The letters 'NM' have to be in the header," Wang explains. "The dynamic scans and 3-D data have to be stored correctly, screen captures need to be compatible with the central PACS system, etc. Once you do that kind of work, you ask, 'Can I interface the images the way MR and CT [are] being interfaced and can I test the networking scheme to see that it works properly with the central archive?' It's doable, but it's nothing that the big companies seem to be able to rigorously build and test in collaboration with the central archive PACS suppliers."

3-D and Quantitative Analysis

Wang illustrates with an example in nuclear cardiology. "Because of the nature of low statistics, the images generated by the scanner have little value to physicians for making diagnosis," he says. "There are other steps that must be taken to produce images or information that are meaningful to the physicians. This phenomenon doesn't exist on any other modality. In nuclear cardiology, for example, first you need to reconstruct a series of 2-D images into a three-dimensional volume. The reconstruction process is a science by itself. This is where the processing protocol comes in. Once you have the 3-D volume, you will need means to visualize it. This is where the display protocol comes into play. The visualization of the 3-D volume will enable the physicians to detect defects.

"But for nuclear cardiology, this is not enough," Wang continues. "The physicians want to know how severe the defects are. This is where the quantitative analysis protocols come into play. There are three or four competing products out there for nuclear cardiology quantitative analysis. Cedars-Sinai's QGS [Quantitative Gated SPECT], QPS [Quantitative Perfusion SPECT], and BPGS [Blood Pool Gated SPECT] are by far the most popular ones, and they are also what we use for our PACS. These are the things [of which] typical PACS people have little knowledge.

"Such features normally can only be found in dedicated nuclear cardiology workstations," he adds. "We take them to an even higher level. With our teleradiology server, we allow physicians to do processing and quantitative analysis over the Web so they can work from home, office, or anywhere in the world with a fast Internet connection. They can even do teleradiology conferencing with their colleagues in other parts of the world with both seeing the same images and mouse movements on their respective computers a world apart. All this is done with the patient images not leaving the server."

Yale's PACS Makeover

Wang describes the situation when he arrived at Yale to work on a PACS solution for the nuclear medicine department. "When we got to Yale," he recalls, "what they had were four Marconi scanners. One workstation was DICOM, the others were non-DICOM."

"Non-DICOM meant that we looked at nuclear medicine images in the nuclear medicine department," says Zubal. "We had no way of interfacing with the central network. The central network requires DICOM connections. We couldn't get the nuclear medicine images into the DICOM."

Zubal describes one of the major problems he presented to Wang during their first meetings. "Nuclear medicine is not recognized by a radiology network," says Zubal. "That means if x-ray sends data into central PACS, it's recognized as an x-ray image. If MR images are sent, they're recognized as an MR scan. But when nuclear medicine tried to interface, the PACS network didn't recognize what it was and gave it a code of 'OT,' meaning 'other modality.'"

Then why not simply work with the OT code? Zubal explains, "Remembering that OT really means 'not understood,' it is not a very satisfying way to have nuclear medicine data archived. Things like this need to be done correctly."

"They had an outdated archival system," Wang recalls. "Since one of the requirements was to send certain images to archive, our first challenge was to figure out a way to interface with an obsolete PACS technology that did not understand nuclear medicine. Our other challenges were to revamp the entire workflow for nuclear medicine, which entailed taking modality work list from the IDX hospital information system, assigning modality work list to the cameras that were non-DICOM, automatically retrieving images from the non-DICOM cameras after scans were completed, archiving the images, and distributing certain images to the hospital PACS."

Yale replaced its older PACS with a Fuji PACS system. "Now we export certain images to the Fuji," says Wang. "But they only allow us to send static screen captures to it.

"Modality work list has been around for CT/MR for awhile, but it is new to nuclear medicine. It is especially new if the scanner does not support DICOM. Modality work list ensures that patient information is correct and consistent with hospital information," says Wang. "The Yale implementation was designed such that the workflow is entirely digital and everything the technologist needs is right there."

Color Issues

The other problem Zubal presented to Wang was the lack of color display on the existing PACS system. "Nuclear medicine and ultrasound require color display for a full diagnostic read," Zubal explains. "The central PACS was aimed at MR, CT, and x-ray, which are black and white. It had movie mode in black and white, but not in color."

Because most x-ray, CT, and MR monitors are monochrome, Zubal explains that color display is not primarily a software issue. "There's no way to rewrite a program to convert a black and white display to color," he says. "It's a matter of how many pixels you really need and whether the monitor is capable of displaying color. The central x-ray monitors have 2,000 pixels across and 4,000 down. The tradeoff is no color. In nuclear medicine, all we need is 1,000 pixels across and 2,000 down, but now from a hardware cost consideration, we can include color. It's a limitation of how fine you can make the picture elements and whether you can afford color or not. Exquisite resolution and color together are not currently available."

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Small Market Opportunities

In technology, it's not unusual for innovation to come from small companies. In fact, it's often the very smallness of a company that allows it to move in a direction that big companies can't or won't go.

"It boils down to the fact that nuclear medicine is relatively a small market," says Wang. "The total nuclear medicine imaging equipment market in North America is still under $1 billion. To put it in perspective, GE Healthcare's annual revenue is $10 billion dollars. So there's little incentive for these major vendors to invest in developing PACS solutions for nuclear medicine. The investment is much larger than the return."

Wang recognizes that technology companies aren't the only big organizations resistant to change. "When we go into these other big hospitals, we don't go in there and tell them we have a wonderful new PACS," explains Wang. "Most hospitals have a 20-person PACS committee," says Wang. "We normally present ourselves as unique solution providers for nuclear medicine, echo cardiology, cath lab, and anything else that is not being handled. Often after seeing what we can do, they would say 'you guys can do everything better than what we have—why don't we just use yours for everything?'"

Looking Ahead

How long will it take big companies to develop their own comprehensive PACS solutions for nuclear medicine? "I would hope that in five years, the big companies will have nuclear medicine and ultrasound and other new modalities integrated," says Zubal. "However the networking evolves in the future, you're going to need a little entrepreneurial solution to getting nuclear medicine into the picture."

Wang also thinks larger companies are a few years away from offering PACS solutions for nuclear medicine. "I don't think they'll offer a solution, not in the next few years, anyway," Wang says. "We had a booth at the Academy of Molecular Imaging's annual conference in March, and we were the only PACS company there. We had a big entourage from one large company come to our booth to check out what we were doing. They decided it would take too long for them to develop what we were doing."

In *Radiology Today*'s March article, experts from several companies said they expected broader PACS support for nuclear medicine would be available in the next two or three years.

"If the big companies really wanted to get good in nuclear medicine networking, they'd buy out one of these small companies," says Zubal. "For a small price—for them—they'd have the networking solution for nuclear medicine, and a small investment for a big company who doesn't want to hire engineers."

Zubal is glad that Yale now has a system that lets nuclear medicine information be shared across a network more like other modalities. "We're very happy with the results," says Zubal. "All the complaints I had at our first interview, they've put together a code and an interface that deals with that. The technologists, the networking people, and the docs are all happy."

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