Implementation of the Medical Information, Communication, and Archive System (MICAS)

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A DEPARTMENTAL picture archiving and communication system (PACS) project evolved after several years of investigations by the Department of Radiology. In June 1995, the Medical Information, Communication, and Archive System (MICAS) task group was formed and given the directive to implement a limited PACS capability with a first-year budget of approximately \$400,000. Additional monies were to be budgeted in subsequent years based on the project demonstrating its clinical utility and cost-effectiveness. The first-year budget did not include any imaging modalities, ie, MR imaging, CT, computed radiography, and so on.

The task group had the constraint that IDXrad, the current radiology information system (RIS), had to be seamlessly integrated with the PACS system. It was realized from the outset that few, if any, existing PACS systems met this requirement. This, however, remained a fundamental requirement of the department's PACS. The clinical information in the RIS relating to the images was of equal importance to the actual images when used subsequent to the initial diagnostic interpretation. Other pertinent information from the Hospital Information System (HIS), Laboratory Information System (LIS), and other health care-related databases would eventually need to be accessed from MICAS.

MICAS was scheduled for delivery in December 1996, and installation eventually took place the third week of February 1997. As to be expected with any complex software and hardware installation, especially with multiple vendors involved, numerous initial problems were uncovered. Thus, this article is being written as MICAS is being installed and tested and undergoing acceptance testing. The current status and the lessons learned will be presented at the June 1997 SCAR meeting.

SYSTEM REQUIREMENTS

The functional specifications and requirements for MICAS evolved over 9 months, resulting in a request for quotation (RFQ) being submitted to numerous vendors. It was requested that all vendors perform a site inspection prior to submitting a bid to acquire the necessary information on the

imaging systems to be integrated into the system and the existing infrastructure. A sampling of these specifications and requirements included the following:

- the RIS and the Radiology Image Database (RID) be totally integrated with all pointers residing on the RIS and no secondary databases
- MICAS would be implemented in a modular approach bringing online imaging modalities that were already digitized and conform to DICOM V3.0 or Interfile V3.3 standards
- automating the input of patient's medical record number (MRN) and the requisition number or accession number (ACC#) into the image header to save the technologist's time and eliminate errors
- all hardware to adhere to open system hardware guidelines and operating system software to adhere to industry software standards; no proprietary components would be acceptable except application software, that must be DICOM compliant
- a single viewer application with a graphic user physician interface (GUPI) had to be provided that could operate on a modality-specific diagnostic workstation or electronic review and consult workstation or therapeutic workstation—orthopedic, radiation oncology, etc, physician personal computer
- "hooks" must be provided to allow future integration of MICAS into the hospital information system (HIS) as well as other relevant information systems
- a version of MICAS that would run on a personal computer would be developed by the end of 1996
- the University would purchase the computer hardware directly.

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As already stated, the PACS had to be seamlessly integrated with the department's existing RIS, with no secondary RIS database being used. As a result of this requirement, turnkey PACS solutions were not a viable option. Software must be available to ensure that all completed imaging studies are matched and verified with the corresponding patient study previously scheduled on the RIS. The patient's MRN and ACC # for the particular study will be used to ensure that the patient imaged and the patient scheduled for the procedure are one and the same. This critical component of the system is to ensure that all patient imaging studies are retrievable from the RID.

MICAS will be implemented incrementally, because the department had a limited first-year budget and because, if components of the system were less than optimal, the economic impact would be limited. The first modalities to be included in MICAS were CT, MR imaging, and nuclear medicine—all intrinsically digital modalities that conformed to Digital Image and COmmunications for Medicine Version 3.0 (DICOM) or Interfile Version 3.3. As it has turned out, incorporating nuclear medicine as part of the initial installation was delayed, because it would be more cost-effective to eliminate the need to convert nuclear medicine from an Interfile format to the DICOM standard. Computed radiography, a film digitizer, and nuclear medicine are scheduled to be implemented in the second quarter of 1997.

VENDOR SELECTION

There are three traditional approaches to implementing PACS¹:

1. A multidisciplinary team is assembled within Radiology, and the team acts as the systems integrator and selects PACS components from various manufacturers, develops system interfaces, and writes the PACS software based on clinical needs.
2. A team is assembled from within and outside Radiology to write detailed specifications for the PACS based on clinical needs, and a manufacturer is contracted to implement the system.
3. The turnkey approach, in which the manufacturer has an existing PACS that meets the clinical needs and is responsible for its installation and initial operation.

Surprisingly, few responses were received from

"turnkey" PACS vendors, with the reason typically given that they could not meet the functional and/or open systems specifications. It was realized from the outset that the initial cost, risk of implementing MICAS with minimal problems, and meeting the functional specifications and requirements of MICAS would depend on which category of vendor was selected.

None of the three traditional approaches to PACS implementation was chosen. The first two methods were not possible because the department had neither the personnel nor sufficient economic resources. The turnkey approach was unacceptable because the seamless integration of the RIS and MICAS would involve a secondary database, added cost, and the risk of "vendor tyranny."

A fourth method was decided upon: a multiple vendor open systems approach with the Department of Radiology as the system integrator. The Department of Radiology is a development partner with ImageLabs (Bedford, MA), a start-up company that had developed an image viewer for electronic review and consult, "Shared Vision." ImageLabs agreed to develop diagnostic viewer software with dual monitor capability from "Shared Vision," a single monitor system. ImageLabs and IDX (Burlington, MA) also were partners in the development of an interface between "IDXView" and "Shared Vision." IDX also had developed an interface between IDXrad, the Radiology RIS, and IDXView, which includes the acquisition engines plus the study verification, query, and image management software.

Digital Equipment Corporation (DEC, Computer Special Systems Group, Merrimack, NH), was selected as the hardware vendor, because the DEC Alpha system can run both UNIX and Windows NT. IDXView and Shared Vision were already running on DEC Alphas. Other vendors were not willing to support the cost of porting the software to their UNIX platform. Over and above the competitive system cost, the DEC Alpha's performance specifications—including 64-bit operating system and 40-Mbit bandwidth from their Redundant Array of Inexpensive Devices (RAID) storage system—were an important factor in hardware selection. Each modality will have its own RAID temporary archive, and these will be backed up on tape to be used to eventually populate the permanent archive. In addition, DEC was willing to integrate, test, and deliver at a reasonable cost

third-party components via DEC's Computer Special Systems group.

Another reason for taking the multivendor approach was that, as an academic department of radiology with limited funding, we wanted to investigate an alternative path to implementing PACS that would allow other institutions with limited resources, both financial and personnel, to incrementally ease their way into the digital radiology era incorporating minimal use of film. It is hoped that this approach will foster the open system concept for PACS and true partnering between clinical departments and vendors with minimal finger-pointing when problems arise.

It should be emphasized that the MICAS approach to implementing PACS is possible only with hardware that adheres to open system guidelines and operating system software that adheres to industry software standards. In addition, the only proprietary components acceptable are application software that is DICOM compliant. This provides the highest degree of compliance in meeting the functional specifications and requirements of MICAS while minimizing cost and allowing "best of breed" hardware and software to be integrated into MICAS as it grows and evolves. It is critical that a well-defined interface between vendor software products exists, with a written agreement that these vendors will cooperate in resolving any problems that may arise.

SHORT- AND LONG-TERM OBJECTIVES

The short- and long-term objectives of MICAS will be achieved as the various phases are implemented over 5 to 7 years. These objectives include the following:

- establish Ethernet, communications, and security infrastructure
- the existing RIS will be seamlessly interfaced with MICAS, and a bidirectional interface between the RIS and imaging modalities will be implemented
- initially interface CT, MR imaging, and nuclear medicine to MICAS and add additional modalities as resources become available
- initial efforts will be directed toward diagnostic workstations and transmitting clinical information within Radiology
 1. develop the functional requirements of diagnostic workstations for each modality

2. validate interpretation from "soft images"
 3. eliminate motorized film viewers and film on a modality-by-modality basis once radiologists are confident in reading "soft images" and the permanent archive is established
- capture all studies on digital tape once a modality is interfaced with MICAS, so those studies can be used to populate a permanent archive once it is established
 - establish a permanent archive
 - develop communication links to off-campus imaging centers and physician offices
 - implement the use of electronic review and consult software on UNIX and personal computer-based workstations
 - digitally transmit *all* images and related clinical information to *all* areas of Radiology and throughout the University of Rochester Medical Center (URMC).

COST CONSIDERATIONS

Cost is a very important aspect of implementing PACS. Although vendors may significantly discount the initial investment in both hardware and software, unfortunately this is only a small component in the total capital and operating cost of PACS, especially if it is implemented incrementally. Typically, the warranty period is 3 months for software and 12 months for hardware. Unfortunately, the service contract for software is usually based on 18% of the list price. If an institution receives a 50% discount on \$200,000 worth of software, the annual service contract will be \$36,000 on the discounted price of \$100,000. The 18% service contract will normally apply to all site and seat license fees, acquisition software, interfaces, and so on.

The cost for acquisition software will be based on the number of imaging systems to be interfaced to the PACS. The important factor to determine in advance is whether this charge will be per imaging modality or the number of imaging systems per modality, and whether the charge will be the same if they are identical systems operating with the same software version from the same vendor.

Normally, a software vendor will charge for a site license plus a license fee for each workstation connected to the system that uses the application. The scope of the site license must be defined: Is it limited to the physical site of the hospital or does it

include affiliated imaging centers and hospitals? The cost for the seat license is usually based on the total number of seats purchased. If possible, a seat license fee should be locked in, based on a projected number of seats that will be required for some time into the future.

In addition to initial and subsequent capital and operating costs, personnel costs must be considered. Even if the number of full-time-equivalents will be reduced, the personnel required to support the PACS will in all likelihood be more costly. The cost of upgrading and maintaining the network infrastructure can be significant and must be considered. Many of the normal radiology operating expenses will be doubled; for example, maintenance and quality control of film processors and motorized film viewers will continue while this same service must be provided for computer systems and monitors. During the initial years of operating PACS, total operating costs in radiology will rise until the cost savings and efficiency of operation can be realized from PACS.

SYSTEM INTEGRATION

Details regarding the infrastructure, hardware, and software aspects of MICAS are presented as a scientific demonstration entitled "Project MICAS: PACS Implementation at the University of Rochester Medical Center."

Partially as a result of the department assuming the responsibility for system integration, a section of Computer and Information Systems was created, which became the system integration team along with the project manager and the IDXrad systems manager. The decision for the department to assume the role as system integrator was based on the significant cost of having a vendor take on this responsibility, and more importantly on an evaluation of the responsibilities of the system integrator. It was determined that for the approach we were taking to implement MICAS, that out-sourcing this major responsibility would be a serious mistake, because it would directly affect the success or failure of the program as well as its future development.

It was decided that DEC, the hardware vendor, would assemble, integrate, and install the operating systems and test all hardware prior to shipment. The hardware was shipped to IDX, one of the software vendors, so the software from both IDX and ImageLabs could be integrated and tested prior

to shipment to URM. As part of the staging of the hardware and software at IDX, the acquisition engines developed by IDX were to be tested with live data from the department's CT and MR systems, which were said to be in conformance with DICOM Version 3.0. In addition, it was essential that the IDXView application be fully tested and integrated with IDXrad, the department's RIS.

In late August 1996, a meeting was held with URM representatives and those from IDX and ImageLabs to finalize software specifications, define responsibilities, and establish a time-line for the project. Weekly conference calls were held to monitor progress and resolve any problems that had arisen.

At URM, the infrastructure for MICAS was installed and tested. The Computer and Information Systems group worked closely with the various information service groups within the university community. Weekly meetings by the integration team were held starting in October 1996 to review the status of MICAS, resolve potential problems, and assemble workflow data to be used to compare the department's operations prior to MICAS being implemented and after it is fully operational for each modality. This group was also responsible for keeping the department informed on the status of the project.

It was anticipated that MICAS would be installed the first week in December, so in early November 6-hour-long informational presentations were made to the radiology clerical staff, technical staff, residents, fellows, and faculty, as well as to interested individuals within URM. These meetings stimulated much interest, as well as some concerns by the clerical staff about losing their jobs and whether retraining opportunities would be available.

It was decided that four radiologists who had significant interest in working with MICAS would be initially trained on the system. These physicians, along with the integration team, would test and perform the acceptance testing of MICAS.

MICAS was installed during the third week in February and took 1 week, with personnel from all three vendors on-site. Many problems were discovered; some were resolved and others were defined to be solved during the following 2 weeks, which happens to coincide with the due date for this article. Training, further testing, and development

of our quality assurance program is proceeding while we wait for resolution of the outstanding issues.

The past 21 months have been an excellent learning experience. Many of the lessons learned have been previously dealt with under different circumstances, but issues have surfaced with a new twist as a result of different terminology and technology. As we proceed through system integration and on to the installation, training, acceptance testing, and quality assurance phase of implementing MICAS, we have and will continue to learn many additional lessons that we will subsequently present.

FUTURE DEVELOPMENTS

The future development of MICAS will depend on demonstration of improved service to referring physicians, improved patient care with possible reduction in length of hospital stay, and most importantly cost reduction in the operating budget of the department. The latter issue will be the driving force in the funding level for MICAS. The greatest cost and time savings will be derived from minimizing the use of film, the related reduction in personnel time of handling film, rapid availability

of images throughout the hospital, and increased efficiency of operation in the department.

During the second quarter of 1997, to facilitate the reduction in film use, two Kodak computed radiography systems and a Howtek film digitizer will be connected to MICAS along with the nuclear medicine imaging systems using the DICOM communication standard rather than the Interfile file format standard. The infrastructure and security for MICAS will also be enhanced. Discussions are currently being held with archive vendors, and it is hoped that during the latter half of 1997 the first phase of the permanent archive will be installed.

For 1998, the plan is to integrate ultrasonography and other imaging modalities to MICAS, as well as to bring on-line imaging centers and offices outside of the hospital and other services and referring physicians within the hospital. In addition, the permanent archive will continue to be developed.

REFERENCES

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