White Paper: Enterprise PACS - A Perspective

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Introduction
Picture Archiving and Communications Systems (PACS) took twenty years to mature as a technology in radiology, and is today a necessity for cost effective, productive imaging operations. In the early years of development, PACS was largely a radiology-centric endeavor with emphasis on improving image accessibility and lowering film and related expenses.

As the technology has matured, so has the necessity to integrate PACS with radiology workflow so that today’s PACS are shifting to radiology information systems, or RIS-centric solutions. The benefits of PACS have been clearly demonstrated, and now other service areas are getting in on the action. The American College of Radiology (ACR) – National Electrical Manufacturers Association (NEMA) image communication standard known as “DICOM” has moved beyond radiology to address the needs of other imaging service areas as part of the standard. The IHE (Integrating the Healthcare Enterprise) is an initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information. The initiative encompasses the intersection of image and textual data, and will further extend the application of PACS beyond radiology.

Based on my consulting experience, I believe the case is strong for organizations to benefit from an enterprise PACS.

A Framework for an Enterprise PACS
To assess the impact of an enterprise PACS, one must first put the concept in perspective. Figure 1 illustrates a framework for consideration of an enterprise PACS, by defining five basic functions associated with PACS activities. The requirements for acquiring images, managing their workflow, and interpreting results are unique for each service area, and are therefore “departmental” in nature. In the case of radiology, the workflow is structured around an “order,” and studies are read sequentially until all the work for the day is complete. Radiologists read cases through a sequential review of images. In the case of a radiograph, this might be by reviewing a series of panels of images, and by comparing the prior with the current image. In the case of a multi-slice CT study, this might be by rapidly moving through a “stack” of images, building up the anatomy three-dimensionally. In some instances, special analysis is performed, such as 3-D reconstructions, which involve the view of images in multiple planes, or 3-D representation, but essentially, it is similar in that it is largely a sequential image display.
In the case of cardiology, the workflow process is less structured than in radiology, as many cardiology procedures are not done from an “order” per se. In terms of acquisition, multiple elements of information are simultaneously recorded, including images, pressures, and other procedural data. Interpretation is frequently done immediately following the study, and involves a review of all of the information acquired. The cardiologist may want to view images of the cardiac catheterization procedure while also viewing the associated hemodynamics (pressures) and medications administered.

In most modern cardiology PACS, a structured report is created interactively at the time of interpretation.

Beyond “departmental” requirements, there are two additional requirements for secondary image accessibility by supporting staff, and the long-term management of the image data. These requirements are more appropriately defined on an enterprise level so as to avoid redundancy and enhance the capability of electronic medical record (EMR) systems. If image distribution and management are treated as part of a departmental solution, the result is the creation of “data silos” that may not be as accessible across the enterprise.

Such a framework allows for uniqueness within departments for specialized needs, while accommodating the need for integration of image information at the enterprise level. Social-and political requirements, must be taken into consideration as well. Departmental desires to “own” and control access to data must be weighed against patient security and rights regulations, as well as what is best for the treatment of the patient.

Many larger facilities are wrestling with marketing campaigns to build referral business, such as in the case of cardiology services. In these instances, it would be advantageous to be able to acquire studies from referral facilities for reading, or for use in conjunction with follow on studies. An enterprise

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**Figure 1 - A Framework for Enterprise PACS**
archive might be configured with multiple partitions to allow acquisition of studies from multiple locations, without the need to fully integrate into individual departmental system’s database. Such an approach may enhance the facility’s ability to act as a “regional referral” without legal issues of external data management.

An examination of several issues relating to image accessibility and management in light of this framework should enhance the case for enterprise PACS.

**Enhanced Image Accessibility**

One key point of an enterprise PACS is to improve the accessibility to patient information across the enterprise. As providers move closer to EMR solutions, the impetus will be on physician use. One incentive for physician use will be to keep things simple. If the EMR must interface to multiple environments each requiring their own viewer to display image results, the complexity may be enough to discourage physician use. For example, let’s say a physician logs on to the EMR to view his patient’s chart and sees that there has been some initial radiology activity including a chest x-ray. After reviewing the report, the physician clicks on the image icon which launches a radiology PACS web viewer to view the image. Next the physician sees that there was a cardiology workup, and reviews the results of a stress echo study. Again, the physician is able to click on an icon to see the image, but in this case, a cardiology viewer is launched. Similarly, there may be some GI work, in which case an entirely different viewer might launch to display those results.

If viewer technology varies significantly between service areas, it may discourage physician use, and be deemed too complicated. Conversely, in the context of an enterprise image management and accessibility environment, it may be possible for one image viewer to present the results from all three service areas, simplifying physician accessibility.

Current PACS initiatives have emphasized physician accessibility within the constraints of the current PACS. If this happens to be a radiology PACS administered by radiology, there may be conflicts with information systems in terms of secure access to the PACS web server from outside the facility, such as a physician office building or the physician’s home. Handing off responsibility for internet connectivity to information systems may make it easier for physicians to access the radiology PACS web server in a secure manner. Getting the physician to use the capability may be an entirely different matter!

Image accessibility by itself may have limited appeal, such as to specialists, but when coupled with other related applications such as an EMR, the rationale for more widespread use may be much greater. This broader use will also encourage a closer look at how images are managed in the physician office. Figure 2 contrasts current film-based physician office workflow with that of electronic access.
Figure 2: Physician Office Workflow Comparison

Note in the case of the film-based model, the physician is dependent on his staff for order, transport, and disposition of the film. Should the film not arrive in time for the patient’s visit, or should the patient forget the film, the appointment may have to be rescheduled, resulting in an inconvenience to the patient, and unproductive time for the office staff.

In the case of the soft-copy model, the physician is no longer dependent on his staff for image accessibility. Various forms of soft-copy access are available to the physician depending on the size and type of practice, and may range from a PC in a consultation area, to a wireless device brought into the exam room by the physician, to a dedicated PC in the exam room. Understanding the physician office workflow and accommodating key physicians with heavy image access are key to an effective PACS implementation, lest physicians continue to order films for their office.
Radiologist accessibility is also an important aspect to a successful PACS implementation. Providers may increasingly look to PACS as insurance in the event of radiologist changes that leave them with either temporary or permanent deficiencies in staffing. Radiology groups also look favorably on PACS, as it provides a potential mechanism to “level-load” staff across facilities and improve accessibility to sub-specialty radiologists.

**Improved Image Life Cycle Management**

An Enterprise PACS that consolidates image data into an Enterprise “view” can improve the overall economics and efficiencies of storage across the enterprise. If each service area makes its own storage plans, the enterprise may end up with “islands” of data that will require management of different media, formats, and locations, resulting in potentially higher costs to the provider. If each area manages their own data, there are likely to be staffing redundancies as well.

In the age of the DICOM standard for image management, it is conceivable that long-term image storage can be more effectively handled at the enterprise level. Costs are spread across service areas, so individual service areas are not as subject to capital issues should storage needs grow faster than planned. Storage migration can also be planned centrally so as to take advantage of newer technology, and all service areas benefit. It should be noted that individual departmental solutions still need a local cache storage that is sized to accommodate accessibility to all current cases including supporting prior images. Such caches are usually sized for around two years to assure optimal performance in terms of retrieval time.

Another advantage of a centralized life cycle management of the information is the ease with which storage rules can be changed. Consider the case where a major legal change impacts the period for which studies must legally be stored. In a distributed environment, this may require a significant effort to investigate individual systems, change storage retention rules, and then purge data. In the case of a centralized approach, it may be possible to simply change the rule set, and allow the application to determine what changes are necessary. The purging of information can go on in the background without any significant impact on operations. If subsequent changes are required, they can be made across the board without further effort than the rule change.

An area related to storage is assuring the integrity of images stored through proper backup and disaster recovery techniques. As with departmental storage, the discipline for backup and disaster recovery management may not be as strong as at the enterprise level. With the 2005 HIPAA security policies, providers must assure that a disaster recovery plan is in place – and that the plan is periodically tested. Besides images, many PACS and related systems recommend periodic database backups. Usually, these are managed by daily tape change outs, with the need to manage a week’s worth of tape for multiple recovery points. Enterprise-scale backups may be able to replace individual tape backup with disk backup centrally through emulation, eliminating the need to manage tapes on each system, making for a more productive process. Enterprise storage architectures are moving toward redundant solutions, shortening recovery time and reducing complexity.
As information ages, the ability to maintain it for current use becomes more complex, particularly if the data is stored in a proprietary format. Should it become necessary to change out the PACS, data migration can be a significant factor in the change out plan. Typical migration services specify that they can convert between two and three thousand records per day. For an archive of several years, this can translate into months of migration time, resulting in either a need to keep the old PACS in operation, or in potential delays in a go-live date for the new PACS.

Similarly, taking advantage of newer storage technology on an existing PACS can be problematic if the PACS vendor has not validated the new media. Newer enterprise image management applications typically support storage transparently, so migration can occur in the background without impacting the individual applications.

Aging information out of the database is another area for concern. Many systems support image deletion, but maintain the record in their database. This would be akin to purging a film folder by removing the film and placing the empty folder jacket back on the shelf! By centralizing the archive function, it may be possible to establish enterprise-wide retention rules that manage the entire patient record, and allow deletion of aged records more efficiently.

**Image Integration and Management Approaches**

Many facilities are today struggling with the implementation of Electronic Medical Records, and may or may not have reached the point of encompassing imaging into the EMR. An EMR that has the ability to link to other applications such as an image viewer can make it convenient under a single sign on for the physician to not only see the report, but to also view associated images.

There are multiple design approaches to handling image integration with the EMR, including the concept of a central repository for image archive, and a distributed approach where the EMR remembers where the information is stored in individual systems, and can request information from these systems when necessary. While the distributed approach has merits in terms of system failure, the centralized approach more effectively addresses the economies of scale for storage, maintains the ability to access images independent of the individual systems, and improves the efficiency of life cycle management of studies.

Another factor in favor of a centralized approach is the situation where multiple service areas may collaborate on results, such as in the case of a nuclear stress test study. In this instance, the nuclear scan may be done and reported in radiology, whereas the wave forms may be assessed by cardiology. The cardiologist may want to view the nuclear medicine study and report when reading the wave forms, which may be complicated if these are separate systems. If results are managed in a centrally accessible archive, it may simplify the ability of either service area to access supporting results.

Another key aspect of image management is the manner in which the data is handled. Not all image data is the same, and the requirements for managing it may be different. Some vendors take the approach of using the DICOM standard as a “wrapper” in which to place all image objects, as the DICOM format can handle the metrics of the contents. Others suggest that a Services Oriented Architecture
(SOA) is a more effective means for handling disparate objects, using different “services” to map object access and manage content metrics. The goal is to create a “patient centric” solution that allows a single view of all related patient information. Also related to the patient-centric approach is the manageability of the patient record. For example, should Mary Smith get married and become Mary Jones, it may be a tedious process to update separate databases. With a patient-centric solution that conforms to standards such as HL7, it is possible to update the entire patient record all at once, and to then notify individual systems of the change. Similarly, if the patient is deceased, it may be simpler to delete the entire record through purging rules than to delete out of individual systems. All are important aspects to centrally managing image information.

Of course, it will be important for individual departmental solutions to be able to accept changes from an enterprise solution. Hence, if the enterprise application can notify the radiology PACS that “Mary Smith” has changed to “Mary Jones,” the radiology PACS will need to have the capability to update its internal database for future reference. This will necessitate pressure from users as well as enterprise vendors to gain acceptance on the part of the service area system vendors to make the necessary changes to support this approach. In the end, this may be yet another paradigm shift for PACS from a departmental-centric, to an enterprise-centric architecture.

**Implementation Considerations**

The primary consideration for IT services in terms of an Enterprise PACS implementation will be to achieve an architecture as illustrated in Figure 1. Individual service area PACS may either already be in place or in progress. The objective will be to address movement toward the enterprise functions of image management and distribution.

One of the first considerations will be the storage technology and topology to be deployed. Can this be an extension of existing storage topology, or is it more appropriate to consider adoption of a secondary platform for imaging? Depending on sizing estimates, it may be appropriate to consider a new platform. Performance factors may also come into play, as image sizes could adversely impact system latency for existing applications. Consider the impact of a Radiology PACS attempting to transfer a 3000-slice CT study that may exceed 1.5 gigabytes of data.

In terms of topology, there are many storage technologies to consider. With the cost of spinning disk media dropping, many facilities consider it now economical to store all data on redundant spinning disk. For most facilities, the rule of thumb is that 90 percent of requests for prior studies will be for those that occur within eighteen to twenty-four months of acquisition. Therefore, one must consider the cost-performance tradeoff of moving information to less expensive media for studies that may have a less than ten percent chance of being retrieved. In this case, a multi-tiered architecture employing spinning disk for the first two years, followed by movement to high density tape or disk media may be appropriate.

An emerging technology that may be well suited to the application is that of iSCSI. This technology employs inexpensive SCSI disk technology on a standard Ethernet network. It allows for additional
capacity to be easily added in multiple locations, and may represent a more viable solution than classical SAN or NAS technology. For large capacity and dispersed facilities, grid solutions such as IBM’s GMAS, Bycast’s Storage Virtualization, or EMC’s Axxiom Grid may be appropriate considerations. The redundant nature of grid storage may be advantageous in terms of acquisition time and redundancy in storage to achieve disaster recovery and performance objectives.

Facilities may already be employing their storage infrastructure for image storage today. Over and above the physical storage infrastructure, there is the importance of applications that can manage the data format and life-cycle management of the data over time. So-called “middleware” applications from such vendors as TeraMedica, Carestream Health, Acuo Technologies, Agfa Healthcare, and DeJarnette Research Systems offer advantages in terms of image management. Such applications employ either a DICOM wrapper or System Oriented Architecture (SOA) to accommodate both DICOM and non-DICOM data sets to map the data into storage. They may employ customizable rule sets to modify how information is stored, and for purging information. They also may have the capability to migrate information in the background, so that as new storage infrastructure is introduced, data can be migrated without impact on the end applications.

Another alternative might be to consider services that offer remote image storage for either long-term and/or disaster recovery storage. Besides several of the above companies, Agfa Healthcare and InsiteOne offer local gateways that connect to their redundant data centers to provide long term and disaster recovery storage using internet connectivity and background transmission. Such an approach provides a more economical means of remote storage, but at a retrieval performance penalty. The choice of services approach should ultimately be based on the objectives for image storage, and the requirements of the service areas.

Accessibility to stored information is another key implementation consideration. If there is already a PACS in place, there may be access to images via that PACS vendor’s web browser. If there is an EMR in place, there may be an API linkage between them that enables launch of the web browser directly from within the EMR. Things get complicated when there are multiple service areas that may have separate web browsers. In this case, it may be necessary to have multiple API’s to the EMR. Alternatively, one might standardize on a single web viewer for interaction through the EMR. Such an approach would certainly simplify things for the physician base, and increase the likelihood of use. Vendors such as TeraMedica and InsiteOne offer an integrated web viewer technology that can provide this simplification. A complication might be the openness of the EMR to supporting API interfaces, particularly if the EMR vendor has their own viewer approach.

Some facilities have established three tiers of viewing capability: dedicated diagnostic workstations for diagnosticians; a direct-accessed web-based application for specialists such as orthopedics; and some form of simple web viewer for the casual viewer who just wants to see an image. The simple web-based viewer can be directly linked to the EMR and provide basic image viewing without much image manipulation. Such approaches may enable facilities to simplify physician access and increase the likelihood of use.
Summary
The case for enterprise image management and accessibility is strong, and should not be viewed as a threat to individual departments. The benefits are many. Conforming to an enterprise PACS can allow the technical management of a PACS to be off loaded to IT, enabling departments to focus on the more important clinical aspects of a PACS. Storage costs can be spread across the enterprise, thereby lowering the departmental cost and potentially freeing up capital for other departmental equipment priorities. Users get a unified view of information across the enterprise, improving satisfaction and diagnosis and treatment productivity. Centralized data storage can also be more efficient in terms of data management, potentially reducing the liability of piecemeal records deletion.

In summary, enterprise PACS can improve the management and accessibility of images and allow clinical services to concentrate on what they do best – provide quality care to their clients.

About Healthcare Integration Services:
Healthcare Integration Strategies (HIS) was formed by Mr. Joseph Marion in 1993 to address the strategy for information integration needs in healthcare IT. HIS has served over 100 clients with consulting engagements ranging from PACS readiness assessment, to vendor selection, and implementation oversight. In addition HIS was an original IBM MedSpeak/Radiology reseller, and has extensive experience with the implementation of speech recognition in healthcare. More recently, HIS has pioneered assistance with the emergence of Enterprise PACS, and has assisted multiple clients with the inclusion of image in the strategic planning process. As Principal, Mr. Marion continues to publish and blogs for Healthcare-Informatics on the subject of Enterprise PACS.