PACS and RIS: Approaches to Integration

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ABSTRACT
PACS and RIS have traditionally been discrete information systems with separate databases. Maintaining more than one database containing identical data sets creates the potential for outdated information being used in parallel with accurate information. Today, because of increased implementation of PACS and improved Web technology, this problem must be solved. Furthermore, as PACS technology is applied to areas outside radiology such database issues become more critical. Application of XML offers a cost-effective and workable solution to many of the thorniest problems that will likely become more prevalent in the post-Y2K era.

KEYWORDS
• PACS
• RIS
• XML
• Integration
• Data exchange
• Radiology
• Web
• DICOM
• HL-7
• Database

Integration is not the same as connectivity. Connectivity for two discrete healthcare information systems may be established through a bidirectional link using HL-7 (healthcare level 7) or DICOM (digital imaging and communications in medicine). Integration implies that the two systems are truly working together. PACS (picture archival and communications system) and RIS (radiology information system) have traditionally been discrete information systems with separate databases. But maintaining more than one database containing identical data sets creates the potential for outdated information being used in parallel with accurate information. Because of increased implementation of
PACS and improvements in Web technology, this problem requires a resolution. Data interchange between incompatible databases is traditionally achieved through specialized interfaces based on the HL-7 standard. But even when applications are HL-7 compliant, data exchange is no mean feat. As vendors accept and adopt emerging DICOM standards, some of the connectivity issues will ease. But the problems encountered with database data exchange will likely worsen as healthcare organizations, insurance companies, large and small hospitals, healthcare networks, and group and small medical practices all struggle to exchange data electronically. Affiliations, partnerships, mergers, joint ventures, and cooperative efforts between various healthcare providers are created and dissolved at a pace that frustrates and confounds the best efforts of MIS and data specialists to prospectively purchase and implement uniform compatible information systems throughout an organization. Furthermore, the difficulties encountered in integrating PACS and RIS systems are a microcosm of the overall problematic situation that exists throughout the healthcare industry. As Web technology is adopted, application of XML (extensible markup language) offers a cost-effective and workable solution to many of the thorniest problems. In the post-Y2K era, XML-based solutions will likely become more prevalent as database connectivity issues arise.

The Situation Reviewed

This article looks at some of the existing problems and reviews various approaches for improving integration between different healthcare systems. Although PACS-RIS integration is the focus and central model discussed, the problems and solutions are applicable throughout the entire spectrum of healthcare information systems.

**HTML.** HTML (hypertext markup language) is simply a display standard used by browsers. HTML describes how text and graphics should be displayed for the user. It also includes the ability to use radio buttons and enter form data. The user views a given page with text and graphics. If he or she needs to view additional text or graphics, that request is transmitted to the Web server and the new page is then transmitted and displayed. Using HTML, if the user is to have a menu choice of several text and graphics pages to view, that menu must be transmitted either as a dedicated page, mapped graphic, or frame. The user then selects the item of interest, which is then transmitted for viewing.

This approach is inefficient because the bandwidth requirements are high due to the frequent exchanges of data required until the necessary Web page is displayed. HTML has many other restrictions. It can only display one language standard at a time. If the browser is configured for Latinate languages, then Korean or Russian, for example, cannot be displayed as nongraphical text. HTML uses specialized tags to describe the manner in which the subsequent data should be displayed. It is similar to a fax-on-demand device. On receipt of a proper request, the document requested is then faxed. Although it is
common to create custom Web pages dynamically based on a specific request using Perl and other scripting languages, the content of such an HTML-coded Web page is fixed, just like a faxed document. When database information is extracted and incorporated into an HTML document, those data are also fixed.

**XML.** Extensible markup language (XML) is actually a family of technologies.¹ The XML standard is managed by the World Wide Web Consortium (W3C).² XML is a great improvement over the more familiar HTML. It is a self-describing language. This means that any XML implementation can use unique or specialized data elements—as long as the descriptors of these data elements and their interrelationships are also described for the browser. XML uses tags, but instead of simply describing how those data should be displayed, XML tags describe the data type (see Figure 1). The type and classes of data sent and

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**Figure 1. Example of the Fundamental Differences Between HTML and XML**

**HTML:** Example of parameters specified in the code:

```html
<font><letter size><color><italic><alignment>
Mr. McGoo has pneumonia
</alignment></italic></color></letter size></font>
```

Result displayed: **Mr. McGoo has pneumonia**

**XML:** Example of parameters specified in the code:

```xml
<patient>
  <first name>Mr.</first name><lastname>McGoo</lastname>
  <allergy>shellfish</allergy>
  <drug-allergy>penicillin</drug-allergy>
  <MR-contraindication>pacemaker</MR-contraindication>
  <font><letter size><color><italic><alignment>
Mr. McGoo has pneumonia
</alignment></italic></color></letter size></font>
</patient>
```

Result displayed: **Mr. McGoo has pneumonia**

Data available for other uses, but not displayed:

Name(first, last): Mr. McGoo
Allergy: shellfish
MR-contraindication: pacemaker
Drug-allergy: penicillin
received are limited only by the arrangement made by the sender and recipient of the rules used. In this situation, demographic, allergy, and MR-contraindication information can be added from the sender’s database into the XML document using a preprogrammed set of XML rules. Using a parser that is programmed to understand these rules, the recipient can extract that data to his or her database. The sender’s and recipient’s databases can be totally incompatible and the data can still be transferred. XML also incorporates the unicode standard, which was issued by the Unicode Consortium.3 Unicode is a method for encoding the alphabets of characters of all the world’s languages. Applications or programs may incorporate XML to aid in processing data at the user’s location, thereby speeding up the interval from initial page request through completion of transactions. XML can store information found in a variety of information systems so that it is invisible to the user until the data are required for another process or function simply requested for display. The actual Web page is then much larger than the actual page. The user controls the content displayed. By reducing the number of transactions required for a user to receive the necessary information and update the databases, bandwidth congestion is reduced for all users.4

The Clinician’s Use of XML. The following example will illustrate the power of XML over HTML and the power of XML in RIS-PACS integration.

MR Exam Order Using HTML. Let’s assume a physician wishes to order an MR (magnetic resonance) examination of a patient’s abdomen. An HTML-based order entry system would optimally allow that physician to select the patient from a patient list (transaction 1) and then open an order-entry screen (transaction 2). The physician then selects MR from the radiology menu (transaction 3) and completes the form for an MR examination order (transaction 4). Finally, to schedule that study for anything other than the next available slot would require a series of transactions to obtain the available slots and find the one that best suits the patient and urgency of the examination.

MR Exam Order Using XML. The physician selects the patient from a list and simultaneously selects order entry for MR from a separate list that is on the same page. Both requests are transmitted to the Web server, or alternatively, XML code within the Web page queries the individual RIS, HIS (hospital information system), and scheduling system databases directly (transaction 1). The patient’s examination history, list of examinations currently ordered and pending, all known allergies and diagnostic interaction information that may be required by the different MR studies, and the MR schedule of available examination times for the next eight weeks are culled by the XML application. The physician selects the appropriate study and completes the examination order details. This information is processed by a Java application locally, and the schedule of available MR time slots is modified based on the examination data that the physician enters. That information has not yet been transmitted from the physician’s station. The physician selects the preferred time slot for the patient and study urgency and transmits the order and schedule information. That information is
either transmitted to the Web server, or alternatively, XML updates the HIS, RIS, and scheduling databases directly (transaction 2).

All healthcare organizations today use more than one database for their operations. Many still have large amounts of critical data in antiquated M or MUMPS databases, whereas others have succeeded in modernizing their database programming. It is very unusual for a healthcare organization to have all of its databases running on one vendor’s product. Furthermore, mergers, acquisitions, and breakups occur at a pace that does not allow the applications and associated databases to be modified and converted for uniformity. (And this doesn’t even include the necessary time lags for implementation and training and the inevitable budgeting and staffing shortages.)

**PACS.** Picture archival and communications system (PACS) is currently the preferred method of diagnostic image distribution. Although PACS today is limited to radiology applications, there is great interest in extending this technology to the fields of pathology, dermatology, cardiology, ophthalmology, and other telemedicine areas. The heart of PACS is image acquisition from whatever unit generates the diagnostic image to the proper display of that image wherever and whenever required. Image archival functions have traditionally also been handled by PACS.

**RIS.** Radiology information system (RIS) is the system through which patient examinations are logged and given a unique study identifier (accessioned). The patient location and the examination status data are both tracked as the examination progresses until the examination is finalized and the result is reported. Many applications also provide registration, scheduling, incident reporting, quality assurance, file folder management, material management, teaching file management, human and technical resource management, and billing functions.

**PACS and RIS Integration.** PACS and RIS have traditionally been discrete information systems with separate databases. But as already noted, maintaining more than one database containing identical data sets creates the potential for outdated information being used in parallel with accurate information. Because of increased implementation of PACS and improvements in Web technology, a resolution to this conflict is needed. Various forms of PACS-RIS brokers have been developed and implemented. Although communication between PACS and RIS is established by means of these brokers, the issue of database ownership is not addressed. IHE (Integrating the Health Care Enterprise) is an initiative jointly sponsored by HIMSS and the RSNA (Radiological Society of North America) to define the interoperability requirements using existing standards. The issues covered by IHE are beyond the scope of this article, and the reader is referred to the two sponsoring organizations for additional information.

**Why Separate Systems?** Optimally, every healthcare organization should have only one information system to address all the needs of all users through a single database. But most organizations today are not sufficiently advanced (or backward) in technology to achieve this goal.
RIS implementation is generally undertaken when the HIS cannot adequately address the needs of radiology, or the practice group that manages the radiology operation needs or desires to segregate their data from the HIS data. Requirements that drive RIS acquisitions include scheduling, insurance and billing, waiting room and throughput management, technologist and file room management, film file control, report transcription and results reporting, quality assurance needs and requirements, regulatory compliance issues, educational and research needs, and management reporting.

PACS is generally implemented to give simultaneous access to diagnostic images without regard for the viewer’s geographic location. In most cases, the decision to purchase a PACS is made primarily based on savings, which are achieved in film usage, reprinting and copying costs, processor chemicals and service contracts, film room staffing, film storage, and archival costs. Legal liability costs resulting from lost examinations or images, increased efficiency and throughput in the clinics and offices, reduced lengths of stay, increased operating room turnaround, enhanced real-time medical decision making, and reduction of unnecessary or duplicated tests due to real-time consultation capacity also are significant. Improved physician and patient satisfaction, ability to increase catchment area, ease of staff recruitment, and competitive advantage with insurance contract negotiations are also issues that must be considered.

The Problem

The drastically different goals that drive the acquisition of a RIS or a PACS have resulted in systems that perform very divergent functions. Traditionally, the RIS manages department work flow, billing, and results reporting, whereas PACS manages the image archive and distribution. This traditional division of labor is no longer valid. Because of improvements in hardware and software, and based on marketplace experience gained, RIS vendors are beginning to assume tasks that traditionally belonged to PACS while PACS vendors are doing the same for RIS functions. Some basic functionality is thus shared between the two systems. Image interpretation is an area to which both systems lay claim. The following examples demonstrate real-world difficulties that exist with PACS-RIS integration.

Example 1: Patient Demographic Information. Simple facts—such as the accurate spelling of a patient’s name—are critical to the correct functioning of a RIS and a PACS. RIS needs to assure that all reports and bills reflect the correct spelling. PACS image archives generally follow the DICOM standard. This standard incorporates patient demographic information, including the name, in the DICOM header data. Using the DICOM standard allows the compliant image acquisition devices (CT, MR, ultrasound) to receive directly from another system the demographic information for the next patient who will be examined. If an error exists in that information, it will be propagated. Demographic information must be standardized between RIS and PACS.
**Example 2: ADT Information.** ADT (admission-discharge-transfer) information is valuable to many hospital clinical systems. RIS requires this information when transport or a ward must be notified that a patient is required for a scheduled study. Federal law stipulates how certain outpatients are to be billed for outpatient services if they are subsequently admitted as inpatients to that facility within seventy-two hours of an examination. Consider also the situation in which a patient’s room is changed while that patient is undergoing examination in radiology. Awareness of the patient’s ADT status is important in all these situations. ADT information is also crucial if diagnostic images are to be routed to a patient’s ward after an examination. The system controlling image routing needs to be aware of that patient’s ward.

**Example 3: Physician Order Entry.** A critical component of RIS functioning is order entry. For a physician to order an examination on-line, a large amount of demographic and specific patient and study-related information must be included as part of that order. Patient name, medical record number, allergies, special precautions, transport method, examination type, priority, clinical indication, and relevant history are some examples of necessary data. When an order is successfully entered, on-line scheduling or notification of the scheduled examination time is useful to the physician, the patient, and other caregivers. In the situation where PACS controls the image archive and prefetching functions, PACS also needs to be aware of the newly scheduled examination to prefetch and route any relevant prior examinations in a timely manner. Assuring that the ordering physician is ordering the examination on the correct patient and that any contraindications, allergies, and existing and recently completed similar orders are available for easy view are basic requirements for on-line order entry. Unfortunately, these data elements likely exist in another or several disparate databases. Assuring that the ordering physician is accessing the most recent and up-to-date data is critical.

**Example 4: Image Archiving and Prefetching.** An example of an emerging problem in PACS and RIS integration is the control of the image archiving and prefetching process. Traditionally, image archiving and retention of the archive address where the image is located has been a PACS function. Based on RIS notification of a scheduled exam or the arrival of an unscheduled patient, PACS would extract (prefetch) the previous imaging studies from the appropriate archives (in anticipation of a request to compare the current exam to the previous exam) and copy them to a location from which they could be rapidly accessed. In this case, the PACS controls the archive and the PACS database is the “official” database of image locations. Some RIS vendors are assuming this role. By overseeing archival functions and issuing DICOM commands to prefetch and copy images and examinations to various locations, RIS vendors are emulating some traditional PACS functions. Users wishing to view a patient’s images may have different results depending on whether they are doing this from the RIS or the PACS. The RIS may have previously issued a prefetch command, and therefore the RIS user receives the image rapidly. The
PACS that did not prefetch the examination and is unaware that the exam is available at a given location would be busy obtaining the examination again from the slow archive. The PACS user is delayed by this lack of integration.

**Example 5: Radiology Report Transcription.** Preparing a radiology report requires that all demographic data on the patient and the examination be accurate. The correct spelling of the patient's name and current, updated referring physician's address are some of the features that are subject to change. Those changes need to be reflected in the report.

**Example 6: The Radiology Report.** When the PACS and RIS can exchange data, the display of radiology reports on the PACS station along with the image is a basic function offered by all current PACS vendors. Some RIS vendors supply a rudimentary X-ray image viewing capability. Both these RIS and PACS products then allow the patient's X-ray image and the report to be viewed. This is not a problem unless more than one of these systems is archiving what it considers to be the final version of the report. If the PACS and RIS both archive a copy of the report and one user on the RIS later amends the report, different versions of it would exist simultaneously. Even if the RIS and PACS were configured so that if one report is updated it must broadcast the report for the other to receive the updated version, the issue of interrupted communications needs to be addressed. If communication between the PACS and RIS is interrupted (network or interface failure), then the other system will fail to receive the broadcasted revision and different versions of the report will still exist on both systems.

**Solutions**

Solutions to these issues can be categorized as *active-passive, centralized,* and *decentralized.* Active-passive applications delegate all database activity to the active application, with local user data entry or display functions relegated to the passive application. The centralized approach requires that one database be given control of one data object (such as medical record number). The actual record containing multiple objects (name, allergies, surgical history) might be scattered among several databases, but there is no duplication of objects. The decentralized approach allows for disparate databases to be used for different data elements or objects. In this way, the centralized and decentralized approaches can actually work together. Although perhaps not an optimal configuration, this combined approach might be preferable to database duplication. Active applications actually become centralized with respect to a single database object. None of these solutions is mutually exclusive of the other, and all three can be implemented together on RIS and PACS.

**Active-Passive Applications.** Applying the active-passive approach to the radiology report issue (example 5) would require that one system alone archive the report. If we assume that the RIS is charged with report archiving, then
PACS cannot archive or even cache a report. In every instance that PACS requires a given report, it must query the RIS for it.

Applying the active-passive approach to the image archiving issue (example 4) would require that one application assume full responsibility for all database archival functions. For example, if the RIS became the active application, the PACS would have no image database at all! All archival, prefetching, and routing functions would be assumed by the RIS. The PACS would be relegated to image display applications running either locally or centrally. Although this is an extreme approach, it may be appropriate in some telemedicine applications. The inverse can also be illustrated with a browser-based teleradiology application. The critical elements of patient list, patient location, image files, previous reports, and referring physicians can all be stored on the PACS database. The RIS would then not serve any vital database function.

Centralized Approach. In order to integrate the report function between the RIS and PACS, only one system may be the designated “official” keeper of the finalized report. This sounds very similar to the active-passive approach described in the previous section for the radiology report (example 1). However, the issue becomes even more complex if the finalized reports are stored on the HIS. Let’s assume that radiology reports are kept in the RIS until they are finalized by the radiologist and are then transmitted to the HIS for storage with the remainder of the patient record. The RIS cannot be considered a passive application with respect to radiology reports because it is the critical system and database for these reports until the moment that they are finalized by the radiologist. PACS, however, can still be considered a passive application with respect to reports, but PACS has no certain knowledge of which database to query for the latest report. If the PACS user is authorized only to view finalized reports, then PACS must simply query the HIS. However, if a user is authorized to view unfinalized reports, the situation is more complex. Although PACS may initially query the HIS to obtain any finalized reports, there may exist an amended report within the RIS that is not finalized but will supersede the existing finalized report when that process is completed. Therefore, for PACS to display a patient’s reports for a user who is authorized to view unfinalized reports, it must make a series of queries to both the RIS and HIS to determine the status of all reports and then actually retrieve them. Centralization is relative in this case. Finalized reports are archived only in the HIS, but reports in progress are centralized in the RIS.

Decentralized Approach. Although the example of the radiology report (example 5) is directly applicable to RIS and PACS, patient demographic (example 1) and ADT (admission-discharge-transfer) information (example 2) are the types of data that can be captured and stored by multiple systems. Creation and designation of a master patient index (MPI) that will be the “official” roster of patient name spellings and other demographic information does not necessarily mean that every system will update its listing of that information when it was updated in the MPI. These issues are not new, and the resolution
of such issues is always a major step toward the integration of diverse systems. As health insurers and massive healthcare organizations take control of their data, it is a distinct possibility that they may want to control the master patient index for their covered lives. The caregivers would then be required to access the insurer’s or central healthcare databank for proper name spelling and other patient information. Using DICOM-Worklist functions, these demographic data can be directly uploaded into compatible diagnostic units such as CT, MR, and ultrasound, thus eliminating spelling errors and other data corruption. From the insurer’s perspective this is a proactive step that the healthcare organization must take to assure compatibility with the insurer’s data. The organization’s compliance with this requirement may help the insurer maintain an advantage over others during future negotiations with that healthcare organization. The same concept is applicable to large healthcare organizations when negotiating with satellite groups and local practitioners.

Browser-based RIS and PACS user interfaces are becoming quite common. The ability to distribute information, display data, and receive inputs from users throughout an organization without regard to their geographical location while using a single client application has great appeal. These three approaches would all benefit by a method of querying and updating multiple databases simultaneously. Character-based or HTML browser–based database interrogation by users would be difficult using the decentralized approach. This dilemma is solved if the browser-based approach uses XML to query and update the separate databases from a single Web page. Data are no longer duplicated, while the database hierarchy is not visible or relevant to the end user.

By its very nature, XML can serve as a bridge between different databases. The ability to read and update information from one or more databases using a single Web page allows the actual database structure to be invisible to the user. This parallel database reading and updating can eliminate the requirement for data to be copied into multiple databases for various users and applications. From a data management point of view, the utility of XML is staggering.

Using an XML-based transcription module (example 5), a transcriptionist preparing a radiology report accesses the unique examination identification (accession number) from the RIS that receives the patient name, medical record number, and other demographic information directly from the MPI. The insurance information is extracted directly from the billing system. All these data along with the diagnostic image location URL (uniform resource locator) are extracted from the RIS or the PACS in real time through one Web page without the transcriptionist needing to shell into and out of myriad applications and screens (see Figure 2). With XML, a single workstation could be a clinician station, transcription, technologist, nursing, or quality assurance workstation solely based on the log-in and permission status of the user.
Because there is the ability to read and update widely disparate databases without retooling and rewriting multiple applications, the unification of different systems with one common user interface becomes possible and achievable. Whether it is the RIS or the PACS user interface that users need to view depends mostly on their primary functions. Registration, reception, scheduling, nursing, and administration personnel are primarily involved with RIS, scheduling, billing, and HIS functions. An XML user interface that incorporates these functions addresses these users’ needs. Radiologists require a primary PACS user interface when interpreting examinations with immediate availability of RIS, laboratory, and pathology data. XML offers such access.

The IHE initiative and expansion of the DICOM standard should also greatly aid in approaching total integration.

Implications for the Future

XML will not replace the need for communications standards such as HL-7 and DICOM. However, it does offer a new approach to sharing information between applications and users without requiring dedicated interfaces and
vendor-controlled access. In the past, in order to populate one database with data from another both vendors had to cooperate and high payments were usually required. XML offers a new and cost-effective approach to this old problem. Integration of data between myriad users, all deeply engaged in their own issues and agendas, now becomes possible. Figure 3 offers a real worldview of the data exchange needs of multiple users. XML as a route of data exchange is a cost-effective and achievable approach. Until recently, such an accomplishment would have been unthinkable.

Figure 3. Realistic Requirements for Data Exchange
References

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