HIS/RIS/PACS Integration: Getting to the Gold Standard

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EXECUTIVE SUMMARY

- *The technology for acquiring, storing, retrieving, displaying, and distributing images has advanced dramatically in recent years. The push is toward enterprise-wide image management solutions, where digital images from radiology, cardiology, and other "ologies" are seamlessly linked with information from clinical information systems and other databases, and they are accessed seamlessly from a single point of end-user interaction.*
- *The "gold standard" of system integration would provide the platform for improved workflow, patient throughput and patient safety, as well as decreased cost. Unfortunately, the gold standard remains elusive in most healthcare environments, even those with new systems.*
- *One of the earliest issues that plagued the progress of hospital information system/radiology information systems/picture archiving and communication systems (HIS/RIS/PACS) integration was a matter of language between Health Level-7 (HL7) and DICOM. This barrier was solved by the broker—a software and hardware device that accepts HL7 messages from the RIS then translates, or maps, the data to produce DICOM messages for transmission to the PACS. Technologist workflow requires patient and exam information from the RIS to flow to the modality. The broker provides support for this by taking advantage of the DICOM Modality Worklist (DMWL).*
- *Two primary problems are inherent in most brokered configurations. Workflow is driven by paper, and RIS information flows in 1 direction only, which leads to duplicative databases.*
- *Overcoming the limitations of HIS/RIS/PACS connectivity requires industry accepted communication protocols/rules. To facilitate this, the Integrating the Health Care Enterprise (IHE) initiative was developed. The goal of IHE is to provide end-users improved access to critical patient and clinical information across all systems within the healthcare delivery network.*
- *While the IHE initiative began to facilitate more efficient, predictable, and functional integration between disparate systems, vendors still had technology hurdles to overcome.*
- *System integration continues to be significantly hampered, not by technology limitations, but instead by business and political issues. In response to these challenges, several vendors have begun to offer consolidated RIS/PACS solutions and/or HIS/RIS/PACS solutions. Consequently, the prospect of the gold standard appears to be on the horizon. Single vendor consolidated systems are not, however, feasible for deployment in many healthcare organizations, and they are not necessarily the panacea.*

The technology for acquiring, storing, retrieving, displaying, and distributing images has advanced dramatically in recent years. Radiology information systems (RIS) and picture archiving and communication systems (PACS) have become more sophisticated; adopted more logical, effective, and consistent user interfaces; and taken advantage of Web technology, the proliferation of broadband, and faster and better hardware to efficiently distribute images outside the confines of radiology departments. Now the push is toward enterprise-wide image management solutions, where digital images from radiology, cardiology, and other "ologies" are seamlessly linked with information from clinical information systems and other databases, and they are accessed seamlessly from a single point of end-user interaction. For the reasons discussed in this article, the "gold standard" of system integration would provide the platform for improved workflow, patient throughput and patient safety, as well as decreased cost. Unfortunately, the gold standard remains elusive in most healthcare environments, even those with new systems.

This article describes the evolution of system integration to today's integrated image management solutions, and provides guidance to PACS, RIS, and hospital information system (HIS) purchasers on how to ensure that the technology they choose provides the right platform for achieving or progressing toward the gold standard of system integration.

Background

One of the earliest issues that plagued the progress of HIS/RIS/PACS integration was a matter of language. Healthcare information systems communicate using a standard protocol—Health Level-7 (HL7), which carries patient data between billing and information systems (Figure 1).

In close parallel, imaging systems, including radiology imaging modalities—e.g., computed tomography (CT), magnetic resonance imaging (MRI), and PACS—all employ the Digital Communications in Medicine Standard (DICOM) to communicate information related to digital images.

The language barrier made it impossible to transfer patient and/or exam information electronically. In early implementations, technologists were required to use a paper requisition printed from the RIS to enter patient and exam data manually into the modality to properly "label" the digital images. This task was prone to error and was time consuming.

Modalities were not the only imaging systems requiring electronic data. The PACS used scheduling and historical report information to facilitate the workflow around softcopy interpretation. The HL7 to DICOM barrier inhibited data flow to PACS. Paper was still needed to overcome the language barrier. The radiologist used paper requisitions printed from the RIS to create queries in PACS to locate exams waiting for interpretation.

Broker Solutions

To solve the language barrier, a translation was needed between HL7 and DICOM. Enter the broker: a software and hardware device that accepts HL7 messages from the RIS then translates, or maps, the data to produce DICOM messages for transmission to the PACS. With RIS information now available electronically, PACS and modalities could accept RIS data (Figure 2).

Technologist workflow requires patient and exam information from the RIS to flow to the modality. The broker provides support for this by taking advantage of the DICOM Modality Worklist (DMWL). Scheduling messages are transmitted from the RIS to the broker and stored. The technologist is then able to request the list of scheduled studies by sending a query from the modality to the broker using the DMWL service. The result of the query would, in effect, provide a list of technologists' "work to do" (Figure 3).

Limitations of the Broker

Two primary problems are inherent in most brokered configurations. Workflow is driven by paper, and RIS information flows in 1 direction only, which leads to duplicative databases (Figure 4).

Paper-Driven Workflow

In a typical paper-driven radiology workflow, technologists are made aware of their "work to do" by the presence of a paper exam requisition. The requisition is printed near the technologists' work area, signaling a patient's arrival.

If the modality does not support DMWL, a technologist must manually key the relevant information into the modality. Mistakes in the manual entry of data are inevitable. Sites installing PACS and PACS vendors often estimate error rates of 30%. While those estimates may be based on anecdotal evidence, they demonstrate the fundamental weakness of a paper-driven workflow. For example, if a technologist types the incorrect medical record number into the modality, the resulting digital images may be lost in the PACS and not tied back to the correct patient information. The examination may not be interpreted, not be billed, and, most concerning, the procedure may go undiagnosed, risking patient safety.

If the modality supports DMWL, a technologist still needs to locate the correct patient and exam (Figure 5). Often the modality worklist contains multiple patient exams; therefore, locating the correct match can be challenging and time consuming. The technologist may still need to type the exam's accession or identification (ID) number into the modality to locate the matching exam or wand a barcode

Figure 1.
HIS/RIS/PACS Compatibility Issues.

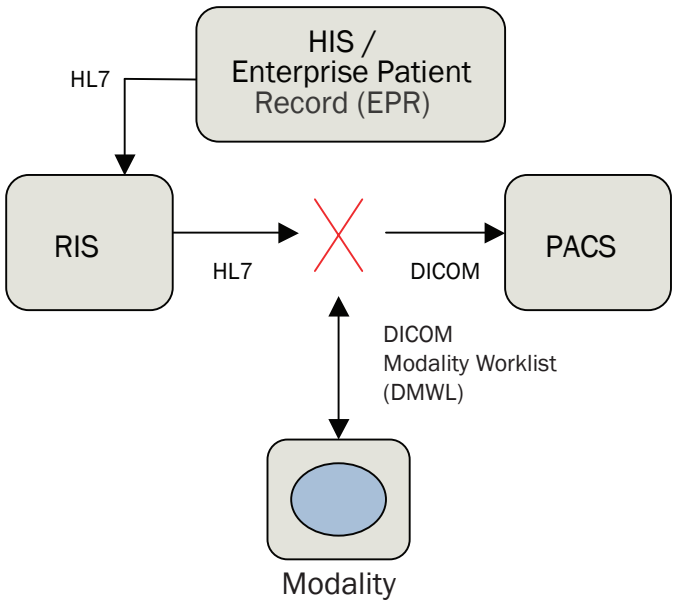


Figure 2.
Unidirectional Brokered Integration.

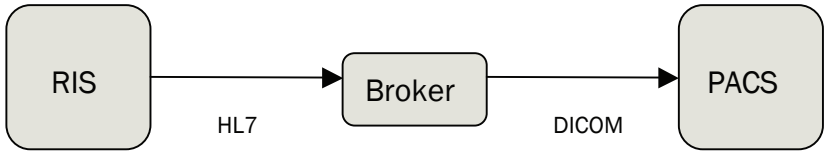
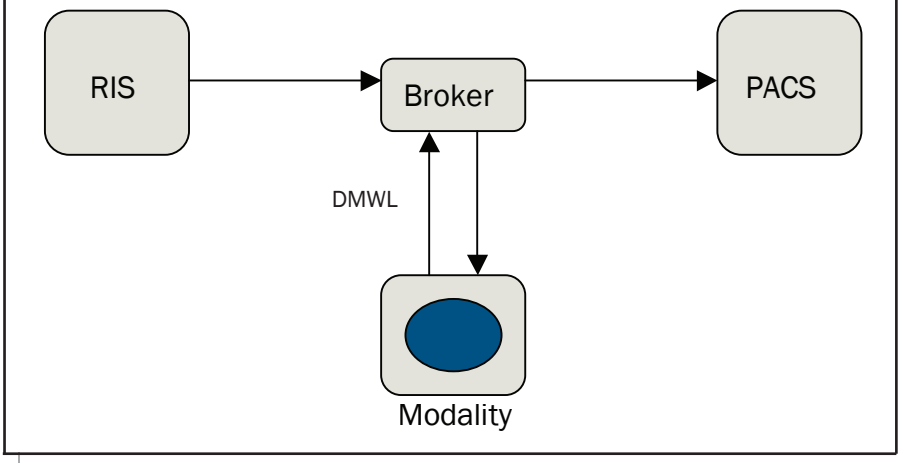


Figure 3.
Modality Query for Patient and Exam Information.



printed on the paper exam request. In both scenarios, there is risk of selecting another patient or exam and acquiring the images using the wrong patient's data.

Unidirectional Dataflow/Data Duplication

In most brokered configurations, information flows in 1 direction—from the HIS to the RIS to the broker to the PACS. As a result, information is duplicated in the RIS, the broker, and the PACS. To ensure data integrity, a single database must be designated as the "master."

The RIS is the master file for all radiology information. All additions or edits to patient data, schedule, and administrative information are managed by the RIS. Sub-systems using RIS data must seek validation and update directly from the RIS to ensure data integrity. A brokered configuration often breaks this rule when validating the information contained in newly acquired images. As examinations are scheduled in the RIS, HL7 messages containing information about the patient and scheduled exam are transmitted to the broker. The broker stores the information and makes it available to the PACS when required (Figure 6).

Newly acquired images are transmitted to the PACS. As images are received successfully, the PACS must verify that the patient and exam information contained in the images are correct and valid. The PACS performs this verification by using the RIS information stored in the broker (Figure 7). If there is a match, the PACS continues to perform functions. If there is a discrepancy, the images are flagged as a "broken study," grouped with other "broken studies" and isolated from the studies that are ready to be viewed by a radiologist. The broken studies must be manually reconciled with patient and order information before they can be read. This process is both time-consuming and costly but unavoidable because proper interpretation and diagnosis may not be possible until the exam has been properly verified and associated with the correct patient, thereby alerting the radiologist of the patient's prior studies and prior reports.

The Role of the IHE

Overcoming the limitations of HIS/RIS/PACS connectivity requires industry accepted communication protocols/rules. To facilitate this, the Hospital Information Management Systems Society (HIMSS) and the Radiological Society of North America (RSNA) established an initiative called Integrating the Health Care Enterprise (IHE). The goal of the IHE is to provide end-users improved access to critical patient and clinical information across all systems within the healthcare delivery network.

IHE had the difficult task of establishing a set of common integration protocols across major industry competitors. The IHE does not establish or define new stan-

Figure 4.
Issues Inherent in Broker-Based Workflow

Paper-Driven Process	Unidirectional Data Flow/Duplicate Data
• Paper is easily lost/destroyed	• Source is unaware of updates/workflow downstream
• Management is time-consuming	• Corrections should only be made in the source system
• Storage is costly	• Requires recycling of messages for updates to flow downstream
• Risk to patient confidentiality	• May lead to lost data, as recycled messages may overwrite other messages
• Promotes manual entry of data	• Increases data management
• Generates duplicate data	• Must be kept synchronized
• Relies on human intervention	• Risk of being out of date
• Introduces data integrity issues	• Requires data mapping
• Resources may be wasted if paper is not available when resource are	• Difficult to manage updates

dards; it provides a framework by which existing standards are to be used. The IHE recognizes HL7, DICOM, and Clinical Context Object Workgroup (CCOW), as well as other established standards. To construct the IHE Technical Framework, a common language was required (Figure 8).

Each integration issue is defined, and an IHE committee establishes standards-based solutions—IHE integration profiles. These profiles set functionality, thereby establishing a convenient way for users and vendors to communicate using standards. They are derived from true, real-world situations and provide crisp solutions. Unlike most standards alone, IHE integration profiles are specific and do not leave a large degree of variability of interpretation.

IHE participating vendors are required to incorporate the profiles into their products within specified timeframes. IT consumers may view a particular vendor's product to determine if that product supports the integration profiles required by that customer's IT environment. This provides the customer, for the first time, a truly powerful set of "integration based functions" to evaluate potential or current systems (Figure 9).

Figure 5.
Tech Re-queries Broker for Updated Information.

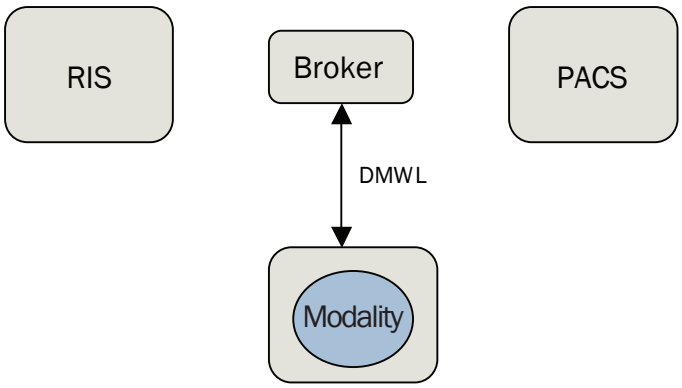


Figure 6.
Unidirectional Brokered Integration.

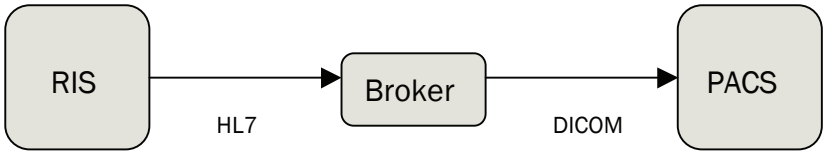
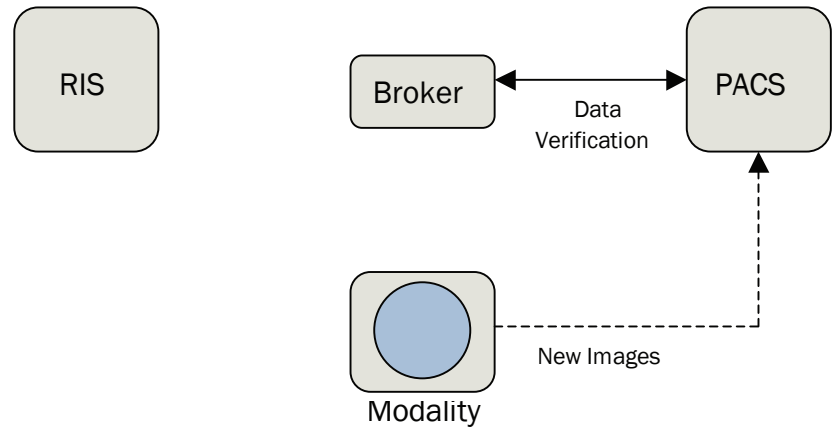


Figure 7.
PACS Requesting Image Data Verification.



Second Generation Integration

While the IHE initiative began to facilitate more efficient, predictable, and functional integration between disparate systems, vendors still had 5 primary technology hurdles to overcome:

- The RIS needed to integrate directly to imaging modalities.
- The RIS needed to have bidirectional communication to PACS.
- RIS and PACS functions needed to be integrated on the desktop, providing the radiologist full access to RIS information from the PACS workstation.
- Dictation or voice recognition needed to be integrated to the RIS and PACS.
- The electronic patient record (the point of system access for referring physicians) needed to be image-enabled—i.e., linked to radiology reports and allowing the end-user to launch PACS image viewing within the enterprise patient record (EPR) user interface.

The first 2 challenges are met by the RIS natively supporting DICOM. In integrated (non-brokered) solutions, DMWL is managed directly from the RIS without the intermediary step (and separate database) associated with a broker (i.e., no need to use the broker to translate HL7 messages to DICOM or send DICOM header information to the modalities). To enable bidirectional connectivity, the PACS supports queries for updated information by the RIS and sends updates to the RIS as new images or changes in status take place in PACS. Note that some PACS configurations continue to use the broker technology, but they reduce the broker

Figure 8.
Commonly Known Systems with the IHE Terminology.

Common Industry System	IHE Actor	Core Function
Hospital Information System (HIS)	ADT	Registration (Admission, Discharge, Transfer)
Hospital Information System (HIS)	Order Placer	Order Entry
Radiology Information System (RIS)	Order Filler	Patient Registered Order Entry Procedure Scheduled Modality Worklist Management
Picture Archiving and Communication System (PACS)	Image Manager	Procedure Scheduled Images Stored Images Available
Scanner, Imaging Device (e.g. CT scanner, MRI)	Acquisition Modality	Modality Worklist Management Images Stored

to function as an interface engine and not as a data storage device.

This new era of broker-less integration presented RIS and PACS with many new capabilities. The RIS was now "aware" of workflow milestones within the digital realm. Specifically, the RIS could perform data verification of images directly and store information about the location of the images within the PACS (Figure 10). This awareness and ability to speak DICOM enabled the RIS to issue commands to the PACS. For the first time, RIS-driven workflow commands could be used to control the PACS. RIS-calculated pre-fetching and auto routing routines could be offered to customers. For example, the RIS could request that the PACS move images from an archive to a Web server for distribution of images to a specific referring physician. Up to this point, the management of images had always been viewed as a PACS function.

The PACS also enjoyed new capabilities. The PACS could directly query the RIS to retrieve a wide array of information about a patient, including history and diagnostic reports, which could be assembled into multi-media documents for use by clinicians and referring physicians. This information was not available to the PACS previously, as the RIS sent only a limited sub-set of information to the broker.

The third challenge requires a feature for enhanced integration of disparate systems—in other words, desktop integration. This integration provides the radiologist with full access to information in the RIS directly from the PACS workstation (i.e., eliminating the need for separate and distinct RIS and PACS workstations). With desktop integration, radiologists now have the ability to access a RIS worklist that provides a robust view of work to be done, including any exam status, and access to the full patient history, including both digital and analog history (reports). Once the radiologist selects an exam on the RIS worklist, the information, patient and exam level context, is transmitted to the PACS workstation requesting it to launch the associated images. While viewing a patient's images in PACS, the radiologist can also view RIS information. The radiologist is presented with a RIS window containing the actual RIS report in real time. This real-time view provided directly from the RIS is guaranteed to be accurate and up to date, and it removes the need to duplicate RIS data.

To facilitate production and workflow, the fourth requirement—dictation or voice recognition—must be integrated into the desktop. The lack of desktop integration results in reliance on paper and manual intervention by the radiologist. To initiate dictation, the radiologist must barcode a paper requisition on a corresponding patient's exam, manually enter an exam ID into the dictation system, or search and select the matching data from a list. These methods are prone to error, are time consuming, and interrupt the workflow.

Desktop integration between the RIS, the PACS, and the report creation system alleviates the need for manual intervention by the radiologist. The newer generation of report creation systems (voice recognition systems, digital dictation systems, and structured reporting packages) capable of desktop integration provides access from either a RIS or a PACS user interface. A user may initiate a report by selecting a button on the RIS or the PACS user interface. This action electronically transfers patient and exam information to the report creation system. The end result is accurate report generation and uninterrupted workflow for the radiologist.

Finally, desktop integration is the foundation that enables bidirectional RIS/PACS communication and RIS/PACS reporting. From a technology standpoint, it is then a relatively straightforward task to image enable the EPR application. The PACS notifies the RIS that digital images are available. The RIS, in turn, incorporates a "tag" (i.e., a unique identifier that points to a particular study) within the diagnostic report reflecting that PACS images are associated with the report. The RIS sends an HL7 message to the HIS/EPR that a report and associated images are available for viewing. The end-user (e.g., referring physician) is able to review completed reports in the HIS/EPR application and access images by

launching the PACS viewer from within the EPR user interface (i.e., the user clicks on a standard hyperlink, which launches the PACS viewing application and notifies the PACS application, by reference to the unique study identifier in the tag, to retrieve the applicable images).

The Next Generation of Integration

With pressure from the IHE and industry leaders, certain—but not all—HIS, RIS and PACS vendors have cooperated to improve integration of best of breed systems. Full second-generation integration as described above, however, is the exception, not the rule. System integration continues to be significantly hampered, not by technology limitations, but instead by business and political issues. Many PACS vendors continue to resist robust desktop integration because these PACS vendors want their PACS, not another vendor's RIS, to drive image management and workflow. At the same time, many clinical information system vendors have refused to cooperate in image enabling their electronic patient records (i.e., enabling users of electronic patient records to launch a third-party PACS viewing application within the EPR user interface). These vendors want to protect their interest in the EPR desktop so that customers will purchase their enterprise image distribution and viewing systems.

In response to these challenges, several vendors have begun to offer consolidated RIS/PACS solutions and/or HIS/RIS/PACS solutions. In certain instances, these systems combine to share a single database and merge functionality to produce a fully image enabled radiology information management system. Such systems have begun expanding to incorporate cardiology data and image objects, and the roadmap calls for further expansion into management of all enterprise digital images.

These single-vendor systems promise to remove the duplication of data and associated data synchronization issues, and thus deliver the ultimate in performance, and access to information and images. Consequently, the prospect of the gold standard of integration appears to be on the horizon. Single vendor consolidated systems are not, however, feasible for deployment in many healthcare organizations, and they are not necessarily the panacea. In certain instances, vendors claiming to provide integrated solution have packaged stand-alone systems without achieving the desired interoperability. In all situations, prudent buyers need to "check under the hood" to examine integration specifications from a functional and technical perspective.

Buyer Beware

When acquiring a HIS, RIS, or PACS (whether a best of breed deployment or single vendor solution), the following set of screening questions will rapidly identify vendors capable of delivering the gold standard and flag those that are not.

- Does the system support bidirectional integration?
  - bidirectional integration using standard-based methods that are compliant with the IHE Technical Framework will provide the best workflow and will enhance the likelihood of a successful implementation.

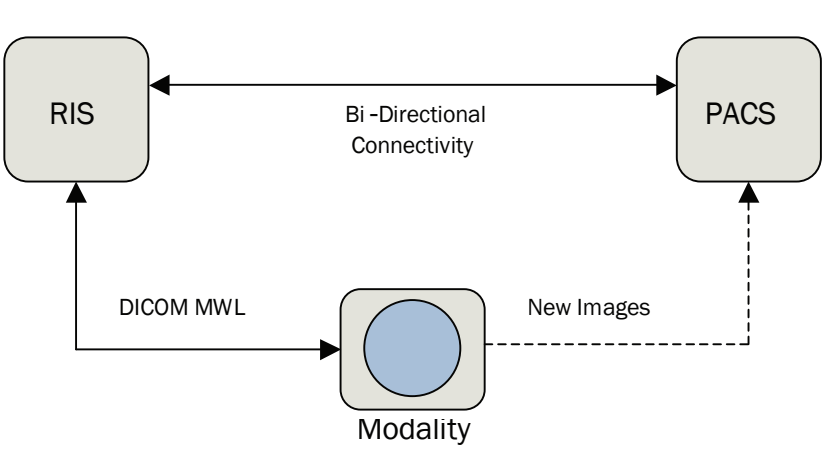
Figure 9.
Why IHE is So Important

IHE:

- Provides a means for vendors to state explicitly their products' integration capabilities
- Allows users to be informed and to hold vendors to their IHE commitment
- Improves service to patients
- Improves service to referring physicians
- Improves efficiency and workflow
- Promotes modernization of imaging and information systems
- Promotes systems integration
- Enables healthcare organizations to achieve clinical goals
- Promotes the use of standards; removes the need to use proprietary methods
- Improves the efficiency and effectiveness of clinical practice
- Improves the flow of information
- Enables interaction among multiple systems
- Breaks down vendor walls by providing a common set of languages and rules
- Improves the use of industry communication standards by removing excessive flexibility
- Enables systems to communicate more efficiently
- Streamlines implementation by providing a clear integration framework

- Which system drives the radiologist workflow, the PACS, the RIS, or paper?
  - For the reasons discussed in this article, a RIS-driven workflow is typically viewed as the most effective and efficient way to manage workflow and reduce the incidence of broken studies.
- Are radiology reports duplicated (or stored temporarily) in any system other than the RIS?
  - Because of the costs and risks associated with maintaining duplicate databases with duplicate sets of reports, it is preferable to have a single source for all reports.
- Does the integration include desktop integration between the RIS and PACS and, if so, what level of desktop integration?
  - The more extensive the desktop integration, the better the workflow. Full desktop integration allows PACS users access to information and images in both the PACS and the RIS, while limiting the amount of paperflow, reducing the need for manual data entry (and, therefore, the likelihood of data errors), and eliminating the need to create and maintain duplicate databases containing copies of orders, reports, and other data generated by the different systems.
- Will paper be required for *any* part of the workflow (technologist, radiologist, report generation, etc.)?
  - By eliminating or limiting the use of paper, the need for manual data entry is decreased, which in turn decreases errors. However, paperless workflow is not always possible due to the limitation of some PACS systems and other legacy systems that are used with a PACS. It is, therefore, important for a PACS buyer to know in advance where paper or manual workflow will persist.
- Does the PACS support DICOM queries and requests from third-party systems, including those transmitted by a RIS?
  - Compliance with standard-based transactions is an important element in integrating a PACS with a RIS and other applications (e.g., voice dictation, report creation, etc). Having to develop and implement proprietary interfaces can hamper the overall success of a PACS implementation.
- How are dictation/report creation systems integrated? Does it include desktop integration? Is the integration driven by the RIS, PACS, or some combination?

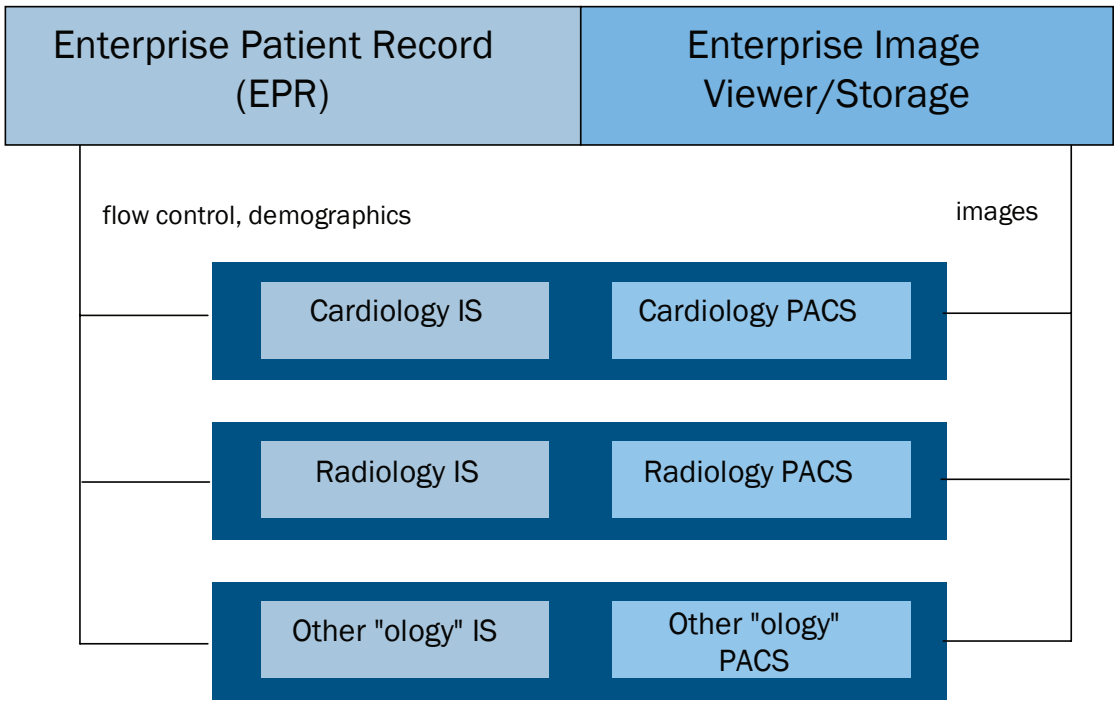
Figure 10.
PACS Requesting Image Data Verification.



  - The integration with dictation/report creation systems is often overlooked and is an area where the use of paper persists (e.g., a paper exam form must be "barcoded" to initiate a dictation session).
- How are images verified (against the RIS directly or by a duplicated database)?
  - Creating and maintaining synchronized duplicate databases presents additional costs and risks (e.g., the possibility that a database may not contain all of the most current and correct data). The best way to limit the risks associated with duplicate databases is to have a single database (e.g., the RIS database) against which images will be verified.
- Does the EPR vendor support an open application-programming interface (API) for integrating third-party PACS viewing systems (i.e., the EPR application integrates with a third-party web viewer, which the user may launch from the EPR user interface)?
  - It is important that the EPR/EMR support the ability to launch a third party webviewer from its clinical results application or web interface. "Image-Enabing" the EMR is a powerful tool and is a critical component of a successful PACS implementation. If the PACS fails to support such an integration, the full benefits of a digital workflow will not be realized, and the overall success of the PACS implementation will be compromised.

If disparate vendor systems will be part of the configuration, a comprehensive multi-vendor integration specification (CMIS) should be developed and included as part of applicable contracts. The CMIS ensures that the workflow goals of the customer are achieved through the careful selection and implementation of best of breed systems. It should be a jointly developed product approved by the customer and all of the involved vendors. The customer should observe the vendors during this process. It is a litmus test to determine

Figure 11.
A Gold Standard Illustration.



the true level of commitment to system integration, and it often sets the tone and frame work for implementation.

The CMIS must include the IHE profiles that are currently supported or will be supported by the vendors. IHE profiles alone are not sufficient. The vendors should be required to include in the CMIS detailed screen shots depicting the desktop integration from each user's perspective (e.g., the radiologist, the technologist, and the clinician). The CMIS should include workflow scenarios and transaction diagrams, with the goal of documenting the flow of information between systems at each phase of the data flow process.

Many of the points of integration described in the CMIS may be "future deliverables." In the CMIS, the parties should clearly commit to dates for promised future features. The majority of integration projects, especially those pushing toward the gold standard, require a phased approach. Even vendors with the best intentions are often held back by legacy technology, closed architecture and large development backlogs. It is often reasonable to accept a phased approach, provided that the vendors deliver a CMIS with all phases and future deliverable dates included.

Conclusion

Over the past decade, the healthcare industry has experienced dramatic advancement in IT and imaging systems. Integration of core systems and the communication protocols connecting them have continued to mature, thereby enhancing workflow efficiencies and quality of patient care. System purchasers need to be educated and savvy, because most configurations do not offer optimal integration, and single vendor solutions do not necessarily result in gold standard integration. The key is to fully examine dataflow and workflow before making purchase decisions, and to require vendor accountability for system integration as part of the contracting process. ☢

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