Demystifying the Hospital Information System/Radiology Information System Integration Process

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Most organizations planning to implement picture archiving and communications systems (PACS) are aware of the need to integrate the hospital information system (HIS) and radiology information system (RIS) with the PACS, yet few are acutely aware of the challenges associated with this requirement. This report highlights the results of collaborative efforts between Children's Hospital Medical Center-Cincinnati (CHMC) applications specialists with expertise in the HIS and CHMC information system, radiology staff familiar with the enterprise and radiology workflow and data flow requirements; and General Electric integration engineers familiar with the SMS HIS and RIS, and GE PACS. CHMC received Board approval, including full funding of the entire PACS project, in October 1998. An aggressive time frame for installation was established, as CHMC's PACS leadership committed to the selection, design, and implementation of PACS and computed radiography (CR) within 18 to 20 months. CHMC selected GE (Milwaukee, WI) as its PACS vendor in July 1999, and began its implementation in November 1999. We will present the four-stage integration process undertaken at CHMC: (1) planning the integration effort, (2) designing the interface, (3) building the interface, and (4) testing the interface.

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INTegration OF THE hospital information system (HIS), radiology information system (RIS), picture archiving and communication system (PAC) will create the required data flow between the information systems, thereby creating such benefits as the single entry of patient demographics, reducing workload for technologists at the modality, and reducing error rates. Traditional hospital information systems such as the HIS and RIS serve as providers of patient information such as admit, discharge, and transfer (ADT) messages, ordering, scheduling, results, and billing. PACS requires an interface to a HIS and/or RIS to correctly associate the patient and examination information with the patient's digital images.

HIS and RIS commonly use the Health Level 7 (HL-7) communication protocol, whereas PACS and connected modalities use the Digital Imaging and Communications in Medicine (DICOM) standard, thereby prompting the need for an HL-7/DICOM interface with properly developed interfaces to relevant information systems and data stores. The de facto standard for the HL-7/DICOM

interface is the Mitra PACS broker. PACS vendors are working to integrate the broker functionality into PACS, yet the issues and process principles in this report will still apply.

PLANNING THE INTEGRATION EFFORT

It is important to align and assess the organization's internal knowledge base before starting the interface design efforts. Many organizations do not possess the necessary in-house resources to complete the integration process. The critical success factors that follow contributed to the design and implementation of a successful HIS/RIS/PACS interface. Children's Hospital Medical Center, Cincinnati (CHMC) completed the interface planning efforts in the initial month of implementation.

Formation of a Multidisciplinary Team to Handle RIS/PACS Integration Efforts

The integration team should include personnel with substantial knowledge of radiology workflow, the enterprise network, and HIS/RIS configuration, capabilities, and message formats. The deeper the skill-sets and experience of the team, the greater the ability to identify process improvement opportunities and pitfalls, and to create interface designs and supporting information systems changes needed to support the new solution. CHMC has undergone formal process improvement efforts over the past 18 months. This endeavor, coupled with Shared Medical Systems (SMS; Malvern, PA) Radiology Management Systems (RMS) version 23 and Lanier implementations, has built a firm understanding of current information flow and workflows throughout Radiology and Information Services staff.

This common understanding dovetailed with in-house expertise with SMS OPENLink, a user-controlled HL-7 interface engine, led to the devel-

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serves as the engine that drives PACS workflow—the prefetching of archived exams, display of acquired images, and the management of modality worklist, and radiologists reading queues.

Each PACS site will be different in its design of the HL-7 environment—different vendors, different architectures, that lead to various information flows and integration strategies. A typical PACS architecture could look like the one shown in Fig 2.

The significant difference is that many sites will use their RIS as the main interface to clinical systems, rather than an interface engine such as SMS OPENLink. Another key consideration is that many sites connect their order entry system into their RIS, rather than the HIS (CHMC). Both differences have triggered active discussions at CHMC as the team reviewed current and future information flows.

CHMC completed the design of the interface over a six-week period characterized by collaborative meetings between the Information System and Radiology staff completing the process highlighted below:

Knowing Data's Role

Human resources serve as the *how* of the integration process; the patient data serves as the *what*. It is important that Radiology and Information System staff know where the data is created, and what data are needed within the radiology environment. CHMC's information systems are configured as follows:

HIS: Interfaces from the HIS to OPENLink

- Scheduling—(to PACS) Scheduling of patient exams will trigger the prefetch of archived images within PACS. This will

allow the reading radiologist to have the historical images for the patient.

- Registration—(to PACS/RIS) Registration serves as the input and edit of patient demographic data.
- Ordering—(to PACS/RIS) Order entry dictate what exam is to be performed. Data such as exam type, body part, reason for exam, and the translation of what will be performed is then transferred to an ICD-9 code (for billing).

RIS: Interface from the RIS to OPENLink and PACS

- Reports/Results (to HIS and PACS)—Signed reports are sent to the HIS (storage) where a copy resides with nonradiology results and PACS at the time of verification.
- Status Updates—"End procedure" triggers status changes in the HIS and PACS.

Assessing the data (input, storage, output) location—who will be entering the original data and its transfer to other systems for storage, output, or as part of another process—is also important. The data must be understood if it is to be usable during all stages of the exam process. This is referred to as timing.

Timing

This refers to the *when* and *where* of the integration process—once the data is identified, the timing is essential because the data is not useful if it is not at the right place at the right time. It is important to note that the complexity of the interface design lies not in the coding (strictly HL-7 on the hospital side), but in the timing of the interfaces to ensure that the needed data arrives at the appropriate time.

Fig 2. Typical digital imaging environment.

Table 1. HIS/RIS Integration Worksheet

Timing	Workflow	Implications for PACS
Exam Scheduled	Exam scheduled via clinic appointment on the Enterprise Scheduling System. Nonscheduled walk-in referrals, emergency patients, same-day surgery patients, and inpatients.	<ul style="list-style-type: none"> • Prefetch historical images the evening before a scheduled exam (ie, 2 AM) • No prefetch on these unscheduled appointments. • A prefetch is triggered by the subsequent order.
Preregistration	All scheduled appointments are preregistered between the time of scheduling and the day prior to exam day.	<ul style="list-style-type: none"> • Patient ADT information sent to PACS and the RIS from the HIS via OPENLink.
Registration	Scheduled appointments, preregistrations are upgraded to full registrations. Walk-ins are registered. Some outpatients, all emergency room patients, all inpatients, and all surgical patients are registered independently of Radiology. Emergency room trauma scenarios—patient information either unknown or not entered at time of exam.	<ul style="list-style-type: none"> • Patient ADT information sent to PACS and the RIS from the HIS via OPENLink. • This ADT will over write existing ADT from the preregistration if changes have been made. • Patient ADT information sent to the PACS and the RIS from the HIS via OPENLink. • For inpatients this will trigger a prefetch of past three exams according to prefetch rules. • An alias system is already in place in the Emergency Department. • Patient information and accession number for exam is merged after the exam.
Order Exam	Order created by HIS. RIS prints requisition in quality-control area or at outpatient facility by clerical staff. Order changed prior to image acquisition.	<ul style="list-style-type: none"> • 16-digit accession number is created at the HIS (11-digit account number and 5-digit order sequence number). • Order message is sent to the PACS and RIS from HIS via OPENLink. • An order is created in the PACS database. If the patient is previously unknown to PACS, a new record is created. • A prefetch by body part and modality type is triggered on PACS for relevant historical studies. This is different from the previous prefetch request in that it is specific to the exam ordered. • The original order is cancelled in the HIS and a cancel order is sent to the PACS and RIS from the HIS via OPENLink. • A new order for the necessary exam changes is then entered into the HIS and a new order message is sent to the RIS and PACS. The new order message contains a new accession number relative to the original order.
Exam Performed	Exam performed at modality. If a change order is required for an exam after image acquisition. End procedure tracking step	<ul style="list-style-type: none"> • Images are sent to the PACS and added to the patient record. The exams status on the PACS remains in an ordered (nonverified) state. • A new order for the necessary exam changes is then entered into the HIS and a new order message is sent to the RIS and PACS. The new order message contains a new accession number relative to the original order. • Using a PACS administration terminal, the new order with the correct exam information is merged with the original order containing the images prior to either of the exams being verified. • The original order is cancelled in the HIS and a cancel order is sent to the PACS and RIS from the HIS via OPENLink. • Exam is then marked as completed at the RIS. • The exam update message is sent to PACS and the HIS from the RIS via OPENLink. • The PACS maps this message to an order update and updates the PACS order with any new information. • Exam status is set at "arrived" in PACS.
Post-Procedure	Technologist performs a quality assurance review of the images.	<ul style="list-style-type: none"> • Study marked as "verified" after quality assurance. • Verified study is then sent to both long-term and short-term storage, thereby appearing on the radiologist's reading worklist.
Read Exam	Radiologist soft-copy reviews study at PACS workstation.	<ul style="list-style-type: none"> • Radiologist dictates report using integrated Lanier dictation system and marks the exam as "dictated" at the PACS workstation. • Transcriptionist enters preliminary report on the RIS. • Radiologist reviews and edits preliminary report and approves the report at the RIS. • A finalized report message is generated at the RIS and sent to the PACS and HIS. • A final report is displayed at the PACS workstation.

Table 1 is a worksheet used by our team highlighting CHMC's integrated workflow and information flow for a scheduled diagnostic examination in a PACS environment:

Each site will have a different integrated environment. The worksheet in Table 1 provides an example of how the HIS/RIS and PACS may interact. The final design of the PACS environment will be impacted by the technologies in place, the desired radiology workflow, and the skill-sets of the integration team.

BUILDING THE INTERFACE

Using worksheets like the one in Table 1 and the GE-provided PACS interface specification, the interface coders at CHMC developed the necessary HL-7 interfaces. CHMC created three new interfaces and altered an existing interface. CHMC took the existing ADT interface between the HIS and RIS, copied it, and modified it for PACS. The scheduling, orders, and results interfaces were created from scratch.

After the initial coding, CHMC then sent sample HL-7 transaction messages (ADT, order, result, and schedule) to GE for validation. GE then mapped the hospital's message structure into the broker. The last test before the interface was built into the broker was to verify that the broker received the messages from OPENLink and passed the correct data through to PACS. Issues such as the addition or subtraction of leading zeroes or special data mapping or manipulation requirements were identified and solved. CHMC completed building and initial testing of the interface in 5 weeks.

TESTING THE INTERFACE

End-to-end testing can begin once the HIS/RIS/PACS interface has been integrated on the HIS, RIS, and PACS, basic connectivity testing is completed, and the PACS database is configured. End-to-end testing is the process whereby the interface is tested for full functionality as outlined below. CHMC completed this phase within 3 weeks. The following highlights various aspects of the testing process:

- (1) *Testing Equipment*—All testing was done on the pre-production PACS environment. One

important note is that the team used GE's database consistency checker (DBCC) data server in the testing to avoid cluttering up the main archive with test data and images.

- (2) *Functionality Testing*—The team tested the GE-designed message processing requirements that reviewed the proper transmission and receipt of ADT, order, and results messages. Additional functionality, such as DICOM Modality Worklist, data manipulation (proper data mapping and report header creation), and PACS broker's ability to process the exam-verified message sent from the PACS, is also tested.
- (3) *Workstation, System Administration Functions, and DICOM Gateway Testing*—Once step 2 was completed, a PACS workstation, system administration workstation, and DICOM gateway workstations were then configured for testing the exam order messages (such as routine or stat exam, change order, cancel order, and begin procedure), patient ADT messages (such as admit, transfer, discharge, outpatient registration, change patient information, and patient merge), and report transfers (such as preliminary, finalized, and amended reports).

Clinical release of the PACS begins once the above testing processes are successful. Modality integration efforts commenced once the HIS/RIS/PACS interface was proven to be stable.

CONCLUSION

The challenge to create accurate interfaces between an organization's information systems can be daunting, but without this integration, a PACS system will create disappointment at the clinical user level. Multiple vendor environments, insufficient in-house resources, undefined budgets, and limited timeframes all add to the common perception that all HIS/RIS/PACS integration efforts are difficult. CHMC has benefited from the skill-sets and experiences of its HIS/RIS Interface Design Team, an outside consulting group, and strong communication with GE and its engineers.