Foreign Exam Management in Practice: Seamless Access to Foreign Images and Results in a Regional Environment

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Abstract A challenge for many clinical users is that a patient may receive a diagnostic imaging (DI) service at a number of hospitals or private imaging clinics. The DI services that patients receive at other locations could be clinically relevant to current treatments, but typically, there is no *seamless* method for a clinical user to access longitudinal DI results for their patient. Radiologists, and other specialists that are intensive users of image data, require seamless ingestion of foreign exams into the picture archiving and communication system (PACS) to achieve full clinical value. Most commonly, a clinical user will depend on the patient to bring in a CD that contains imaging from another location. However, a number of issues can arise when using this type of solution. Firstly, a CD will not provide the clinical user with the full longitudinal record of the patient. Secondly, a CD often will not contain the report associated with the images. Finally, a CD is not seamless, due to the need to manually import the contents of the CD into the local PACS. In order to overcome these limitations, and provide clinical users with a greater benefit related to a patient's longitudinal DI history, the implementation of foreign exam management (FEM) at the local site level is required. This paper presents the experiences of FEM in practice. By leveraging industry standards and edge devices to support FEM, multiple sites with disparate PACS and radiology information system (RIS) vendors are able to seamlessly ingest foreign exams within their local PACS as if they are local exams.

Background

In 2001, Canada Health Infoway (CHI) was created and funded by the Canadian federal, provincial, and territorial governments with the goal of "One Patient, One Record." The objective for this mandate is to set up an environment where a patient can travel across different regions in Canada and, regardless of where they travel, have their health records available for any qualified clinical user.

As part of this overall objective, the goal of making diagnostic images and exam results more readily available is managed at the provincial level. In Ontario, a government agency—eHealth Ontario—oversees the implementation of the provincial eHealth strategy, which includes the creation of four shared diagnostic imaging repositories (DIRs). The details in this paper focus on the work accomplished in one of the four DIRs established in the province, Hospital Diagnostic Imaging Repository Services (HDIRS), which manages the DIR for sites in the Toronto-East region of Ontario.

HDIRS Environment

The HDIRS DIR uses Agfa's IMPAX Data Center solution. There are currently 74 individual sites publishing diagnostic images and results to HDIRS, totalling over 3,500,000 exams per year. The contributing sites make up 33 separate identify pools, 21 unique PACS databases, and 8 unique PACS vendors with various implementation standards and conventions, which present potential challenges for seamless sharing. The

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breakdown numbers of contributing sites related to the respective PACS vendor are as follows:

- 16 Agfa sites
- 1 Carestream site
- 1 Fuji site
- 19 GE sites
- 26 Intelerad sites
- 7 Philips sites
- 2 RSS DiMed sites
- 4 SECTRA sites

HDIRS covers over 150,000 km^2 (58,000 mi^2) and serves over 4 million people.

In order to ensure that all stakeholders possess a common understanding of the term *foreign exam management*, the following definition was developed by the CHI Standards Collaborative Working Group 10: *foreign exam management: an instance of a radiology exam with images and/or reports that were originally acquired outside of the local enterprise* [3].

There is increasing attention on health information exchanges (HIEs) that provide the ability to discover and access information from multiple facilities across a region. Typically, an HIE will leverage the integration profiles contained in the integrating healthcare enterprise (IHE) such as cross-enterprise document sharing (XDS). In the imaging component of an HIE, like HDIRS, the IHE profile cross-enterprise document sharing for imaging (XDS-I) is leveraged to provide access to the information through the use of a regional viewer. Despite the fact that XDS profiles are useful in the discovery of records, and aid in the access through shared viewers, they do not fully address the needs of all clinical users in the diagnostic imaging environment.

Historically, in a hospital/clinic environment, diagnostic images reside only within the PACS where the images were originally acquired and are only available to healthcare providers who share the *same* PACS system. Conversely, within a DIR environment, when foreign exam management is applied, authorized users are able to access images and/or reports that were originally acquired *outside* their local PACS in a way that is consistent with accessing images that were acquired locally [2].

The contributing sites that send DI content to HDIRS make up over 33 separate patient identity pools. HDIRS does not use an electronic master patient index (EMPI) to match a patient's longitudinal records; therefore, all contributing sites must include the patient's Ontario health card number (HN) in the order, which is used as the global identifier across all of the sites. The IHE profile, multiple image manager/archive (MIMA), was created to allow multi-enterprise regional environments to support multiple patient identifier assigning authorities [1]. Unfortunately, the MIMA profile is currently not an appropriate option for the HDIRS environment, as one of the required values (issuer of accession number sequence) is not currently fully supported by the DIR solution or any of the ingesting local PACS vendors.

The import reconciliation workflow (IRWF) IHE profile discusses the efficient importation of digital imaging and communications in medicine (DICOM) patient data from an external source (i.e., transferred on CD-ROM, transmitted electronically, delivered from film, etc.). There are some principles of IRWF that were applied and leveraged to effectively execute FEM; however, the current IRWF profile does not cover many required use cases and feature functionality such as the following:

- Import of prior exams (via pre-fetch "pull" or "push" or from removable media)
- Typically, "priors" need to be handled differently by an image manager/archive

- Flushed from the system rather than archived
- Configurable behavior on the timing for this flushing that differs from normal workflow exams
- Flushing of foreign exam study records from database rather than just deletion of image files/objects
- A new exam order may be required to properly manage a foreign study [2].

Typically, a local PACS is not built with the ability to properly manage foreign exams. The local PACS will often have trouble differentiating a foreign exam from a local exam, and a local PACS is not usually built with the ability to pre-fetch foreign content for which the local database has no record. We suggest that an expansion of the IRWF profile that addresses the limitations listed above could be a standards-based approach to handling FEM from a local PACS perspective.

The HDIRS sites that have the same PACS vendor as the DIR solution were able to natively pull foreign exams from the repository as there is proprietary functionality between the site PACS and DIR solution; however, customizations were required to the local PACS systems to support FEM, and work continues to refine the pre-fetching capability. The rest of the HDIRS sites required a proxy server to provide the ability to fetch, retrieve, and ingest foreign exams.

Methods

Phase 1—FEM Without a Proxy Server

By leveraging proprietary functionality when a site PACS and the DIR solution are of the same vendor, a number of sites were able to natively look up and retrieve longitudinal exams

without the use of a proxy server. As previously mentioned in this paper, the Ontario HN is used as the means of matching a patient's longitudinal records across multiple facilities. When exams are published to the DIR, the Ontario HN value is mapped to populate the DICOM tag "Other Patient ID Sequence" (0010, 1002). The local PACS sites do not support the ability to query based on the DICOM tag "Other Patient ID Sequence"; however, the local PACS is able to query based on a private tag reserved for a global patient identifier (GPI). This private tag is configured to cross-reference with the "Other Patient ID Sequenced" located at the DIR, which allows these sites to discover and retrieve longitudinal matches.

Longitudinal records are ingested through the use of either foreign pre-fetch or an ad hoc search. Foreign pre-fetch is triggered when a local order is placed for a patient; at this point, the PACS will natively attempt to query and retrieve the set number of "relevant" years and exams that match the patient's Ontario HN. If a clinical user wishes to see if there are other longitudinal records that did not qualify in the pre-fetch, a manual search is possible through the client.

From the local PACS patient jacket, the user will see an option to "Find other studies in Enterprise." If the user selects this option, the PACS will then perform a longitudinal query against the DIR, searching for patients with a matching Ontario HN. If additional records are found, the patient jacket will indicate how many exams were discovered.

A clinical user can select a foreign exam from the "found results" and retrieve images from the DIR and/or view the report immediately.

By default, the PACS does not discriminate between a local and a foreign exam; as a result, customizations were put into place that allows the PACS to properly manage foreign exams. A concern that motivated one of the customizations was the risk of ingested foreign exams becoming "stale" in the local PACS. This can occur if subsequent changes are made to the exam at the originating site after it was consumed by another site. To address this concern, a deletion script was created and rolled out at all applicable sites to ensure foreign exams are purged from the local PACS after a set period of time (e.g., 8 days). The integration profile image object change management (IOCM) specifies how one device may communicate DICOM level changes on existing imaging objects to other devices that manage copies of the modified image objects. At the time of writing, IOCM is not supported by the DIR vendor or any of the ingesting site PACS vendors. It is possible that in the future, as the IOCM profile becomes supported across the vendors participating in HDIRS, the need for a deletion script and concern of stale exams will be less of an issue.

A second customization, at the request of clinical users, was a notification to inform the user that the exam is foreign. A notification script was created and implemented that displays a pop-up alert when a user selects a foreign exam. The notification script was deemed optional, as some clinical users requested to disable the pop-up alert.

Phase 2—FEM Enabled with a Proxy Server

At the time of writing this paper, FEM with a proxy server has successfully been implemented at 12 sites, which use GE Centricity and Sectra PACS as their local PACS. In order to accomplish this, a third-party edge device was required to facilitate foreign exam management for these sites. Rialto Connect (the proxy) was selected as the edge device to support FEM. Regardless of which vendor was the consuming PACS, the following design requirements for ingested exams had to be met:

Foreign exams:

- Will display in the local patient's list
- Will not be re-archived to the DIR
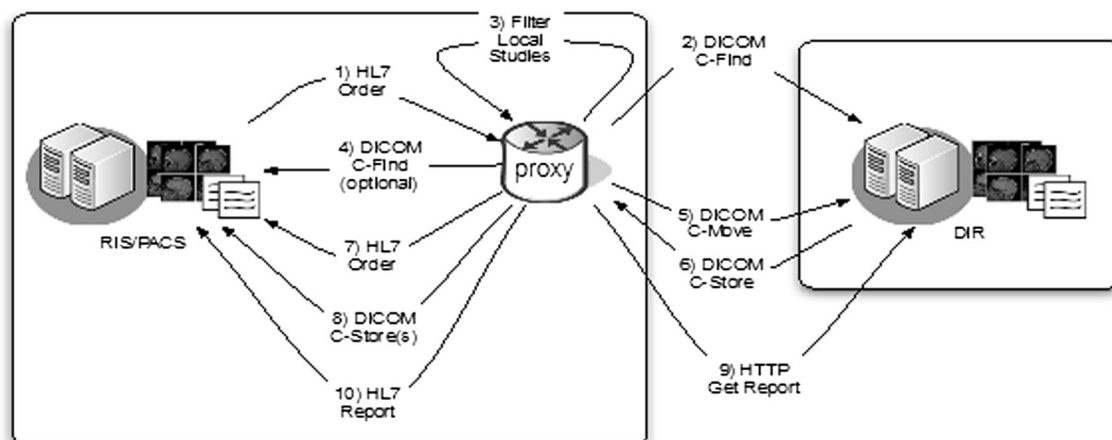- Will purge from local PACS based on a configurable date

Fig. 1 Flowchart for pre-fetch with proxy server

The proxy can discover and ingest foreign exams through a pre-fetch or an ad hoc search.

(a) The proxy accomplishes foreign pre-fetch in the following way (see Fig. 1):

The proxy receives a health level 7 (HL7) order response message (ORM) from the site radiology information system (RIS). This event triggers the immediate fetch of foreign priors. The proxy will perform a DICOM C-FIND query based on the local Patient ID contained in the ORM, and the Issuer_of_PatientID derived from the sending facility in the ORM. The DIR provides matching results based on patients with a matching Ontario HN, which is located in DICOM attribute "Other Patient ID Sequence" (0010, 1002). From the search results, the proxy filters out all local exams by disregarding any exam with a local Issuer_of_PatientID.

The proxy will receive the exam from the DIR. Depending on the ingesting PACS, an HL7 order may be required. If that is the case, the proxy will construct and submit an HL7 ORM to the PACS. Currently, among the ingesting sites and the present DIR solution, there is a no native support for the DICOM tag "issuer of accession number sequence." Without this value, it is difficult to identify the assigning authority that issued the accession number. To ensure that the originating site can be identified by the accession number, and to avoid potential duplicate accession numbers, an alternative method was instituted that assigns a prefix of the originating site to the accession number. As a result, the ORM will contain a localized Patient ID, an accession number pre-fixed with a site identifier related to the originating site, and a procedure code that exists in the local PACS dictionary.

There is currently no standard terminology set for sites contributing content to the DIR. As a result, each site may have a different procedure description for the same performed exam (i.e., CR upper extremity vs. CR wrist). To handle this, the local site creates a set of procedure codes to be used for FEM exams in their local PACS. The local site also provides a set of mapping rules against which the proxy server creates a local procedure code. As there is no standard terminology set across the DIR, the terminology mappings are fairly broad when localized. To accomplish the mapping, the proxy will reference the DIR for foreign procedure description keywords from DICOM attribute Study Description (0008, 1030). Based on the mapping rule, the proxy will set the normalized modality to DICOM attribute Modality (0008, 0060) and will set the normalized procedure code in HL7 attribute OBR-4.1 (Universal Service Identifier—Identifier) of the order and the report.

The proxy begins forwarding the images only after the order has been accepted by the local PACS. The Patient ID, accession number, and procedure code related to the images are morphed to match the localized ORM. The site AE title that the images are transferred to will not re-archive the foreign images and will purge foreign exams from the PACS after a set period of time; usually, after about 1 week, the images will be purged.

The standard DICOM method for ingesting reports is through the use of DICOM structured reports (SRs). Despite the fact that the DIR supports the storage and transmission of SRs, at the time of writing this paper, none of the sites connected to HDIRS use a PACS vendor that supports the display of SRs. Due to the inability of ingesting sites to view SRs, the DIR provides the reports to the proxy via a well-formed HTTP URL. The proxy is then able to "scrape" the contents of the URL and create an observation result (ORU) message. After the final image has been accepted, transformed, and forwarded to the PACS, the proxy will retrieve the associated report from the DIR's HTTP protocol.

(b) The proxy also provides the site with the ability to perform a manual query against the DIR directly from their local PACS. The following describes how this is accomplished (see Fig. 2):

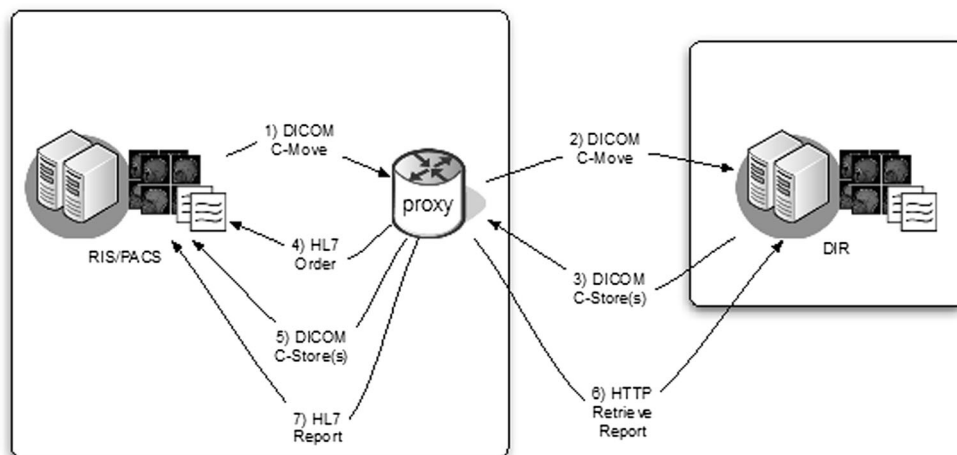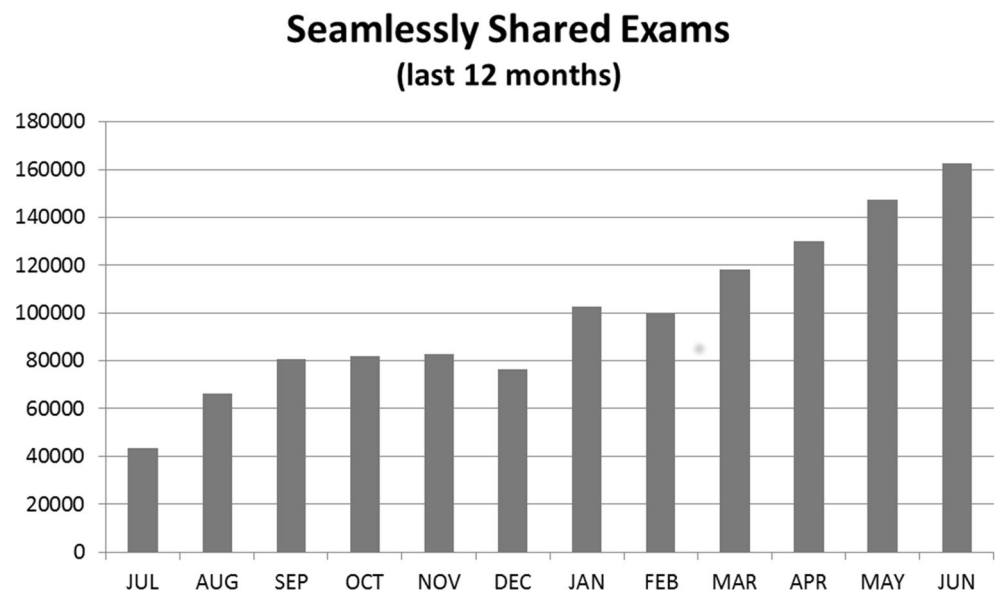Fig. 2 Flowchart for ad hoc query/retrieve with proxy server

Fig. 3 Chart of foreign exams retrieved between July 2013 and June 2014

Seamlessly Shared Exams
(last 12 months)

When a clinical user performs a manual enterprise query, the proxy receives a DICOM C-FIND request from the local PACS. If the DICOM C-FIND request includes a local Patient ID, the proxy will include the site assigned Issuer_of_PatientID in the passing query to the DIR. The DIR provides search results based on patients with a matching Ontario HN. A clinical user may search based on the Ontario HN, which the proxy passes as a query. The DIR will provide the C-FIND results through the proxy server to the local PACS.

The C-FIND results in a manual search are non-localized. This means the clinical user will see Patient IDs that originate from other facilities. Upon retrieving an exam, the proxy will use the same mechanics as described in the pre-fetch scenario to create an ORM and morph the Patient ID, accession number, and procedure for the ORM and images and will extract the report from the HTTP protocol. After the exam arrives in the local PACS, it will be purged after a set time period has passed.

Results/Evaluation

The ability to provide clinical users with foreign priors has demonstrated many benefits. Sites have reported that there are a reduced number of CD imports. Formal site surveys have indicated that physicians find the FEM capability has improved their productivity, has prevented unnecessary re-scans, and has improved the site's ability to share patient information.

Over the past 12 months, the number of foreign exams ingested into the HDIRS consuming sites has grown significantly. The following chart illustrates the months between July 2013 and June 2014 and the total number of foreign exams that have been retrieved.

The number of ingested foreign exams has exceeded 160,000 in a single month, which shows evidence of the growing need and to locally display a patient's longitudinal DI record (see Fig. 3).

The total number of ingested foreign exams per site for May 2014 and the 12 months previous is as follows (see Table 1).

While HDIRS is able to capture the results of how many foreign exams are retrieved from the DIR into an ingesting site, HDIRS as a regional DI repository has no visibility into a site's local PACS and therefore is unable to see how many times a retrieved foreign exam was accessed. At the time of writing this paper, we are currently engaged with our member

Table 1 Breakdown of ingestion of foreign exams per consuming site

Ingesting site		
Hospital	Month	Year
Hospital corporation 1	19,708	197,751
Hospital corporation 2	7,946	20,396
Hospital corporation 3	7,072	17,326
Hospital corporation 4	21,196	117,153
Hospital corporation 5	7,785	27,281
Hospital corporation 6	11,195	113,179
Hospital corporation 7	14,536	159,596
Hospital corporation 8	725	29,525
Hospital corporation 9	34,728	147,255
Hospital corporation 10	1,900	5,924
Hospital corporation 11	14,161	144,804
Hospital corporation 12	21,777	211,216

site's PACS vendors to create a local audit report for each site to see how often foreign exams are being accessed.

Conclusion

The setup and implementation of a regional diagnostic imaging environment allows clinical users to easily view diagnostic images and reports that originate from any participating hospital or private imaging clinic. This can provide a more comprehensive view of the patient's medical history, as the clinical user is able to seamlessly access the full longitudinal records of a patient's DI history. We expect that in the future, as standards evolve and demand for this capability grows, this type of functionality will become inherent in PACS systems and will not rely as heavily on the implementation of proxy devices. It is interesting to note that the required functionality, i.e., management of foreign exams within PACS applications, is quite separate from, though complementary to, the typical requirements to facilitate sharing of information such as IHE's XDS/XDS-I profiles. Whereas the

IHE profiles facilitate discovery of information, and facilitate access to information from multiple sources through a unified viewer, foreign exam management facilitates access through the existing PACS application channel, greatly enhancing "seamlessness" of access and clinical functionality for core PACS application users such as radiologists.

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