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From shared data to sharing workflow: Merging PACS and teleradiology

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ABSTRACT

Due to a host of technological, interface, operational and workflow limitations, teleradiology and PACS/RIS were historically developed as separate systems serving different purposes. PACS/RIS handled local radiology storage and workflow management while teleradiology addressed remote access to images. Today advanced PACS/RIS support complete site radiology workflow for attending physicians, whether on-site or remote. In parallel, teleradiology has emerged into a service of providing remote, off-hours, coverage for emergency radiology and to a lesser extent subspecialty reading to subscribing sites and radiology groups.

When attending radiologists use teleradiology for remote access to a site, they may share all relevant patient data and participate in the site's workflow like their on-site peers. The operation gets cumbersome and time consuming when these radiologists serve multi-sites, each requiring a different remote access, or when the sites do not employ the same PACS/RIS/Reporting Systems and do not share the same ownership. The least efficient operation is of teleradiology companies engaged in reading for multiple facilities. As these services typically employ non-local radiologists, they are allowed to share some of the available patient data necessary to provide an emergency report but, by enlarge, they do not share the workflow of the sites they serve.

Radiology stakeholders usually prefer to have their own radiologists perform all radiology tasks including interpretation of off-hour examinations. It is possible with current technology to create a system that combines the benefits of local radiology services to multiple sites with the advantages offered by adding subspecialty and off-hours emergency services through teleradiology. Such a system increases efficiency for the radiology groups by enabling all users, regardless of location, to work "local" and fully participate in the workflow of every site. We refer to such a system as SuperPACS.

1. Introduction

The business model for radiology practice around the world varies by geography. In general, however, one can identify the following business models: (i) a single facility (hospital or imaging center) employing a number of radiologists, or outsourcing the radiology professional services work to an outside radiology group; (ii) an enterprise with multiple facilities, employing radiologists, or outsourcing the radiology professional services work to a radiology group; and (iii) a radiology group providing professional services to several related or unrelated facilities (in terms of ownership). The facilities may employ IT systems such as Picture Archiving and Communication Systems (PACS), Radiology Information Systems (RIS), and Teleradiology Systems from one or multiple vendors [1].

Regardless of the business model, the outcome of the radiologist work is a final report [2] delivered to the relevant radiology stakeholder (referring physician, patient, administration). The report is expected to be accurate and delivered in a timely manner [1]. In selecting information systems that support the generation and delivery of the final report one parameter governs – how effective they are in increasing radiologist's efficiency [3]. We define efficiency as:

$$\textbf{Efficiency} = [\textbf{Speed} + \textbf{Accuracy}] \text{ in producing and delivering any } \textbf{clinical} \text{ or } \textbf{business} \text{ result.}$$

Clinical result means delivering a *final report* to the referring physician that contains clinically useful information (narrative and images) *applicable to the patient care*.

Business result means the ability to deliver the *clinical result* FAST under any business scenario (i.e. number of sites, multiple vendors for IT systems, multiple imaging locations, multiple reading locations, result distribution scheme, etc.).

The business model where a radiology group provides professional services to several unrelated facilities (to be referred to as

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the "***Disparate Model***") is perhaps the most challenging in terms of building an IT infrastructure and system to maximize the efficiency of the group. A typical scenario (Fig. 1) is where a radiology group contracts to deliver complete radiology services, including subspecialty reading, to several sites covering a large geographical area. Each site has multiple information systems from multiple vendors. The sites have different owners and may even compete with each other. Reports and consultations have to be provided to on-site and off-site referring physicians. Each site has its own billing system triggered by its RIS or Hospital Information System (HIS). The radiology group employs subspecialists, but not enough to man each facility with all required subspecialties. Radiology services are required around the clock all year.

It is clear that an information system that maximizes efficiency for radiologists in the Disparate Model would definitely maximize efficiency for the other business models mentioned, as they represent sub-sets of the Disparate Model.

This article will begin with a brief review of the major professional services expected from radiology groups by their stakeholders followed by a discussion of current solutions for the Disparate Model and their limitations. We will then introduce an architecture and system that addresses these limitations and provides unlimited flexibility for solving requirements of single and multi-site radiology service operations. The proposed solution will be named SuperPACS.

2. Stakeholders' expectations for radiology services

Boland [4] and Patti et al. [2] have identified three key stakeholders who look to radiology to expedite the diagnostic process: referring physicians, patients, and hospital administrators. Boland [4] lists four major service expectations and one administrative expectation by these stakeholders:

(i) *Help increase patient access to imaging*. This means facilitating a timely access of patients to the radiologic examinations appropriate to the clinical indications. The implication for a radiology group serving multi-sites is a timely appropriateness check [2], setting the examination protocol, interviewing the patient when needed, guiding the modality technician during examination and assessing the quality of the exam.

(ii) *Customer service*. This includes consultations to walk-in and call-in physicians, allowing "add-on" procedures, providing emergency reading, attending clinical and administrative meetings, teaching radiology and non-radiology residents and providing after hours coverage [5].

(iii) *Expedite report turnaround and image availability*. Provide referring physicians with a final report and relevant images on time so as not to delay continued patient treatment. Provide critical finding notification [6].

(iv) *Accuracy and quality of reading*. Referring physicians are increasingly looking for greater expertise in radiology reports and expect subspecialty reading [5,7]. Peer review and consultation between fellow radiologists are important factors in improving accuracy and quality of reports.

(v) *Understanding the business of radiology*. This is a business/administrative expectation. Radiology is one of the highest revenue sources for medical institutions who in turn expect to increase this revenue through higher patient volumes and throughput at minimum cost. This requires the radiology group serving them to work at maximum *efficiency*, as this term is defined in Section 1.

Considering the above stakeholders' expectation, it is imperative that any radiology group providing service under the Disparate Model must assign appropriate and sufficient ***local*** radiologists to staff the sites it serves as well as provide timely ***subspecialty and off-hours reading and consultation*** to those sites [2,7].

3. Current solutions for the Disparate Model

As detailed in Section 1, the Disparate Model is characterized by multiple sites, each with several information systems of different vendors, with no cooperation between the sites except that each site allows remote access to the members of a radiology group for the purpose of delivering radiology services.

To satisfy the expectations of its stakeholders, radiology groups under the Disparate Model typically use the following solution:

(i) Place radiologists at each site during work hours. Each radiologist reads and reports locally using the locally available information systems: PACS, RIS, Reporting System (dictation, speech recognition, structured report, etc.) [1]. Additional patient information to support the reading may be accessed locally through the site's Electronic Medical Record (EMR), if available. Local worklists that manage the reading amongst the radiology staff are typically driven by the RIS or PACS. Reports are sent to the local RIS that triggers the billing.

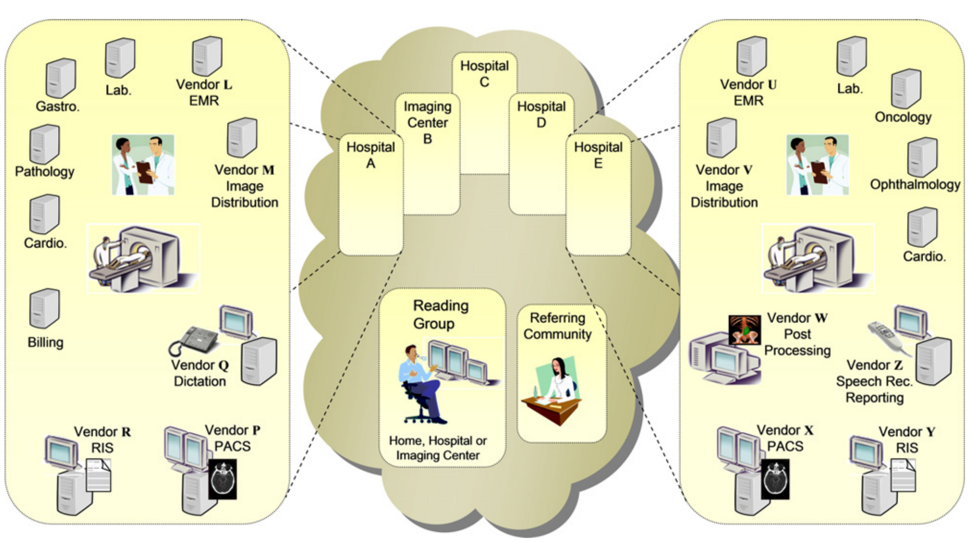

Fig. 1. The Disparate Model. A radiology group provides professional services to several unrelated facilities. Each site has multiple information systems from multiple vendors.

(ii) If a subspecialty reading is required at site B and the relevant subspecialist is at site A, several options are available [8]. The most advanced option is for the subspecialist to log in to site B from site A over a secured line using the teleradiology or remote access system of site B. Once connected to site B, the subspecialist looks for his worklist and selects the case for reading. Most teleradiology systems, however, do not offer native reporting, and to report the case, the subspecialist has to have remote access to the reporting system of site B, including ability to electronically sign the report once it is available for signature. The subspecialist repeats this process with sites C, D, E, etc., each time using the relevant site's teleradiology and remote reporting systems. The workflow gets more complicated if, in order to properly diagnose the case, the subspecialist requires volumetric (3D) post processing not available through the teleradiology system [1]. The above is undoubtedly a tedious operation and less advanced options involve even more intensive manual work [9].

If the radiology group lacks one or more subspecialty expertise it may employ a third party "dayhawk" teleradiology service [7,8]. This service will be discussed later.

(iii) For off-hours, the group may assign some of its members as on-call radiologists to be on-site, or remain off-site and use teleradiology [7,8] in a manner similar to the subspecialist work described above. Off-hours work involves mainly emergency radiology whereby referring physicians are often asking for a preliminary report based on a yes/no question [10]. Alternatively, the group may hire a third party teleradiology service ("nighthawk") to cover its off-hours duties [7]. This service will be discussed later.

(iv) Distribution of reports to referring physicians is done *locally* from each site, usually manually. In some cases, referring physicians are granted limited electronic access to a site's teleradiology and/or RIS systems for review of images or reports. A referring physician working with more than one site will have to communicate with each site separately.

(v) Balancing the workload of the group members across all sites is a manual operation. There may be cases where a site has a long backlog of studies to be read while radiologists at other sites are less busy. Assigning some of the studies to be read remotely require manual coordination and the remote reading is done in a manner similar to the subspecialist work described above.

From a business standpoint, a radiology group would like to maximize the number of interpretations per unit time per group member without sacrificing accuracy (namely, increase *Efficiency*). Its ultimate goal is to have tools to *automatically balance* the workload of its members across all sites, regardless of their physical location, and without compromising the *local services* expected by its stakeholders. In other words, it would like its members to be able to interpret and report studies from multiple locations through the course of a day without having to take note of where the studies were originally obtained. The same applies for off-hours coverage.

Considering the above, the typical current solution described for handling multi-sites under the Disparate Model is far from being efficient. The main drawbacks are: (i) the need to use multiple, *unsynchronized*, IT (PACS, RIS, Reporting, Teleradiology, EMR) systems of different vendors with different user interfaces; (ii) inability to easily build a global view of the workload status across sites; (iii) the need for multiple, secure connections and access controls from each site or radiologist's homes to other sites, which slows work down; (iv) difficulty in reviewing off-site patient history even if it is available in another site served by the group; (v) the use of nighthawk and dayhawk services generates excessive manual work and does not improve overall efficiency for the radiology group or the sites it serves (as will be discussed below); and (vi) suboptimal use of human resources.

A special note should be given to the issue of teleradiology outsourcing service providers, also referred to as nighthawks and dayhawks, as these services draw considerable attention in the literature [5,8,10,11–18].

The nighthawk service helps radiology groups improve their quality of life by outsourcing their off-hours, on-call duties, to a third party. It is estimated that more than 50% of U.S. radiology groups now use this service [9,13,18,19]. The main use of nighthawks is for emergency radiology [19]. The relevant studies and supporting data are "pushed" by various (electronic and manual) means to a nighthawk server and accessed by the nighthawk radiologist for interpretation [6]. If information is missing or additional supporting data is required, manual intervention is needed. The report is returned to the originating site via e-mail or fax and entered manually as a preliminary report ("wet read") [20] into the RIS of the originating site [8,18]. The site's attending radiologist reviews the study and the preliminary report the next day and issues the final report. In the vast majority of cases today, it is the radiology group who pays for the nighthawk service. This service does not contribute to increased efficiency of the overall operation (radiology group and the facilities it serves).

Based on the commercial success of nighthawk teleradiology services, a new radiology "dayhawk" market is emerging [9,21] offering primarily fast turnaround for subspecialty reading [7]. For the dayhawk business, however, studies are usually more complex, requiring comparison with old studies and reports, and in some cases, access to other pertinent clinical information (such as pathology, surgery reports, etc.) before an accurate report could be generated [18]. Because most dayhawk companies are not integrated with hospital information systems, the required data has to be pushed to them electronically and by a system of faxes, e-mails and telephone calls [6,20]. The report is delivered to the originating site in the same manual manner like a nighthawk report, with the additional complexity that key images and 3D processed images, when part of the report, have to be delivered to the originating site and stored there manually. This is an inherently inefficient process [9,10].

In summary, current solutions for handling multi-sites under the Disparate Model are inefficient since it is challenging to run them at high level of throughput. A more technologically advanced solution has to be introduced to overcome these challenges.

4. The SuperPACS

SuperPACS is a system that allows a radiology group serving multiple sites having disparate PACS, RIS, Reporting and other relevant IT systems (the Disparate Model) to view these sites as *virtually one site* and use *one virtual desktop* to efficiently complete all radiology work including reporting. The system allows the group to fully satisfy its stakeholders' expectations, including on-site, subspecialty, and off-hours coverage. Each radiologist can *read globally*, namely, fully participate in the reading workflow of each site regardless of their physical location. The reports generated are automatically delivered to the RIS at the site originating the study.

4.1. Key functionality

Building a SuperPACS requires architecture and technology that enables the following core functionality.

4.1.1. Global worklist

To avoid the tedious operation described in Section 3 for members of a radiology group serving multiple sites, they should be able to obtain, regardless of their physical location, a *global worklist* from their desktop and select studies for reading without having to take note of where the studies were originally obtained. The global worklist is the sum of all individual worklists at all sites. It can be filtered by any parameter, such as subspecialty of reader, modality type, etc. and further sorted by any other parameter such as priority, time of scan, etc. It also provides study locking, a feature used to avoid a study being unknowingly read by more than one radiologist.

The most efficient technical way to achieve a global worklist with minimum burden on local sites' databases and communication links is for all sites to send their *metadata* (patient and scan information without images) through a local SuperPACS "*Agent*" to a central location ("Data Center" or "DC") that acts as a registry for such data. This operation will be referred to as "*Synchronization*". The DC then provides the global worklist to all sites through their local Agents. Radiologists may view the global worklist on their local PACS workstation or use the *SuperPACS Client Application* provided by the Agent. This application is Web based and may run from any desktop, including the local PACS workstation. The Agent and its Client Application comprise the cornerstone of the SuperPACS and will be described later.

4.1.2. Global access to imaging studies and supporting data

If, for example, a subspecialty reading is required at site B and the relevant subspecialist is in site A, he will select the study from the global worklist. The selection will be forwarded through the Agent of site A to the DC and then to the Agent at site B, which will get the study and relevant prior studies ("priors") from the PACS at site B and deliver them on the same path back to the requestor. If any relevant priors are available, say, at site C, they will also be delivered to the requestor.

If the requestor uses the SuperPACS Client, the study and priors can be streamed back to him, which significantly speeds up interpretation over slow networks.

For increased efficiency, many remote readers prefer moving a batch of studies from the global worklist into their local workstation and reading them locally. With the SuperPACS Client, they can also "lock" these studies on the global worklist such that other radiologists will not report them. Moving the batch of studies can be done in the background, while the remote reader is reading a study.

The SuperPACS will always deliver the requested study over the fastest possible path. Thus, if in addition to connecting to the DC, sites A and B are connected to each other over a faster line, the requested study will be delivered from site B to site A directly and not through the DC. The same principle applies for requesting a local study.

Supporting data other than priors (such as requisition and other data inputted to the RIS as well as pathology, surgery reports, etc.) is inputted to the local Agents by using standard interfaces such as HL7 and the IHE ("Integrating the Healthcare Enterprise" initiative) XDS ("Cross Enterprise Document Sharing") [22], or by an input tool for non-standardized data (such as PDF or scanned documents, video, and other digitally available data). Using the SuperPACS delivery mechanism described above, this data can be delivered to the SuperPACS Client or to any XDS client ("Document Consumer") [22].

In many countries patients do not have a countrywide unique identification number (ID). They may receive a different patient ID when they are served by different, unrelated, healthcare facilities. In fetching the patient's priors from multiple sites it is therefore important to be able to match his different IDs across sites. The SuperPACS uses a Master Patient Index (MPI) mechanism for this purpose. Ideally, the MPI will comply with the IHE PIX ("Patient Identifier Cross-Referencing") profile [22].

4.1.3. One virtual desktop to complete all radiology work

Being able to efficiently read globally requires the reader to possess all the necessary tools to support reading from any location (e.g. home, office, hospital). In addition to the limited features available in traditional teleradiology clients and the more advanced PACS workstations (such as image manipulation, navigation between and comparison of image sets), these tools should include volumetric post processing, ability to display supporting clinical data and full reporting capabilities (dictation, speech recognition, structured reports, etc.). We will refer to a client application featuring the above capabilities to *roaming users* as "*Virtual Desktop*". A roaming user is a user that is not attached to a specific workstation at a specific location, and his user profile and privileges are centrally defined and "roam" with him to whatever desktop he uses. The SuperPACS Client application provides Virtual Desktop capabilities.

Reporting directly from the SuperPACS Client application is a significant efficiency booster as without it the user would have to interface and report to multiple, different reporting systems and would be slowed down considerably (see Section 3). With the SuperPACS, the user reports directly to the SuperPACS Client, which in turn delivers the report and any key/processed images to the RIS (report) and the PACS (images) at the originating site. This requires a two way interface with each local RIS.

4.1.4. Global access for referring physicians

Allowing a single point of access for referring physicians to electronically review their patients' reports and images over the Web will avoid the inefficiencies described in Section 3(iv) [23]. The SuperPACS Data Center serves as a *portal for referring physicians* of all sites served by the radiology group, with each physician having a folder containing their patients that can be viewed using the SuperPACS Client or another appropriate viewer. The portal facilitates on-line consultations between radiologists and referring physicians [18].

4.1.5. Workflow optimization and monitoring tools

To maintain efficiency in serving multiple sites, a radiology group must have tools to create workflow, continuously monitor its performance, and display status over a meaningful "*dashboard*". There are five major components to this process:

(i) **Folder creation**. Provide wizard to create folders. Important folder types include: *Worklists*, with continuous updating feature; *Conferences*; *Teaching Files*; and *Doctor Callbacks/Consultation/Critical Results Follow-up*.
(ii) **Workload distribution and balancing**. This includes: Logic to determine in which folder to place a case; and Balance the workload for reading radiologists.
(iii) **Reports signature queue**. Show how many unsigned reports are waiting at each facility and for each radiologist.
(iv) **Contacts**. Provide an integrated list of contact details for referring physicians, patients, facilities, etc., and an audit trail for all communications.
(v) **Facility and group statistics**. Provide for each facility running totals of STAT cases to be read, total unread cases, report turnaround time, total unsigned cases, and a list of radiologists that are logged in and their locations.

4.1.6. Access control and security

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) requires, among others, protection of patient data from unauthorized access [24]. In this respect, a SuperPACS shall include

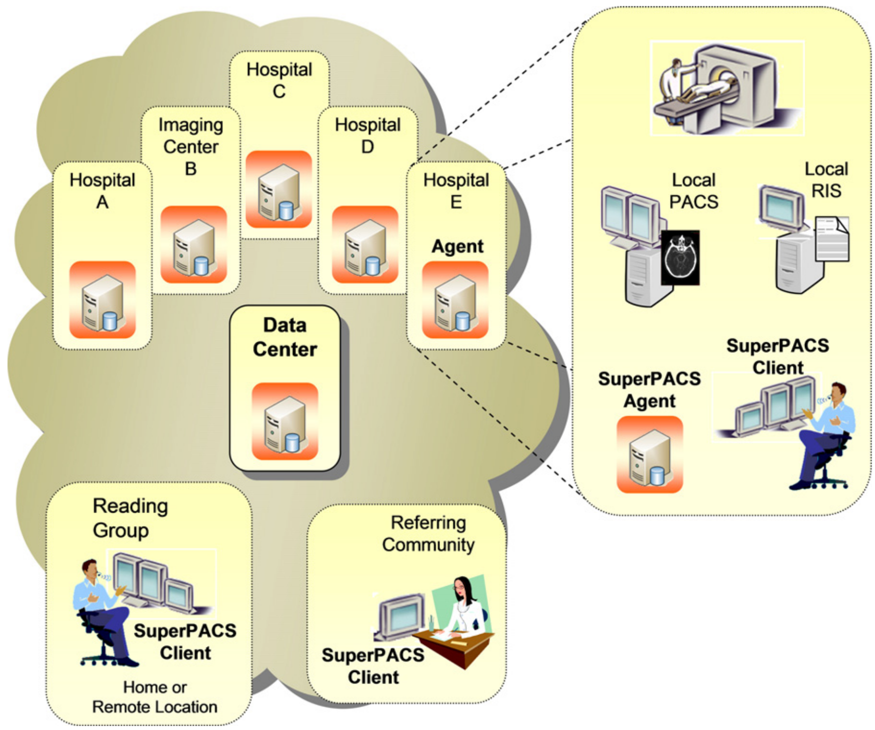

Fig. 2. A typical SuperPACS architecture under the Disparate Model. An Agent is placed at each participating site and at the data center. Note that the Agent can also serve as a local PACS, where needed.

a comprehensive access control tool that allows, for example: referring physicians to access data (at the DC) of their patients only; radiologists in a specific site to read studies from their site only but fetch relevant priors from other sites, too; radiologists to read studies only from facilities where they have hospital privileges [25], etc.

In addition, all other security provisions relevant to a single site and remote reading shall apply; for example, maintaining audit trails, using secured communication lines, user authentication, etc.

4.2. Implementation considerations

The core functionality described above for the SuperPACS represents a "Federated Approach", where all patient data stays local, the DC has a global view of the physical location of each data item, and consolidation of requested patient information from multiple sites is done on the fly. This approach minimizes data ownership issues when unrelated sites allow viewing their data to authorized users but do not allow storing it out of their control.

Speed of response under the Federated Approach can be further enhanced if the Agents at each site have a cache for temporarily storing image data, since the cache avoids the need to retrieve images from the local PACS.

Multiple sites with common ownership, while possibly having disparate information systems, are sometimes interested in a "Consolidated Approach", where the data are stored centrally. This requires adding storage and storage management capabilities to the server at the DC.

Other multi-site business operations call for a combined Federated/Consolidated approach to maximize efficiency and minimize cost of data management. In this case smaller sites store their data in the DC while the bigger sites work with the DC using the Federated Approach.

From above it is imperative that managing storage would be a useful and cost effective feature for both the Agent and the DC servers. Considering all other functionality required from these servers, one may use an identical "***One Box***" solution for both. In this solution, ***the same box, or Agent, will be placed at each site and at the Data Center***. A summary of the functionality of the Agent is provided below:

(i) ***Interfaces***: DICOM, HL7, HTTP, XDS, and an interface tool for non-standardized data.
(ii) ***Synchronize metadata***: local PACS and RIS forward all images and exam data to the local Agent, which synchronizes the Agent at the DC using the metadata of the received information.
(iii) ***Caching***: ability to store images and data received from local PACS, RIS, any input tool, or another Agent.
(iv) ***Archive and database manager***: including compression and multi-tier storage, backup, disaster recovery and image and data life-cycle management.
(v) ***Workflow manager***: providing worklists, folders and routing logic and mechanism for image and non-image data.
(vi) ***Image and data distribution WEB server***: including compression and streaming.
(vii) ***WEB Client*** (the *SuperPACS Client*): ability to log into the Agent, download and seamlessly install the SuperPACS Client, which is a fully featured *PACS, 3D and Reporting* workstation application.

Each Agent thus provides, in one box, the functionality of a complete Web based PACS, with its client application combining the capabilities of advanced PACS and 3D workstations and a Radiology Reporting System. Fig. 2 shows a typical SuperPACS architecture under the Disparate Model.

With the above capabilities, facilities employing a SuperPACS can gain additional benefits. Among these are: (i) use the DC also for central archiving and disaster recovery; (ii) use the local Agent also as a backup to the local PACS, thus providing full business continuity during downtime of the *local* PACS; and (iii) ability to continue receiving full service from off-site radiologists and allowing referring physicians access to imaging studies even upon downtime of the DC (provided that the Agent at the local site is also open for access from the Internet).

Two features of the SuperPACS mentioned above deserve further discussion. These are:

(i) *Reporting*. The ability to report directly from the SuperPACS Client is a major efficiency booster. The reporting radiologist uses a *single reporting interface* for all sites and the SuperPACS delivers the report to the RIS at the site originating the study. This requires each local RIS to have a two way HL7 interface, which is challenging.

(ii) *Workflow management*. The SuperPACS creates the global worklist and manages the multi-site reading and report distribution workflow. The local RIS manages the patient scheduling, admission, billing, and the local sites technologists' workflow. This allocation of tasks minimizes the required local interface points between the Agent and the local PACS and RIS and simplifies the SuperPACS implementation.

5. Discussion

When originally introduced, PACS was mainly concerned with digital archiving of image data at individual facilities ("single sites"). Later on, workflow features, *at a single site level*, were added, including mainly the ability to create worklists and display protocols and better integration of the PACS with the local RIS and reporting systems. With the availability of reasonably priced secure communications with adequate speed, many facilities enable remote access for authorized local personnel to the facility's IT systems (such as PACS, RIS and EMR). This has created systems that are efficient on a single site level.

With the communications technology that allows cost efficient, remote access to data, it was just logical for owners of *multiple facilities* and for radiology groups serving *multiple facilities* to look to consolidate their reading resources across all sites. The only efficient way to achieve this is to *share workflow* across all sites and not only share some of the data. Sharing workflow in this respect means that radiologists in the group, regardless of their physical location, by using *one virtual desktop*, can: (i) view the multiple sites as *virtually one site* where all data – including data from prior examinations and all patient records – are seamlessly available to them; and (ii) complete their interpretation work including reporting as if they are working within the facility originating the data.

Most current PACS are designed for single site operation and, at best, allow multi-site, shared workflow operation only if all sites install the same PACS. They are therefore not suitable to address the Disparate Model. Some third party teleradiology services claim to address the Disparate Model by virtue of their ability to work with multiple, unrelated sites. However, today these services offer mainly *remote*, off-hours, coverage for emergency radiology and to a much lesser extent daytime subspecialty reading. As these services typically employ non-local radiologists, they are allowed to share some of the available patient data necessary to provide an emergency report but, by enlarge, they do not share the workflow of the sites they serve. Sharing (some) data available at a given site without being able to share in the site's workflow does not help increase efficiency or reduce cost for the relevant parties [6,10].

The SuperPACS "merges" the capabilities of PACS and teleradiology services and allows radiology groups serving multi-sites to work *efficiently* both *locally* and *remotely* and fully satisfy their stakeholder's expectations. It can automate every step in the reading flow that does not require human eyeballs, while eyeball dependent operations can be expedited by the *One Virtual Desktop* (as defined in Section 4.1) available to each radiologist. Its *One Box* feature allows unlimited flexibility in building, expanding and modifying configurations to satisfy any business scenario. This feature also enables storage virtualization over many disparate systems. The architecture and dashboard enable planning and monitoring of every productivity element throughout the operation and provide a framework for obtaining business information and mining of clinical data. The SuperPACS thus supports the goal of achieving *Zero Latency Radiology*, namely reducing to (virtually) zero the time between patient scan and the radiology report delivered to the referring physician under any radiology operations setting.

It would be interesting to discuss a SuperPACS solution in relation to the on-going debate in radiology literature about commoditization of radiology and the fear that "nighthawk" and "dayhawk" teleradiology firms are competing with private radiology practices and will eventually threaten their existence [9,10]. As discussed earlier (see Section 2), it would be impossible to fully satisfy stakeholders' expectations for radiology services with teleradiology alone [26]. Nevertheless, it would behoove local radiologists to recognize that changes in organizational structure and service expectations are taking place through the availability of teleradiology and adapt new business models to their advantage.

Thrall [6] has suggested that smaller groups within a state could join together in a larger group of sufficient size to provide around the clock coverage and offer subspecialty reading. This may be done through a merger or while each group maintains its independence. The SuperPACS is a perfect vehicle to implement such a venture. Further, "local" SuperPACS systems in a country or across countries may link together to form a national or international registry of patient data and provide quick access to it.

6. Summary

Declining reimbursement, increased demand for expert, subspecialty radiology services, increased volume of imaging data and shortage of radiologists drive radiology service providers to look for tools to increase their efficiency. We defined "efficiency" as the ability to deliver the radiologist's end product – the report – with maximum *speed and accuracy* under any business scenario.

Maximizing efficiency when serving multi-sites presents significant challenges to radiology service providers. Today, they try to increase productivity by means of using PACS and teleradiology. These are typically separate systems using some shared data but not sharing a single workflow that seamlessly leads to the production of the end product. A new system is called for – merging the workflow management capabilities of the PACS with the remote access features of teleradiology.

The SuperPACS architecture and system described here addresses the above challenge. It gives radiology stakeholders the benefit of being served by a local group, and the local group the advantage of using remote reading in an efficient manner. This can open new practice options for radiologists on a local, regional and cross-country level and provide a vehicle for implementing governmental initiatives to better utilize radiology services over large areas.

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