Meta-Manager: A Requirements Analysis

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The digital imaging network–picture archiving and communications system (DIN-PACS) will be implemented in ten sites within the Great Plains Regional Medical Command (GPRMC). This network of PACS and teleradiology technology over a shared T1 network has opened the door for round the clock radiology coverage of all sites. However, the concept of a virtual radiology environment poses new issues for military medicine. A new workflow management system must be developed. This workflow management system will allow us to efficiently resolve these issues including quality of care, availability, severe capitation, and quality of the workforce. The design process of this management system must employ existing technology, operate over various telecommunication networks and protocols, be independent of platform operating systems, be flexible and scaleable, and involve the end user at the outset in the design process for which it is developed. Using the unified modeling language (UML), the specifications for this new business management system were created in concert between the University of Arizona and the GPRMC. These specifications detail a management system operating through a common object request brokered architecture (CORBA) environment. In this presentation, we characterize the Meta-Manager management system including aspects of intelligence, interfacility routing, fail-safe operations, and expected improvements in patient care and efficiency.

BEFORE 1997, the medical diagnostic imaging system (MDIS) predominated as the picture archiving communications system (PACS) in the majority of deployed sites within the Department of Defense (DOD) and the Veterans Affairs (VA). The benefits of this new technology have been described. These consist of reduced film-loss rates, reduced repeat rates, and near 100% availability of images. Report turnaround times were also favorably influenced. Tripler Army Medical Center noted a 50% improvement in turnaround times from 10 hours to 5 hours for routine examinations. Other non-DOD facilities have had similar experiences. In 1999, the Great Plains Regional Medical Command (GPRMC) began the installation of digital imaging network (DIN) (PACS). DIN-PACS is a DOD contract that calls for a Digital Imaging and Communications in Medicine (DICOM)-based system with rule based automated routing protocols to internet protocol (IP) addresses within a facility. Rerouting of work can be accomplished by manual reconfiguration. This is adequate for workflow management within a facility. However, the GPRMC is envisioned as an enterprise network of radiology facilities or a virtual radiology environment (VRE), including two medical centers (MC) and eight community level medical treatment facilities (MTF). This enterprise network will also require incorporation of a preexisting MDIS PACS.

Opportunities now exist for widespread access to subspecialty radiology consultation. Additionally, with appropriate band-width and workflow management tools, the enterprise can further improve report turnaround times to near real-time for all examinations and ameliorate the delays created by batch reading at the subspecialist and resident training levels. Initially, inter-PACS communication will be provided by a T1 network called MedNet. This network will allow a limited Brooke Army Medical Center centric teleradiology operation. However, it is not a dynamic examination routing system. Brooke Army Medical Center and the University of Arizona are defining a set of intelligent agent algorithms that will determine where examinations are to be routed for reading based on a knowledge base of the entire VRE. The set of algorithms, called the Meta-Manager, is hierarchical and uses object-based communications between MTFs and MCs that have PACS networks. The initial design process and the resultant development specifications will use unified modeling language (UML).[1-3] The communications is based on use of common object request broker architecture (CORBA) objects and services to send patient demographics and examination images from DIN-PACS networks in the MTFs to the DIN-PACS networks at the MCs for diagnosis. The Meta-

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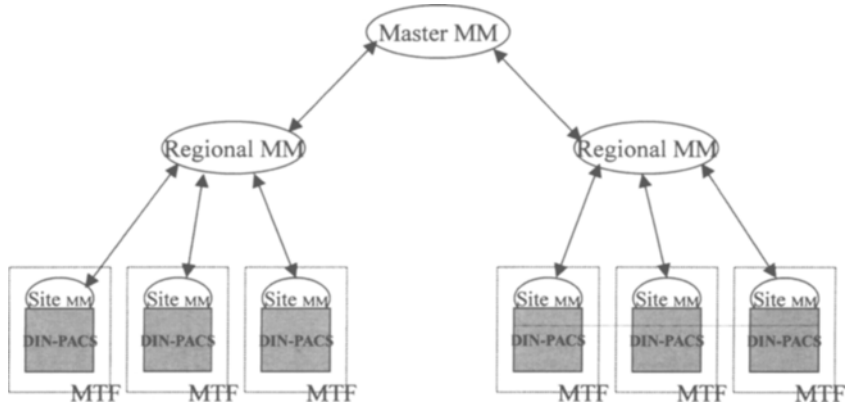

Fig 1. Hierarchical design concept.

Manager is also responsible for updating the diagnosis at the originating MTF. CORBA services are used to perform secure message communications between DIN-PACS nodes in the VRE network.

FAIL-SAFE

The Meta-Manager has a fail-safe architecture that allows the master Meta-Manager function to float to regional Meta-Manager sites. A prototype of the CORBA-based Meta-Manager is being developed by the University of Arizona's Computer Engineering Research Laboratory. The prototype will implement the main functions described in the Meta-Manager design specification. Modeling and simulation of the prototype will produce initial performance data. Figure 1 displays the hierarchical design concept. Figure 2 depicts the interface level of the Meta-Manager network with the PACS network in the VRE.

ROUTING

Each site maintains autonomy with respect to others in the region until site-definable threshold criteria or specific requests are received in the PACS. For instance, the following threshold condition may exist: "There will be no more than 10 unread chest radiographs locally." The acquisition of the eleventh examination will cause the local client Meta-Manager to request routing instructions from the regional Meta-Manager. The region Meta-Manager will look to its preset criteria to identify another site that has the radiology resources to handle the case. Prior to this, intelligent agents will have monitored the regional sites' workload conditions, availability of radiologists (current and future), and the state or condition of the network connecting the various sites. Once identified, the local PACS will be instructed to send the examination to the site with the available resources.

Currently, the minimum information for dynamic routing determination is listed in Table 1. This information is obtainable from the DICOM header. Since there is not a standardized nomenclature for examination naming, the current procedural terminology (CPT) code will be used as a look-up table (LUT). Additional information that will be useful in subsequent iterations of Meta-Manager development is listed in Table 2.

As the DICOM header information does not allow for stipulation of the reading radiologist by

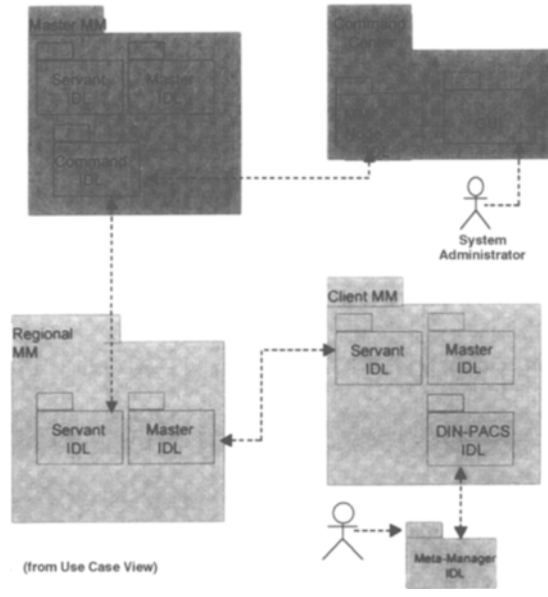

Fig 2. Interface level of the Meta-Manager network.

Table 1. DICOM Header Information for Routing Determination

Examination name—ie, PA and Lateral Chest, Skull Series, IVP, etc (CPT Code)
Modality Type—ie, CT, CR, US, etc
Patient age—Birthdate or Family Member Prefix (FMP) will determine if examination is pediatric or adult. The FMP comes from the military patient ID number
Urgency—ie, STAT, ASAP, Routine
Date and Time of Examination
Originating site location—for report return

the referring physician, the physician will be able to develop a default preference table based on his or her preference of radiologists by subspecialty. Unless we alter the function of one of the physician fields, we may not be able to otherwise make a determination of requested radiologists. The urgency may be subprioritized depending on the patient location.

The Meta-Manager will also perform accounting functions ancillary to the routing function. These will be used to establish a regional productivity account. This will provide the basis for resource sharing compensation between the medical facilities. Currently, workloads are evaluated on the basis of examinations performed and interpreted, not by a weighted value determination. The accounting function will also serve to track examinations within the VRE and their status. Links to other Meta-Manager functions will allow determination of rerouting requirements. The information required is again obtainable from the original DICOM header data and is shown in Table 3.

Table 2. Additional DICOM Header Information for Routing Determination

Requesting Physician
Inpatient or Outpatient
Patient Location—ICU, ER, OR, etc

Table 3. DICOM Header Information for Accounting

Date and Time of Examination
Date, Time and Destination of routing
Physician and/or Specialty routed to
Urgency
Inpatient or Outpatient
Body Part and Modality
Patient Name and ID
Origin and Destination Examination name (or CPT Code)

CONCLUSION

The results of this project are expected to reengineer the process of radiology in the military and have extensions to commercial radiology environments. Current DIN-PACS performance does not automate the functionality requisite to an enterprise wide VRE. A flexible and dynamic routing process is not available to level workloads and provide either subspecialty or preferred radiologist functions regardless of the current location of these resources. Radiology currently accepts 24-hour report turnaround as an acceptable norm. We must strive to reduce this delay to less than 1 hour and preferably to less than 30 minutes. The feasibility of achieving this has been previously demonstrated.[4] Additionally, subspecialists are not used to maximal efficiency. These resources are expensive and can be in short supply. The Meta-Manager provides the capability to favorably influence these deficiencies.

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