SESSION 5: Digital Technologies

Study Status Consistency and Duplicate-Read Protection in a Distributed Architecture

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This presentation will discuss the benefits and pitfalls of implementing a study status and duplicate-read protection mechanism within a distributed picture archiving and communication system (PACS) architecture. There are many advantages to a distributed PACS network in which image studies are proactively pushed to reading stations before they are required by a radiologist. The absence of a central server, which serves on demand, makes managing study status and protecting against duplicate reads challenging. The system to manage study status and read access must be efficient, robust, and easy to administer. A system is presented that accomplishes these goals while maintaining the advantages of a distributed architecture. **Methods:** The basic workflow of the system is that image studies acquired at a modality device are automatically sent to an archive server. Using a set of advanced routing rules, the archive automatically routes studies to diagnostic workstations where studies are candidates for diagnostic read. The workstations display a list of all local studies available for reading. A monitor application running on the workstations coordinates access to studies for diagnostic read. Once the status of a study has been changed, the workstations on the networks and the archive are notified, which causes the study to be automatically removed from any list on a workstation where it might be a read candidate. **Results:** Implementation of this system provides a balanced workflow throughout the system while minimizing the need for costly high-speed network hardware. Additionally studies are read as soon as they are available by the next available radiologist. This workflow is enabled without the need for specific interaction by any of the radiologists on the network. By having the images available at the workstation in an organized worklist, this methodology increases the efficiency of the radiologist. **Conclusion:** The implementation of this system enables a radiology department, or even a specialty group within a department, to gain the benefit of a distributed system as well as the benefits

provided by a central-server architecture. This can be done very cost effectively with minimal configuration overhead and hardware requirements.

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PICTURE ARCHIVING and communication systems (PACS) with a distributed architecture—systems that intelligently “push” images to reading stations—in certain applications have some distinct advantages over a central architecture where images are “pulled” on demand. However, a system of independent, intelligent workstations presents some interesting challenges for managing study status and protecting against duplicate reads of a single examination.

This report details the workflow of a distributed PACS architecture, explores the advantages that can be gained by this architecture and describes a solution for study status management and duplicate-read protection that will work in this environment.

DISCUSSION

The distributed PACS architecture referenced here features PACS components that provide highly configurable rule sets. This allows the deployed PACS systems to be tailored for optimal workflow in a distributed architecture.

The archive server automatically routes or “pushes” images to where they are needed throughout the system. The system allows users to query for images on demand, but the goal is to route 80% to 90% of the images to workstations where they are going to be used without requiring any human intervention. In a similar manner, the archive uses rules to automatically retrieve pertinent prior examinations from short-term or long-term storage and route them to the same location as the new examination. So, without a single keystroke, the radiologist will have available at his workstation the new examination to be read, as well as any pertinent prior examinations. Both the autorouting and prefetch rules are

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0897-1889/01/1402-1015\$35.00/0

doi:10.1053/jdim.2001.23818

custom-tailored to fit the workflow requirements for each PACS system that is deployed.

The workstations within this PACS system have similar intelligent capabilities. Using the local image database and configured parameters, each workstation can provide tailored worklists to assist radiologists, technologists, and referring physicians in their daily work. Since the worklist is generated by the workstation and images are stored locally, information will still be available should there be a failure of the network, archive server, or other components of the PACS system.

While there are some clear advantages to this architecture, when examinations are being read at more than one workstation it creates some problems for the user unless the status of images is synchronized throughout the system. If, for example, an image exists on a workstation designated for reading neurology cases but a radiologist decides to read that examination at a workstation elsewhere in the system, it is imperative that the examination is marked "Read" on all workstations in the system. If not, it is likely to be read a second time by another radiologist. Likewise, if an examination is currently being read by one radiologist, a second radiologist should not be able to open it and begin dictating. If an examination is prefetched from the archive server as a relevant prior, it should not appear in an unread worklist. There must be some synchronization across the system to prevent duplicate reading of examinations.

The following design criteria was created to accomplish this synchronization and communication in a distributed PACS architecture:

- (1) Broadcast status changes immediately to all nodes in the system.
- (2) Notify users on all workstations when an examination is in use and by whom.
- (3) Give the first user to open a study exclusive reading rights for that study.
- (4) Allow users to open any study for view, even if it is currently locked for reading on another workstation.

The challenge was to design a software product that would communicate with all the devices in the system to accomplish these goals.

RESULTS

A software package was developed to meet these design objectives. This software package can be incorporated in a distributed PACS architecture to accomplish the necessary status communication throughout the system. This system has been deployed clinically with excellent results.

In a system with this software deployed, when a user on any workstation in the system opens a study for read, this image will show up as "OPEN_FOR_READ" in the data selector on any other workstation where it resides. A query to the archive server from any workstation will also show the "OPEN_FOR_READ" status. This allows all workstations in the system to know a study is in use. If a user should try to open an examination currently marked "OPEN_FOR_READ," a dialog box will appear telling them that this examination is currently locked. The message also specifies which workstation and user have the examination locked. The user may choose to continue to open the study in "VIEW ONLY" mode or return to select another study. This feature allows for simultaneous consultation on workstations in the system without allowing duplicate reading. This is an important feature we found was not present in some of the PACS architectures we reviewed.

Any time the status of an examination is changed on a workstation, that status change is broadcast immediately throughout the system. This broadcast has two important effects. First of all this allows synchronization of reading worklists throughout the system. If an examination exists on more than one reading station, as soon as it is marked as "Read," it will be removed from the "Unread" worklist on every workstation where it resides, not just the one where it was read. This is an important feature when workflow dictates that examinations can be read on a variety of workstations. The second major effect of the status broadcast is it immediately informs the archive of status changes as well. Users querying the archive for an examination will know if it is still unread before they import it to dictate.

In addition to meeting the study status and duplicate-read design goals for a distributed PACS system, a graphical user interface allows maintenance and surveillance of all registered nodes in the system. This tool is intended for administrators of the PACS system to allow a single screen to

view all currently locked studies and all active nodes, to unlock studies that were locked and not released by a given user, and to perform general system troubleshooting.

There are a few limitations in deploying this status management application. First, the software requires that only valid Digital Imaging and Communications in Medicine (DICOM) values can be used for status communication. Thus, users who have developed custom tags such as "Dictated" to indicate when a study has been read will have to change to the DICOM equivalent "Read." A second problem is that if any workstation stops communicating with the network, they will not receive status updates or be able to participate in study locking. If the user is not aware that this workstation stopped communicating with the network, they will be falsely informed about the status of studies. Monitoring functionality of devices on the network and restoring communication is typically the role of a PACS administrator, but it is important to note that the application cannot maintain status communication if the network fails. Once network communication is restored, operation returns to normal.

CONCLUSIONS

PACS systems with a distributed architecture and intelligent, independent workstations and servers offer some clear advantages to the user. The most obvious is that images will move to workstations where they are going to be used without requiring any human intervention, saving valuable time. Images will already reside at the locations where they are to be used and be available for

immediate review. The bottom line is that radiologists will not have to spend time looking for examinations or waiting for images to be retrieved.

In addition to reducing the time required to request examinations on demand, this model allows PACS to be deployed without costly high-speed network infrastructure. Since the prefetch of prior examinations is based on the schedule of new examinations, these images can be retrieved and routed to workstations during off hours for the PACS. Autorouting of images also provides better network load balancing than ad hoc queries. Using a query-on-demand model as in a centralized architecture, the network will be hit heavily from all directions during the busiest hours of the day.

With the local image database and worklist design capability inherent in this PACS architecture, each workstation is capable of providing a tailored unread worklist to the radiologist. This worklist would be available for use even if there are failures in the network communication or archive server of the PACS system as a whole. This provides another level of redundancy and fault tolerance in the system. Reading workstations can operate intelligently in a stand-alone configuration until communication with other components of the PACS network is restored.

With the status management software developed it is possible to deploy a distributed PACS architecture that provides all the above advantages, as well as study status consistency and duplicate-read protection throughout the system. Initial clinical testing at several sites has returned positive results from radiologists, as well as PACS administrators.