



The J Group

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AFMS TELRADIOLOGY STATUS

- AF/SG DESIGNATED AMC "LEAD COMMAND" FOR AFMS TELEHEALTH
- "BIG ROCK" DECREASED NUMBERS OF AF RADIOLOGISTS
 - FY 00: 148 AF RADS
 - FY 01: 119 AF RADS
 - FY 02: 92 AF RADS
 - FY 03: 70 AF RADS
- WORKLOAD STEADY: 1.3 MILLION EXAMS/YR
- DEPLOYMENTS INCREASED
- RADIOLOGIST DEPLOYMENTS
- "VIRTUAL DEPLOYMENTS"
- DEVELOP BENCHMARK "TELE-RADIOLOGY MODEL" AT DAVID GRANT MEDICAL CENTER
- SG COMMISSIONED TELE-RADIOLOGY IPT



AFMS TR IPT Charge

■ IPT CHARTER:

- Develop/implement a AFMS TR sustainment model
- Provide guidance necessary to ensure a systematic approach for teleradiology throughout the AFMS
- Maximize radiology capacity at a AF Medical Center
- Act under oversight of IM/IT Panel, with additional support from In-House Care Panel and Global Engagement Panel



Advantages of Electronic-based Image Management "Why We Like PACS"

- Electronic representation of images can allow easier, more cost-effective storage and distribution
- Can drastically eliminate lost, repeated, duplicated studies throughout the system
- May improve patient outcomes by significantly improving study accessibility throughout the enterprise (both with respect to image access time as well as more comprehensive access to prior studies)
- Can allow for simultaneous access by multiple users ("ubiquitous distribution") and system-wide "virtual" collaboration






Advantages of Electronic-based Image Management

- Can improve physician productivity by improving image navigation and interpretation efficiency of large, complex multispectral image datasets (helical CT, MR)
- Can provide greater options and flexibility with respect to radiologist staffing throughout the system
- Will allow easier integration with other medical information resources (electronic medical record)
- "Images anytime, any place"






"Legacy" PACS

- Much has been learned from existing PACS approaches
- From a radiology-centric perspective, digital image management is feasible *within the radiology department* (with enough resources)
- However, traditional PACS have significant limitations and liabilities when present and near-future image management requirements are considered




Limitations of "Radiology-centric" PACS

- The functional requirements have changed *"The target has moved"*
- Technological and architectural limitations
- Inadequate (non-scalable) workflow modeling and functionality




"The target has moved"

- Advances in data acquisition technology
- Increased treatment options and complexity
- Health care enterprise is becoming increasingly complex
- Trend towards consolidation and therefore increased physical distribution
- External, economic, and staffing constraints significant
- *"Do more in less time with greater constraints in a more complex distributed environment"*




Technological Limitations of Traditional PACS

- Too expensive ("heavy iron / brute force" approach)
 - Network infrastructure requirements
 - Archive and database architecture
 - Thick client based workstations
- Too complex and "brittle"
- Rather primitive server-client communication protocols (transfer syntax) using very large data block transfers (usually requires prefetching)
- Scalability to large distributed enterprises not demonstrated




Inadequate Workflow Modeling

- Radiology-centric workflow
- Enterprise image distribution viewed as "afterthought" rather than critical requirement
- Cannot easily accommodate non-radiology image objects (cardiology, pathology, endoscopy, dermatology, etc.)
- Integration with electronic medical record (EMR) difficult





Radiology-centric PACS models radiology workflow *too well*

- Exploit important constraints and features unique to the radiology department:
 - "Reading room" topology advantageous (brute force approach can work)
 - Radiologist workflow behavior relatively predictable (prefetch can work)
- Informatics integration relatively limited (OK for radiologists for now)
- Dedicated highly specialized workstations acceptable (for now)
- *The above does not apply to workflow outside of radiology*





Radiology-centric PACS workflow fails outside of radiology

- "Auto-routing" or "prefetching" to designated workstations: common strategy used so that the user does not have to "pay the penalty" of transfer waiting time.
- While this strategy can work for the "centralized" radiology department and radiology reading rooms (where user location and context is highly predictable), it fails frequently when applied to other clinicians since it is difficult to predict from where these users will request to view studies (ICU?, clinic?, office?, home?).
- This model will also be a liability with "distributed" radiology





Legacy PACS Workflow Model

- Almost completely driven by “data generation” (write) events
- Exploits the close temporal relationship between data generation (write) events and data access (read) requests that comprise radiology workflow
- This temporal relationship fails outside the radiology department: for most of the enterprise, data access requests show very limited correlation with data generation events





Enterprise Distribution of Images

- Tenable strategies for ubiquitous distribution of diagnostic images throughout the enterprise essential
- Cost savings cannot be realized without acceptable enterprise distribution
- Distributed radiology workflow is dependent on no-compromise enterprise distribution solution
- “Going filmless” within the radiology department is “easy;” enterprise image distribution is very challenging





Requirements for Enterprise-wide Image Distribution

- Flexibility: must provide for needs of a wide variety of users, including those who require *full fidelity* images
- Performance: non-radiologist users can be even more demanding of delivery performance.
- Scalability: must be able to provide high performance *ubiquitous distribution* of images throughout a large, expanding (physically distributed) enterprise





Requirements for Enterprise-wide Image Distribution

- Cost effectiveness: must be able to provide services leveraging usually limited infrastructure (network) and modest clients (PCs)
- Image visualization: must be “optimized” not “crippled”
- Integration into Electronic Medical Record (EMR): the “Holy Grail:” the multimedia enabled EMR with both synchronous and asynchronous collaboration
- Security: must be more robust than legacy PACS





Strategies for Enterprise Image Distribution

- Extension of radiology PACs
- Thin client (web-based) approaches using subsampled or compressed images
- Thin client approaches using “just in time” data delivery model





Extension of Radiology (Legacy) PACS

- Enterprise as “extension” of radiology department
- Leverage of existing network, archive, and workstation infrastructure
- Limited number of “designated remote” areas of enterprise (ICU, OR, ER)





Extension of Radiology (Legacy) PACS: Advantages

- Can provide full fidelity datasets
- Image delivery performance can be high
- Security may be more straightforward
- Almost any legacy PACS can be “extended” this way





Extension of Radiology (Legacy) PACS: Disadvantages

- Cannot practically provide ubiquitous distribution to “every desktop” (Physician workflow may require this)
- Forces relatively severe “triage” limitation of remote sites
- Expensive and lacks scalability
- Legacy workstations frequently “stripped down” yet costly
- Difficult to integrate into EMR





Thin Client (Web) using Subsampled or Compressed Images

- Addresses problem of limited infrastructure (network bandwidth) and modest host resources by distributing (via web) compressed representations of images
- Very popular strategy





Thin Client (Web) using Subsampled or Compressed Images: Advantages

- Can be cost effective solution
- Can leverage existing enterprise investment in PC-type hosts
- If compression high enough, image delivery performance can be high
- Integration into EMR easier



Thin Client (Web) using Subsampled or Compressed Images: Disadvantages

- Requires lossy compression (global subsampling).
- Difficult to provide full fidelity on demand
- Difficult to determine *a priori* what degree of compression is acceptable for all clinical contexts.
- Usually associated with limited compromised image dataset navigation/presentation
- IT challenge: essentially a subsampled recapitulation of the main image archive (“web servers”), especially if permanent persistence is required
- Probably unacceptable for distributed radiology



Limitations of Traditional Server-Client Transfer Syntax Model

- Before a user can view and navigate through an image dataset, the *entire dataset* is first transmitted to the workstation (or closely associated cache).
- Only after the entire dataset is transmitted (transferred) is the user able to interact with the images
- The problem: medical image datasets are LARGE (and getting larger)
- Even with compression (quantization), the size of datasets still results in large data block transfers
 - Increases archive sustained transfer rate requirements
 - Can rapidly saturate network resources



Thin Client using "Just in Time" Data Delivery Model

- Instead of globally subsampling the dataset, uses a "just in time" data delivery model that delivers what the user requires just when it is required at arbitrary fidelity, including full fidelity
- Exploits the increasing mismatch between acquisition dataset magnitude and display capability



Dynamic Transfer Syntax - DTS (AF Adopted Model)

- "Just in time" delivery model: delivers that portion of the image dataset to the user just when (or just before) it is required.
- Intelligent context-sensitive server-client communication protocol that is dynamically linked to user interface.
- Able to deliver arbitrary level of image quality including full fidelity *without use of compression*



Dynamic Transfer Syntax

- Wavelet encoding: provides flexible and lossless data representation that allows scalable access to images
- Context sensitive interactive server client communication: In response to user's navigational input, the server/client communication protocol (DTS) transfers data from the server to the client corresponding to the subband that is required to augment the thin client's existing dataset state in order to service the request.



Thin Client using "Just in Time" Data Delivery Model: Advantages

- Provides full fidelity access to images throughout enterprise using modest network and host resources
- Provides almost immediate access to image datasets throughout enterprise
- Can provide full navigation/presentation functionality and flexibility
- Can leverage existing enterprise investment in PC-type hosts
- Integration into EMR easier

Thin Client using "Just in Time" Data Delivery Model: Disadvantages

- Requires sophisticated integration of scalable access to dataset with context sensitive server client communication. Must be seamless and transparent
- Some implementations require low latency network connection
- Data persistence model must be carefully considered; must be seamlessly integrated into archive design


DTS Advantages: Flexibility

- DTS model supports thick, medium, and thin client viewers using the same engine and viewer software.
- Software adapts itself to available network and client resources (as well as user requirements)
- DTS viewers can be easily integrated into electronic medical record without compromise to image quality or presentation/navigation
- Significantly simplifies permanent persistence archive architecture

WITSS


DTS in Distributed Radiology

- Ability to access full fidelity image datasets with full navigation functionality with very rapid access advantageous in distributed radiology workflow model
- Ability to leverage modest host and network infrastructure an advantage
- Example: "iRadiology Lite"




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iRadiology "Light"

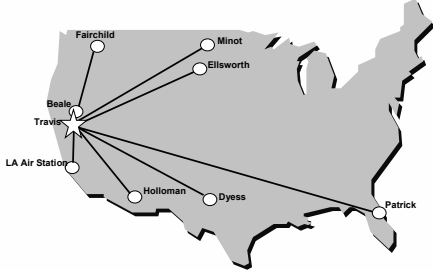


- Radiologist able to "lock" studies to be read




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AF Teleradiology Spoke Sites Phase I

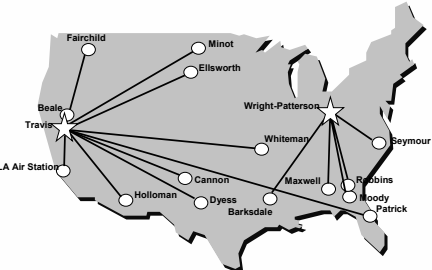



TOTAL FILMS: 34,000



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Teleradiology Spoke Sites Phase 2

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Summary: Next Generation PACS

- Must be able to scale to the demands of the modern health care delivery system; this will require at least an order of magnitude improvement in performance
- Must be much more cost effective; must leverage existing IT resources
- Must be able to address the challenging problems of enterprise image distribution and newer distributed radiology workflow models
- Must be able to accommodate all medical image objects
- Must be integrated into the multimedia enabled EMR



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It is no longer just about film savings; PACS must also result in significant improvements in FTE productivity, efficiency, and quality of service throughout the enterprise





*It is no longer just about images;
PACS solutions must “complete”
the informatics cycle by providing
up to
“near real-time” image study
interpretation and consultation in
order to deliver true value*