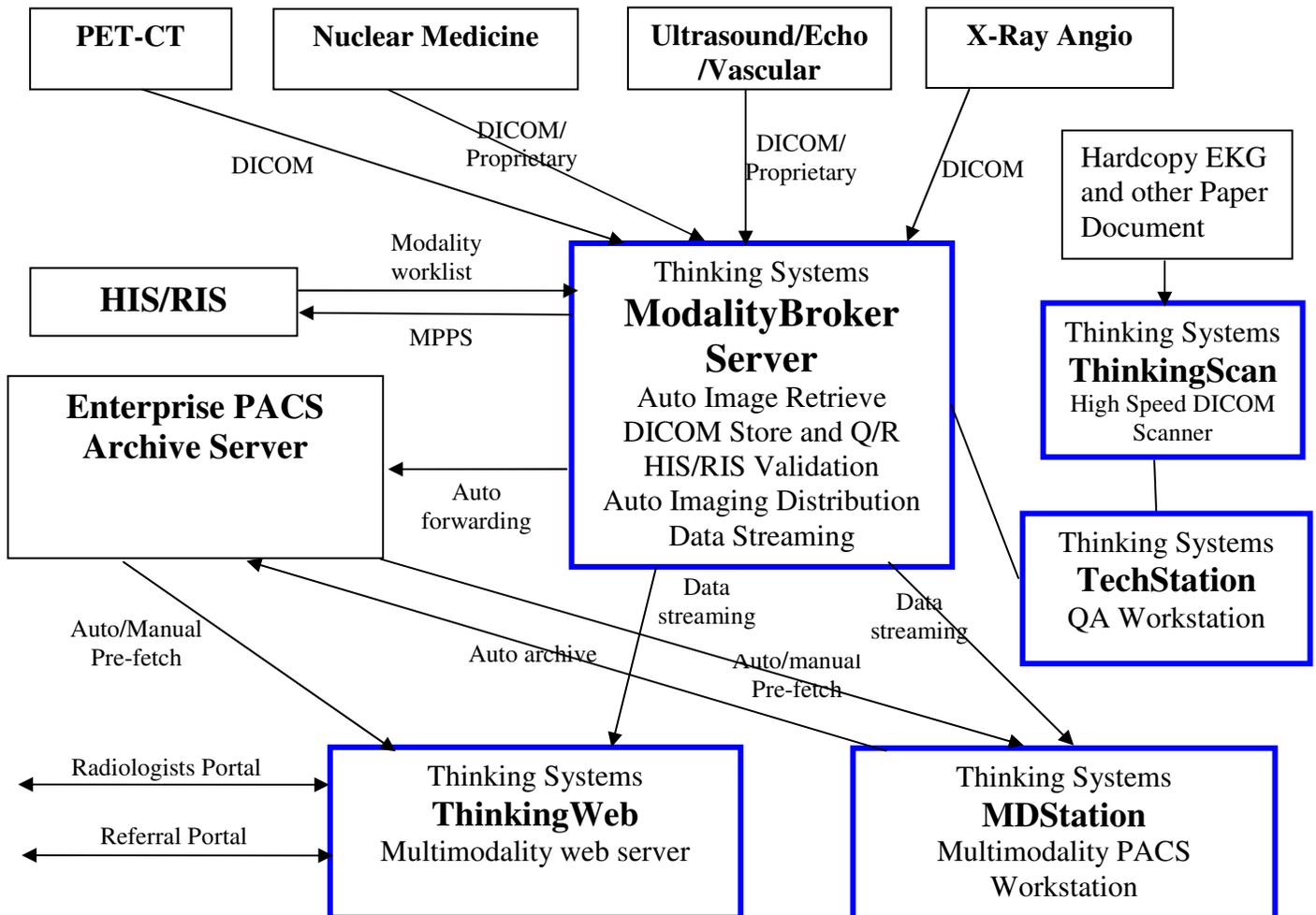


# Integrating Modalities to Enterprise PACS through Thinking Systems

## 1 The Need

For most enterprise PACS implementations, traditional CT, MR, CR, DR and general Ultrasound are of primary concerns. Not much attention has been paid to the other modalities. However, as hospitals and imaging centers move towards fully digital and filmless, it is becoming a necessity to include the other more complex imaging modalities, such as nuclear medicine, nuclear cardiology, multi-slice CT, PET-CT, echocardiogram, vascular ultrasound, X-ray angiography and ECG. Providing necessary clinical tools for each modality is also becoming part of the requirements for PACS implementation. Thinking Systems has been a leader in providing modality integration and clinical solutions for PACS.

## 2 Overall Architecture



## 3 Thinking Systems Components

Below are the descriptions of the Thinking Systems components that are required to integrate modalities to hospital/enterprise PACS.

### 3.1 ModalityBroker Server

This component is key to integrating modalities other than general radiology (CT, MR, CR, and DR) to hospital/enterprise PACS.

One of the main reasons that the majority of the PACS cannot support the non-general radiology modalities, such as nuclear medicine, PET-CT, ultrasound, echocardiogram, vascular ultrasound, X-ray angiography, wave forms (EKG/ECG), etc., is the lack of the fundamental technologies essential to support these modalities. These fundamental technologies include connectivity, data encoding/decoding, and clinical protocols.

The main purpose of the ModalityBroker server is to shield the enterprise PACS from having to deal with every single modality scanner.

Minimally one ModalityBroker server is required for each site. Depending on the number of modality scanners and the data volume, additional separate connectivity gateways may be needed.

The main functions for the ModalityBroker server are listed below.

#### 3.1.1 Connectivity

Even though the majority of the new modality scanners offer DICOM options, it is well understood and accepted that not all DICOM are created same, especially when it comes to the specialty modalities (modalities other than CT, MR, and CR/DR). Therefore, despite the effort of DICOM, how to connect to modality scanners in a heterogeneous environment still poses major challenges to most PACS vendors.

Thinking Systems' ModalityBroker server addresses these challenges with the following solutions:

1. **Proprietary Protocol/Format to DICOM Gateways.** In the case that a scanner either does not support DICOM or the vendor's version of DICOM is not adequately implemented, we provide an interface that connects directly to the proprietary systems and then automatically convert the proprietary data into fully implemented DICOM 3.0 format. We also provide the reverse conversion to convert DICOM data back to proprietary format without lose proprietary information. This is especially important in nuclear medicine, because almost all vendors' scanners depend on some proprietary technologies that cannot be adequately encapsulated by DICOM.
2. **DICOM Customization, Verification and Validation.** Due to the complexity of the specialty modalities, especially nuclear medicine, DICOM implementations vary greatly among vendors, even between different versions of the same product. Since most of the PACS do not support these modalities, even though they accept and store images from these modalities, often the images become unusable when retrieved back to the modalities. In such cases, Thinking Systems' ModalityBroker provides customized DICOM interfaces to the modality and the PACS, and provide data verification and validation for both directions of the communications to ensure data integrity.

### **3.1.2 HIS/RIS Validation**

As soon as the ModalityBroker server receives a study from a modality scanner, it queries the modality worklist server of HIS/RIS, and then validates study information received from the modality against the information provided by HIS/RIS. Any inconsistency will be corrected using the information provided by HIS/RIS.

### **3.1.3 Image Distribution**

Thinking Systems ModalityBroker server provides rule based automatic image routing. The criteria used to determine routing rules include modality type, image source, reading physicians, referral physicians, etc. The images communication methods used include DICOM, secure data streaming, and third-party proprietary protocols.

### **3.1.4 Short Term Storage**

The ModalityBroker server provides short term storage to facilitate quick retrieval of recent studies back to the modalities when needed. The image retrieval can be through with DICOM or proprietary protocols.

The storage space is managed using first-in-first-out policy.

## **3.2 MDStation**

MDStation is Thinking Systems flagship multimodality PACS workstations. It is the one and only PACS workstation in the market that supports not only the essential PACS functions such as DICOM query/retrieve, DICOM store, pre-fetch, hanging protocols, presentation state, annotation, window/level, but also the essential clinical tools that are specific to each modality and image type. The following features are what make MDStation different from any other PACS workstation:

1. Nuclear cardiology processing, quantitative analysis with Cedars Sinai's QGS/QPS and Emory Toolbox, and image review
2. PET-CT fusion with all necessary tools such as MIP, SUV measurement, alpha blending, and current-prior comparison.
3. General nuclear medicine review and SPECT processing
4. Cardiac PET quantitative analysis
5. PET brain quantitative analysis
6. Orthopedic templating
7. Advanced 3D visualization
8. 3D CT vascular analysis
9. CT cardiac calcium scoring

## **3.3 ThinkingWeb**

ThinkingWeb is another flagship product of Thinking Systems which brings the advanced featured offered by MDStation to the web.

ThinkingWeb offers a radiologist portal and a referral physician portal.

The radiologist portal is based on thin-client technology that enable radiologist to perform the same functions as offered by MDStation, such as general radiology (CT, MR, CR, DR) image review tools, 3D and MPR, PET-CT fusion, nuclear cardiology processing, etc.

The referral portal offers light-weight and easy to user interface to allow referral physicians to review key images and reports.

### **3.4 TechStation**

TechStation provides intuitive and easy to use user interface to the ModalityBroker server to allow technologists to perform image quality control and assurance, patient demographic information editing, server database management, manual image transfer, and control of the ThinkingScan document scanner.

It also provides tools for technologists to send image data back to modality scanners or workstations using proprietary protocols.

### **3.5 ThinkingScan**

ThinkingScan is a high speed DICOM document scanner that can scan up to 32 pages/min, either simplex or duplex. It is ideal for scanning paper documents, such as EKG print out, patient charts, hard copy reports, etc. The operation is as simple as a single button push.

The scanned results are converted to DICOM images and inserted into patient image database.

If a patient does not exist in the patient database, a new one can be created using either modality worklist or manual patient creation.

## **4 Workflow**

### **4.1 Nuclear Medicine**

#### **4.1.1 ADAC, Marconi/Picker, Siemens ICON, and Cameras that Support Interfile Output**

##### **4.1.1.1 Acquisition and Processing**

The workflow for acquisition and post processing will remain the same.

##### **4.1.1.2 Archiving of Modality Generated Data**

The raw and processed data on these systems will be automatically archived to Thinking Systems' ModalityBroker server by Thinking Systems' DICOM Gateways, which is part of the ModalityBroker server. As soon as images are acquired and processed on the proprietary workstations, our gateways automatically pull all data over.

*Note: In the case that the ModalityBroker server has to handle many scanners, the gateways may be separated out and run on a separate piece of hardware.*

### **4.1.1.3 Image Distribution**

Once the raw and processed images are stored into the ModalityBroker server database, they are immediately routed to hospital/enterprise archive server, Thinking Systems' ThinkingWeb server, and Thinking Systems' MDStation.

### **4.1.1.4 Pre-fetch, Image Review, Image Processing, and Quantification Analysis**

When Thinking Systems' ThinkingWeb server and MDStation workstations receive images from the ModalityBroker, they automatically pre-fetch relevant prior studies of all modalities from hospital/enterprise PACS. Physicians can then review current studies, compare current studies with prior studies of various modalities, and perform further images processing or quantitative analysis.

### **4.1.1.5 Archive of Workstation and Web Server Generated Data**

Any new data generated by Thinking Systems MDStation and ThinkingWeb server, such as SPECT reconstructed data, quantification results, dynamic and static secondary screen captures, etc., will be automatically archived to hospital/enterprise archive server.

## **4.1.2 Siemens Cameras**

### **4.1.2.1 Acquisition and Processing**

The workflow for acquisition and post processing will remain the same.

### **4.1.2.2 Archiving of Modality Generated Data**

Thinking Systems' ModalityBroker server will be added to Siemens eSoft's workflow as an additional DICOM destination. With this addition, all new raw and processed data will be automatically archived to the ModalityBroker server at the end of each eSoft protocol.

### **4.1.2.3 Image Distribution**

Once the raw and processed images are stored into the ModalityBroker server database, they are immediately routed to hospital/enterprise archive server, Thinking Systems' ThinkingWeb server, and Thinking Systems' MDStation.

### **4.1.2.4 Pre-fetch, Image Review, Image Processing, and Quantification Analysis**

When Thinking Systems' ThinkingWeb server and MDStation workstations receive images from the ModalityBroker, they automatically pre-fetch relevant prior studies of all modalities from hospital/enterprise PACS. Physicians can then review current studies, compare current studies with prior studies of various modalities, and perform further images processing or quantitative analysis.

### **4.1.2.5 Archive of Workstation and Web Server Generated Data**

Any new data generated by Thinking Systems MDStation and ThinkingWeb server, such as SPECT reconstructed data, quantification results, dynamic and static secondary screen captures, etc., will be automatically archived to hospital/enterprise archive server.

## **4.1.3 Cameras with DICOM Output**

### **4.1.3.1 Acquisition and Processing**

The workflow for acquisition and post processing will remain the same.

### **4.1.3.2 Archiving of Modality Generated Data**

Thinking Systems' ModalityBroker server will be added to DICOM destination lists on the modality workstations. All new raw and processed data can then be transferred to the ModalityBroker server via DICOM.

### **4.1.3.3 Image Distribution**

Once the raw and processed images are stored into the ModalityBroker server database, they are immediately routed to hospital/enterprise archive server, Thinking Systems' ThinkingWeb server, and Thinking Systems' MDStation.

### **4.1.3.4 Pre-fetch, Image Review, Image Processing, and Quantification Analysis**

When Thinking Systems' ThinkingWeb server and MDStation workstations receive images from the ModalityBroker, they automatically pre-fetch relevant prior studies of all modalities from hospital/enterprise PACS. Physicians can then review current studies, compare current studies with prior studies of various modalities, and perform further images processing or quantitative analysis.

### **4.1.3.5 Archive of Workstation and Web Server Generated Data**

Any new data generated by Thinking Systems MDStation and ThinkingWeb server, such as SPECT reconstructed data, quantification results, dynamic and static secondary screen captures, etc., will be automatically archived to hospital/enterprise archive server.

## **4.2 PET-CT**

### **4.2.1.1 Acquisition and Processing**

The workflow for acquisition and post processing will remain the same.

### **4.2.1.2 Archiving of Modality Generated Data**

Thinking Systems' ModalityBroker server supports GE, Siemens, and Philips PET-CT. The ModalityBroker will be added to the modality workstations or acquisition consoles as an additional archive destination. With this addition, all new raw and processed data will be archived to the ModalityBroker server with a single mouse click at the end of processing.

### **4.2.1.3 Image Distribution**

Once the raw and processed images are stored into the ModalityBroker server database, they are immediately routed to hospital/enterprise archive server, Thinking Systems' ThinkingWeb server, and Thinking Systems' MDStation.

### **4.2.1.4 Pre-fetch, PET-CT fusion, Image Comparisons**

When Thinking Systems' ThinkingWeb server and MDStation workstations receive images from the ModalityBroker, they automatically pre-fetch relevant prior studies of all modalities from hospital/enterprise PACS. Physicians can then perform PET-CT fusion, fusion comparison between current studies and prior studies, and comparison of different modalities.

#### **4.2.1.5 Archive of Workstation and Web Server Generated Data**

Any new data generated by Thinking Systems MDStation and ThinkingWeb server, such as quantification results, dynamic and static secondary screen captures, etc., will be automatically archived to hospital/enterprise archive server.

### ***4.3 General Ultrasound, Echocardiogram, Vascular Ultrasound***

#### **4.3.1.1 Acquisition and Processing**

The workflow for acquisition and post processing will remain the same.

#### **4.3.1.2 Archiving of Modality Generated Data**

Images generated by these modalities currently might be archived to the hospital/enterprise PACS. We recommend that the current data flow be kept. In addition to the existing data flow, these images should be sent to Thinking Systems' ModalityBroker server as well.

#### **4.3.1.3 Image Distribution**

Once the images are stored into the ModalityBroker server database, they are immediately routed to the Thinking Systems' ThinkingWeb server and Thinking Systems' MDStation workstations. They can also be routed to hospital/enterprise archive server as needed.

#### **4.3.1.4 Pre-fetch, PET-CT fusion, Image Comparisons**

When Thinking Systems' ThinkingWeb server and MDStation workstations receive images from the ModalityBroker, they automatically pre-fetch relevant prior studies of all modalities from hospital/enterprise PACS. Physicians can then perform image review, measurements, comparison of current studies and prior studies, and comparison of different modalities.

#### **4.3.1.5 Archive of Workstation and Web Server Generated Data**

Any new data generated by Thinking Systems MDStation and ThinkingWeb server, such as dynamic and static secondary screen captures, etc., will be automatically archived to hospital/enterprise archive server.

### ***4.4 X-Ray Angiography (Cardiac Cath, DSA)***

#### **4.4.1.1 Acquisition and Processing**

The workflow for acquisition and processing will remain the same.

#### **4.4.1.2 Archiving of Modality Generated Data**

Images generated by these modalities currently might be archived to hospital/enterprise PACS. We recommend that the current data flow be kept. In addition to the existing data flow, these images should be sent to Thinking Systems' ModalityBroker server as well.

#### **4.4.1.3 Image Distribution**

Once the images are stored into the ModalityBroker server database, they are immediately routed to the Thinking Systems' ThinkingWeb server, Thinking Systems' MDStation. They can also be routed to hospital/enterprise PACS if needed.

#### **4.4.1.4 Pre-fetch, PET-CT fusion, Image Comparisons**

When Thinking Systems' ThinkingWeb server and MDStation workstations receive images from the ModalityBroker, they automatically pre-fetch relevant prior studies of all modalities from hospital/enterprise PACS. Physicians can then perform image review, measurements, comparison of current studies and prior studies, and comparison of different modalities.

#### **4.4.1.5 Archive of Workstation and Web Server Generated Data**

Any new data generated by Thinking Systems MDStation and ThinkingWeb server, such as dynamic and static secondary screen captures, etc., will be automatically archived to hospital/enterprise archive server.

### **4.5 Hardcopy Documents (EKG print out, patient chart, report)**

#### **4.5.1.1 Scanning**

All paper documents, such as EKG print out, patient charts, and reports, can be scanned using Thinking Systems' ThinkingScan high speed DICOM paper scanner. The scanned results are stored into the ModalityBroker server's image database as DICOM images.

If a study does not exist to save the scanned results into, a new one can be created by using either modality worklist retrieved from HIS/RIS or manual data entry.

#### **4.5.1.2 Image Distribution**

Once the images are stored into the ModalityBroker server database, they are immediately routed to the Thinking Systems' ThinkingWeb server, Thinking Systems' MDStation, and hospital/enterprise PACS.

#### **4.5.1.3 Pre-fetch, Image Review, Image Comparisons**

When Thinking Systems' ThinkingWeb server and MDStation workstations receive images from the ModalityBroker, they automatically pre-fetch relevant prior studies of all modalities from hospital/enterprise PACS. Physicians can then perform image review, measurements, comparison of current studies and prior studies, and comparison of different modalities.

#### **4.5.1.4 Archive of Workstation and Web Server Generated Data**

Any new data generated by Thinking Systems MDStation and ThinkingWeb server, such as dynamic and static secondary screen captures, etc., will be automatically archived to hospital/enterprise archive server.

## **5 Recommended Hardware Configurations**

### **5.1 ModalityBroker Server**

- 2 x Dual Core Xeon 3.20GHz CPU
- 4GB RAM
- Windows Server 2003 with 10 CAL
- 8 x 300GB SAS 10K RPM Configured as RAID-5
- Rack mount chassis
- Redundant Power Supply
- Giga bit NIC
- CD-RW

## **5.2 ThinkingWeb Server**

2 x Dual Core Xeon 3.20GHz CPU  
4GB RAM  
Windows Server 2003 with 10 CAL  
6 x 146GB SAS 15K RPM Configured as RAID-5  
Rack mount chassis  
Redundant Power Supply  
Giga bit NIC  
CD-RW

## **5.3 MDStation**

Dual Core Xeon 3.20GHz or Dual Core Pentium 3.40GHz CPU  
XP Professional  
4GB RAM  
500GB SATA drive  
16x DVD+/-RW  
30" LCD display  
nVidia Quadro FX3450 Video Card  
USB Keyboard  
USB Optical Wheel Mouse

## **5.4 TechStation**

Dual Core Pentium 3.40GHz CPU  
XP Professional  
4GB RAM  
250GB SATA drive  
16x DVD+/-RW  
21" LCD display  
USB Keyboard  
USB Optical Wheel Mouse