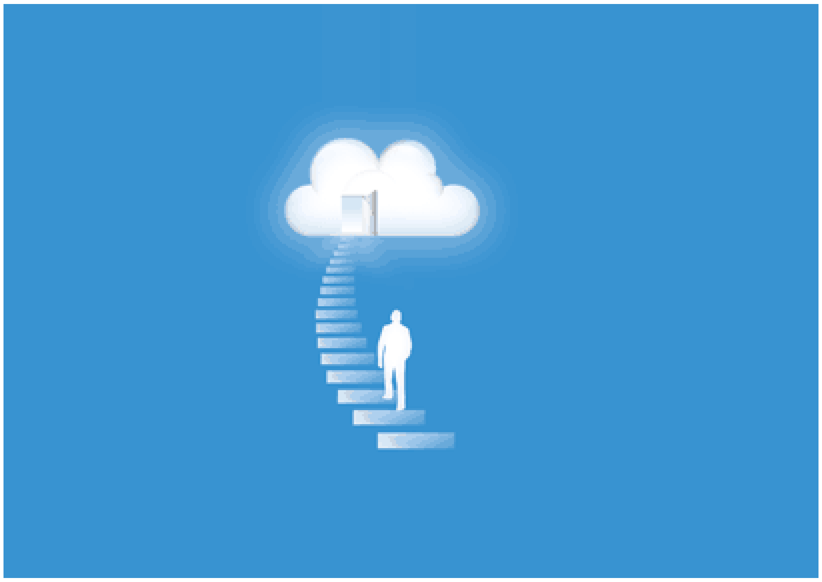

Cloud Infrastructure in Vendor Neutral Archive Configurations

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Message

Today, most thought leaders in healthcare analytics see a health information exchange (HIE) as a data source to tap into, but not as a place for executing an analytic. The IT revolution to Cloud Infrastructure is changing these perceptions and enabling new solutions for healthcare IT. Through a metadata-driven and policy-based approach to information assembly, for purpose, and with appropriate access controls, protections and audit capabilities, communities of information collaborators will emerge with known lineage. Provenance associated with a derived information set will redefine the future of health information exchange. To adequately master clinical, operational and financial policy and subsequent analytics, rich meta-data must be used to find increasingly granular data patterns which optimize pathways and improve the feedback loop.

How do we create rich metadata that describes all of the data objects which belong in the patient's longitudinal health record? How do we manage and exchange that metadata? How do we mine that metadata? While the DICOM standard has got us to where we are, it has also been holding us back from where we need to be. We need a new medical image data management and distribution paradigm.

As Accountable Care Organizations (ACO) emerge as a market focus, they will require that providers accept and contract for financial risk management of a specific patient base. ACO's will require unique aggregation and enrichment of data from both a clinical and financial aspect in order to reconcile the risk/reward equation. Solving the privacy and security issues for the HIE will reduce the friction of data flow from the point of care to physicians and clinicians, to the PHR solutions, and eventually to the clinical trial owners and other data consumers. It is premised that, the subsequent reduction in friction will lower costs dramatically while contributing positively to outcomes, thus forcing adoption. Secure Information Exchange technologies, demonstrating the value of contextual analytics in the Cloud, leveraging federated information under appropriate policy based control will improve quality, lower cost and attack fraud. The U.S. National Health Care Anti-Fraud Association (NHCAA) estimates *conservatively* that 3% of all U.S. health care spending—or $68 billion—is lost to health care fraud. Alternatively, the FBI places the loss due to health care fraud as high as 10 percent of our nation's annual health care expenditure – or $226 billion each year. Secure and Cloud-based analytics of health information will save money and drive new research on how to do research.

This is where health data management needs to go.

A Vendor Neutral Archive (VNA) is an important cornerstone in the foundation of a secure healthcare Cloud. Today healthcare providers suffer the silos of inaccessible data hidden behind proprietary data schema. More painful still, is the inability of the person being treated to control how their information is viewed and used throughout the health ecosystem. To this end, there will likely never be a singular policy end-point, but rather a set of federated policies that provide insight as to the general policy of their federated information. Moving forward we need active, contextual control of information by its owner: the patient and their advocates, with a level of auditable transparency so as to minimize complexity while enforcing controls. As the healthcare marketplace adopts foundational elements like VNA and Cloud Infrastructure, caregivers will have a more complete and informed choice at a lower cost.

This white paper describes the foundational technologies that become transformative as we ultimately create a portable health record in an increasingly portable device driven society.

Preface

The concept of Vendor or PACS Neutral Archive has recently emerged in the medical imaging market. The concept represents a paradigm shift in how and where medical image data is managed. The responsibility for managing the image data is shifted from individual departmental Picture Archiving and Communications Systems (PACS), which typically store the data in closely associated storage solutions, to an independent (hence Neutral) enterprise-class Archive system.

The Vendor Neutral Archive is an Enterprise-class data management system that consolidates primarily medical image data from multiple imaging departments into a Master Directory and associated Storage Solution. The VNA replaces the individual archives associated with departmental PACS, systems with unfortunate proprietary characteristics that limit their interoperability. Furthermore, by virtue of having consolidated all of the enterprise image data in this independent Archive, the VNA also becomes a unified image data repository for the Electronic Medical Record (EMR) system.

The primary purpose of the VNA is to resolve many of the “pains” associated with today’s departmental PACS, most of which result from the way PACS modify and “archive” the image data they have ingested. Departmental PACS typically alter existing metadata associated with the ingested image data objects as well as create new proprietary metadata to be associated with the images. While the vendors may argue useful benefits to their customization of the data, both functions effectively create a somewhat proprietary database. PACS tend to be self-contained and are often designed to be closed systems.

They manage their own data and frequently do not easily share their data with other systems. This metadata manipulation and selfish possession of the data complicates data portability between disparate departmental PACS, and in the long run dictates a complicated and expensive migration of the image data when the time comes to replace the PACS. The primary purpose of the VNA is to dynamically resolve these metadata idiosyncrasies between disparate PACS. A secondary, nevertheless important purpose of the VNA is to consolidate all of the different departmental PACS storage silos into a single enterprise storage solution, thereby achieving the economies of scale while simplifying support.

While fixing the data portability issue and consolidating the PACS storage silos were the two initial drivers for the VNA, other important data management issues soon emerged. Principal among these is what to do about non-DICOM image data objects that should be part of the patient's longitudinal medical record. Some of these image objects might be created or managed by small department PACS that simply don't support DICOM. For example, there are Dental and Ophthalmology PACS that only support/manage JPEG image objects. There are also a number of imaging departments that do not have a departmental PACS, and in these departments, Source devices simply produce digital image data that is typically captured to hardcopy or written to CD/DVD. Examples of these imaging Sources include high definition Endoscopy cameras, and digital cameras used in Dermatology and Surgery. The first issue is what to do with the non-DICOM image data and the second issue is how to support image acquisition and management for departments that do not have their own PACS.

In a White Paper[1] that I recently authored, I have made an extensive argument in favor of converting non-DICOM image data objects to DICOM objects wherever feasible. This conversion can be handled either internal or external to the VNA, as part of the interface process connecting the departmental PACS or individual imaging Sources to the VNA. In general, I have argued that the VNA should remain largely a DICOM oriented archive until such time as it becomes prudent to add Cross-enterprise Document Sharing (XDS) functionality to the VNA. XDS will enable the VNA to efficiently manage both DICOM and non-DICOM data objects. The XDS Repository and associated Master Patient Index (MPI) provides the identifying metadata required to capture, manage and retrieve the otherwise unstructured data. The XDS-compliant Document Consumer then brings both DICOM and non-DICOM patient data together at the presentation layer, which for most physicians will be the Electronic Medical Record Portal Viewer.

In those departments where the image Sources do not have benefit of a local department PACS to organize their data, the VNA must then provide all of the PACS functionality including the acquisition interface, QA and QC tools, and some method for displaying the images. The VNA becomes the PACS for all of the departments that otherwise do not have a PACS.

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[1] Best Practices Strategy for Dealing with non-DICOM Data objects in a PACS-Neutral Archive. By Michael J. Gray; Principal, Gray Consulting; October 18, 2010

As mentioned above, there are arguments for delaying deployment of XDS and MPI at this point in the market. XDS and especially MPI add considerable cost to the VNA configuration, and many potential Document Consumers would be legacy PACS and DICOM display stations that would require expensive upgrades to add XDS functionality. It could take a number of upgrade and replacement cycles to bring XDS and MPI into the mainstream.

That leaves us with the issue of what to do TODAY about a number of non-DICOM image objects that do not lend themselves to being converted to DICOM as well as numerous unstructured data objects, which probably belong in the patient's longitudinal medical record. At the very least we need someplace to store those data objects in the pre-XDS era. We will come back to this issue later in this paper.

The VNA concept has evolved in the manner in which I have described it in this preface: [1] problem solver for DICOM PACS systems; and [2] enterprise-class storage device for image data objects outside of conventional department PACS. The reader can discover much more granular detail of the VNA or PACS-Neutral Archive in an article[2] posted on my web site http://www.graycons.com. Other useful information on the subject is organized on the web site under the category PACS-Neutral Archive.

While the medical image market pro-actively focused on solving PACS problems and finding a home for as many of the patient's medical images as possible, a different medical informatics movement was underway, deploying an Electronic Medical Record system and its associated Physician Portal. The EMR would bring all types of clinical information to the caregiver's computer, tablet or phone screen. One of the earliest issues was image enabling the EMR, and that typically meant building an interface to the Radiology PACS. That would follow with a need to build an interface to the Cardiology PACS, and so on and so forth until we had interfaces to all of those individual silos of image data scattered across the enterprise. And all of those interfaces meant individual viewing applications and individual viewing sessions. As these multiple interfaces propagate links into the EMR, the department migration challenges grow exponentially with broken links to be found and repaired. The watershed moment arrived when it occurred to nearly everyone looking at this scenario that the better solution would be to deploy the VNA for all of the aforementioned reasons and then take advantage of the fact that the VNA had effectively become the consolidated Enterprise Image Repository for the EMR. A single interface from the EMR to a single multi-modality viewer which in turn drew image data from the VNA was the better approach to image-enabling the EMR. The UniViewer concept was born, and thus we round out our description of the VNA.

[2] Essential Ingredients of a PACS-Neutral Archive By Michael J. Gray, Principal, Gray Consulting December 15, 2009

Early VNA Configurations

The Vendor Neutral Archive is first and foremost a suite of integrated software applications including: data management scheme capable of logical separation of individual organizational nodes, the all-important tag mapping engine and associated tag library, a meta-data driven Information Lifecycle Management program, an HL7-driven Pre-fetch and Auto-rout capability, and the ability to aggregate patient data across multiple organizational nodes and multiple medical record numbering systems. The UniViewer application is often thought of and deployed as a separate subsystem, and as such the viewer may be interfaced with, rather than integrated into, the VNA software. There is some sense to this separation. Medical image viewing is a complicated application; the best viewers are often developed by independent vendors specializing in image display. The other rationale is hardware related. The ideal UniViewer features [1] a zero client download, [2] server-side rendering of the image data and [3] a progressive streaming of the pixels that constitute the HTML version of the image to be displayed. This functionality typically required a specialized card to render the pixels. It is this physical card that makes it difficult to virtualize the display application. Unfortunately many of today's UniViewer applications are somewhat tied to hardware. Even if the VNA application suite can be virtualized…run in the organizations VMware environment…the hardware-dependent UniViewer remains a separate application on dedicated hardware. Ideally the UniViewer would be a software-only application, so it too could be computing in the data center and not on a PC.

And what about the Physical Edition of the VNA? The Physical Edition is somewhat hardware agnostic and typically hosted on a number of low-cost servers under a series of load balancers. The application suite itself may run under a specific operating system (i.e. Windows) and be based on a specific DBM application (i.e. SQL).

As for storage…the VNA is storage agnostic, making it possible for the organization to choose whatever storage solution best meets their needs. This openness also creates the opportunity year after year for the organization to stay current with the latest in storage technologies. Yet many of the early VNA installations were typically deployed with the types of storage solutions that were recommended for years by their PACS vendors… simple NAS and SAN configurations connected to the VNA servers through NFS and CIFS mount points (file system interfaces). Only a few of the early VNA configurations included "intelligent" storage solutions, server-based applications sitting in front of the storage which could use metadata describing the image data to determine how many copies to make, which type of media to use to store those copies, and when to move the data from tier to tier as it becomes less "relevant". In short, most early VNA configurations are Physical Editions of the software applications running on somewhat generic servers and using somewhat generic storage solutions. These VNA configurations look a lot like their large department PACS predecessors, meaning the early VNA configuration is only a small step forward from a large PACS.

Where the early VNA configurations differ from the department PACS is in their methodology for addressing Disaster Recovery and Business Continuity. Most VNA configurations are comprised of mirrored Primary and Secondary subsystems that are physically separated from each other, one in each of the organizations on premise data centers. Each subsystem is a complete VNA containing a copy of the VNA application suite and a copy of the data. The two subsystems are synchronized in near real time. The loss of data in one storage solution can be replaced by its copy in the other storage solution. The loss of the entire Primary subsystem causes the failover to the Secondary subsystem. Short of the complete loss of both subsystems, Disaster Recovery and Business Continuity are assured.

Allow me to emphasize once again, that despite the advanced approach to Disaster Recovery and Business Continuity and the fundamental ability to manipulate the DICOM header, the early version of Vendor Neutral Archive is not technically far removed from a big PACS. This is so typical of the medical imaging community, taking baby steps with respect to innovation, when there is so much more potential available. After a quick description of the market in the next section, we will be prepared to look at some of the technical innovations that will move the VNA into the next generation of medical data management and distribution. Specifically we will see how a VNA application paired with the EMC® Atmos® Cloud Infrastructure can deliver on the full promise of the Neutral Archive.

Market Description

The popular description of a technology-oriented market uses such terms as: Early Adopter to describe the leading edge customers of a new technology, Early and Late Majority to describe the largest segment of customers under the bell curve, and Laggards to describe those customers that are the last to purchase a new technology. Early Adopters are risk takers and innovators. The Majority purchase the technology when they see it as proven and very stable. The Laggards are risk adverse or simply uncomfortable with change.

The Radiology PACS market is nearly 100% saturated, meaning only the Laggards (represented by the small hospitals and imaging centers) are still using a film-based image management system. The VNA market is emerging from the Early Adopter phase. The Early Adopters are those Heathcare organizations that have recognized the source of their PACS "pains" and understand the risk-reward ratio of pulling the A out of PACS and developing a separate enterprise data repository for all of the clinical data objects that belong in the patient's longitudinal medical record. These organizations are large, probably have multiple facilities, generate large annual data volumes, have an established EMR that is image-enabled with at least radiology images, and they are well along in establishing their claims for reimbursement for Meaningful Use. They have a well-funded and well-staffed Information Services department, which is already managing dual data centers and is comfortable purchasing and self-managing multi-component solutions (hardware/software).

Contrary to this very sophisticated profile, they have a tendency to want to store all of their data on-premises, distrusting the off-premises service provider.

The Early Majority are those Healthcare Organizations that are very similar to the Early Adopters except for their view of risk-reward. The Early Majority is evaluating the VNA as the technology matures. They want to be #100 on the user list, rather than #10. They probably don't have two data centers, and their IT staff is not comfortable self-monitoring complex, multi-vendor systems. Many of the Early Majority will feel better with a turn-key VNA solution from a single vendor, a solution that looks like a big PACS and is supported by a big company.

As the technology adoption process progresses thru the back side of the curve, the Late Majority will be characterized by those organizations that have fewer IT resources and even more aversion to risk. The VNA configuration that will appeal to this market segment will most likely look very different than the configurations being deployed today. In addition to the single solution, big vendor approach, that future VNA will probably have to be a delivered service, and because of limited IT as well as physical resources, the majority of what constitutes the VNA will probably be off-premises.

In the next section we will explore some of the technologies that are expected to lead the way in moving the VNA into its next generation and through the bulk of the technology adoption curve. Throughout that discussion we will reference the various market segments and see how the innovations that emerge in the later phases of this market will eventually be implemented by the earliest adopters.

Leading Edge Innovations in Storage Solutions

Smart VNA, dumb storage is a fair description of today's VNA configurations and that is probably the way several VNA vendors would like it to remain, with their newly positioned VNA application at the center of the universe, but that is not necessarily in the best interest of the healthcare organization. The guiding principal of the VNA is to give the organization ownership and free access of its data, which should mean that all VNA solutions are interchangeable without a data migration, and there should be multiple ways to access and retrieve the data. The early configurations of the VNA, with their file system interfaces to mass storage are limiting the accessibility of the data and limiting the full potential of the Neutral Archive. The key to the next generation of the Neutral Archive and coincidentally the key to expanding the market into the Early Majority phase is the pairing of the VNA application suite with the flexibility and benefits of Cloud Infrastructure.

In general, Cloud Infrastructure is a storage model that stores data on multiple virtual arrays, which may be located either on-premises or off-premises, as opposed to the dedicated storage at the end of the NFS and CIFS file system interfaces so common in today's PACS and VNA configurations.

Cloud Infrastructure lends itself to the managed service model, which means that a significant percentage of the storage could easily be located off-premises in a shared data center. This model also means that the ever-expanding need for storage can be contracted on a pay-as-you-go basis. These two features of the Cloud Infrastructure should be very attractive to the Early Majority who characteristically have limited IT and funding resources. There are also significant technology advantages to Cloud Infrastructure, which not only end up reducing the overall cost of ownership, but provide numerous data management and data access features that the current VNA application can not provide.

The key features of the Cloud Infrastructure model and a brief comment on each is presented in the following paragraphs.

HTTP Access Methodology - The Cloud Infrastructure application layer not only supports the traditional NFS and CIFS file system interfaces, it also supports the newer web services interfaces REST and SOAP, both of which are based on HTTP, the underlying technology of the web. With the REST access method there are no LUN's and no file system to support, thus lowering the cost of maintenance. Furthermore, HTTP is a much more efficient access method for the VNA, as there is less overhead and the PUT and GET protocols are well defined.

HTTP is at the core of numerous other technologies used in medical imaging including: Web Access to DICOM persistent Objects (WADO); Cross-enterprise Document Sharing (XDS), the key to all types of data object exchange across healthcare enterprises; and the latest generation of server-side rendering image viewers (UniViewers).

The use of HTTP as an access method also opens up the storage solution to wider data access. Accessing the data in today's VNA requires using the Directory database of the VNA to find and retrieve the data from the storage solution. In the very near future any authorized device that can submit basic identifying information like a patient name or an accession number via an HTTP call directly to the Cloud Infrastructure (storage) can identify and retrieve the data without having to go through the VNA. A UniViewer using the HTTP access method can locate and retrieve image data directly from the Cloud Infrastructure without having to go through the VNA.

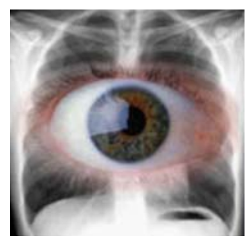
Metadata -The Cloud Infrastructure application layer collects metadata associated with each of the data objects that it ingests and manages. The VNA using the REST access method to the Cloud Infrastructure passes the data object to the storage solution as a byte stream. Immediately following the data object, the VNA sends an XML package of the metadata associated with the data object that the Storage solution will use to intelligently manage that data. The VNA will pass perhaps as many as a few dozen ID tags like patient name, sex, date of birth, study accession number, study description, etc. in this XML package. There really is no limit to the number of tags that can be passed to the Cloud Infrastructure application. The amount and type of metadata passed to the Cloud Infrastructure is determined by the level of granularity desired in the data management and data mining applications.

The Cloud Infrastructure application can use this metadata associated with the data objects to conduct all of the typical storage maintenance tasks such as back-up, data replication, data de-duplication, lifecycle maintenance governed by user-defined data protection and retention policies. The user doesn't have to bother with these maintenance tasks, thus reducing (if not eliminating) many of the costs of maintenance associated with traditional data storage.

A Directory database in the Cloud Infrastructure application manages all of this metadata and the pointers to where the data objects are physically stored. Direct HTTP access to the Cloud Infrastructure solution's Directory actually opens up the data to a larger group of consumers than would otherwise have access, because access is no longer limited to those consumers who access through the VNA.

Because of HTTP and the metadata Directory, the Cloud Infrastructure solution is capable of managing the widest possible array of data object types (DICOM and non-DICOM) and the widest array of data object consumers, thereby greatly expanding the concept of the Neutral Archive with increasingly granular informed consent controls.

Introducing MINT - The acronym represents Medical Imaging Network Transport. MINT is an effort started up in 2010 by members of the medical imaging community to solve a number of problems with the use of the DICOM standard as the mechanism for transferring image data between medical imaging systems. MINT takes advantage of the structured nature of the DICOM data object, but utilizes HTTP as the transport mechanism and XML as the means for encoding the metadata that fully defines the data object. MINT is a straightforward extension of the DICOM standard that allows utilization of up to 80% of the available network bandwidth. An introduction to MINT can be found at http://www.gotmint.org. There you will be able to download a PowerPoint presentation[3] that describes MINT. MINT is expected to replace the WADO portion of the DICOM Standard, which means that once it is accepted by the DICOM standard committee, the MINT version of web services will be on its way to becoming the preferred methodology for exchanging DICOM images between PACS, Storage Solutions, UniViewers, and Specialty Workstations. As stated in the PowerPoint presentation, "MINT leverages HTTP – the enterprise standard technology for information transport. This allows it (MINT) to benefit from related technology advances and general understanding by IT." In my opinion, the MINT effort is yet another visible sign that the medical imaging community recognizes that it has to move beyond DICOM to an HTTP/metadata paradigm, because we desperately need a more efficient and reliable way to exchange both DICOM and non-DICOM image data between systems, and a performance boost is a requisite for exchanging data with the off-premises Cloud.



[3] MINT Technical Overview, October 8, 2010

The Cloud's Infrastructure's Directory database can also be a powerful metadata query engine. Authorized access can probe the directory of metadata tags in search of patterns in the data. Combinations of imaging characteristics can be used to predict key diagnostic and therapeutic events. Ramin Khorasani, MD, vice chairman department of radiology at Brigham & Women's Hospital in Boston recently stated[4] that "Mining imaging databases creates an opportunity for quality improvement. If we could identify those databases and harvest data from them, we could create a virtual dashboard of our practice to get us started in a meaningful way." The Cloud Infrastructure's Directory database is not limited to the metadata forwarded with DICOM data objects by the VNA. It can potentially contain metadata associated with all of the non-DICOM data objects assembled in the patient's longitudinal health record. Once again this greatly expands the concept of the Vendor Neutral Archive.

Multitenancy – the Cloud Infrastructure's application layer supports multitenancy, meaning that the data is logically separated for users from a single global namespace that may be physically separated (i.e. different departments, facilities, and organizations). This enables security and utilization tracking, isolation of administration, optimization of policies for individual tenant's data, and continued sharing of total available storage capacity independent of location for maximum utilization.

Public or Private - The Cloud Infrastructure can be either Public or Private, meaning that a large Independent Delivery Network (IDN) or a large multi-facility Healthcare Organization can deploy its own Cloud Infrastructure in its data centers and share that storage with each of its member organizations. Smaller organizations can contract for their storage space from a much larger public Cloud Infrastructure provider.

Physical or Virtual - The Cloud Infrastructure can be either Physical or Virtual, meaning that application layer can be virtualized with the server and storage hardware spread over the enterprise wherever there is network access and power. Alternatively the application layer can be installed on commodity hardware

General Description of EMC[2] Atmos

Atmos is a software Cloud Infrastructure platform that leverages low-cost, high-density commodity hardware and scales to petabytes. It was designed to help users automatically manage and optimize the distribution of unstructured object data across the enterprise, whether that means a single facility Healthcare Organization, multi-facility Independent Delivery Network, or a regional Health Information Exchange.

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[4] Practice Management at RSNA: Survival of the Fittest by Lisa Fratt, Editor of *Health Imaging & IT* Nov 5, 2010

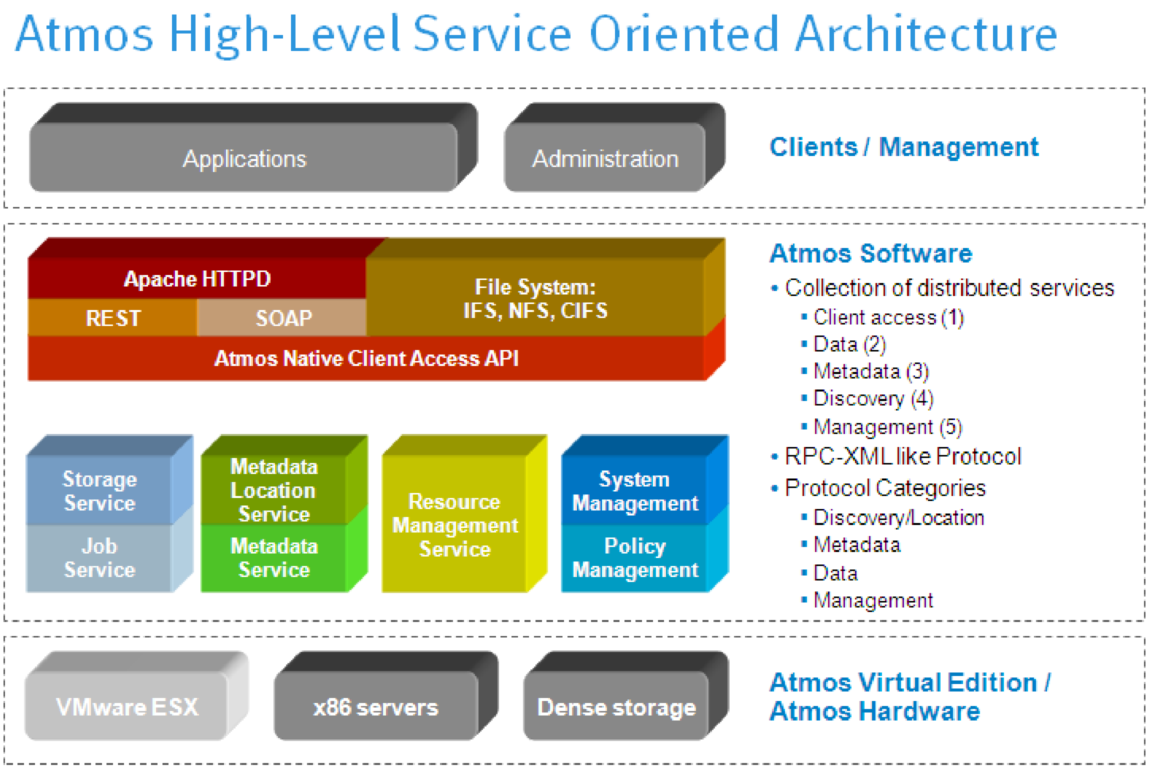
Atmos uses its metadata to drive user-defined Information Lifecycle Management policies that include the option to flex out to public Cloud Infrastructure services.

The list of Atmos features and functions describes a truly innovative Cloud Infrastructure platform that is ideally suited to pairing with a Vendor Neutral Archive, to achieve the full potential of enterprise-class medical data management. An excellent resource paper[5] describes Atmos for readers with an IT background. The first six pages of this paper will significantly reduce the learning curve on this subject for most of us. That paper can be found at http://software.intel.com/file/31978 Following is a summary of the major features and functions of Atmos that are most significant to a VNA configuration.

It supports web services access by the VNA and UniViewer applications. The simple HTTP (REST) method is a much more efficient and scalable access method than a traditional file system interface. Yet Atmos also supports the traditional file system interfaces, which might be more suited to legacy imaging sources.

Atmos web services access methods require data sources to submit associated metadata that defines the data object. This means that DICOM data can be submitted by the VNA and non-DICOM data can be submitted by any Source that supports either web services or a file system interface. Alternatively Atmos can ingest and manage non-DICOM data objects that are submitted by an XDS Registry and Repository making Atmos an ideal storage platform for this IHE driven methodology of managing and distributing medical data. EMC^2 Documentum, the document management system, supports a REST interface. Considering all of the types of data objects and all of the potential Sources of that data, Atmos can therefore manage all forms of DICOM and non-DICOM clinical data that belong in the patient's longitudinal medical record.

[5] Intel Cloud Builders Guide: Cloud Design and Deployment on Intel Platforms



Atmos uses metadata driven Policies to automatically move information to the appropriate storage location based on its value throughout its lifecycle. That includes the ability to move the oldest less-relevant data off-premises to a public cloud or to on-premises disks that the software can spin down. This provides modern logical isolation of data in a cloud pool, as well as built-in Disaster Recovery and Business Continuity.

Atmos metadata-driven Information Lifecycle Management Policies go far beyond the more limited ILM Policies provided by the VNA. Yet Atmos can synchronize its Policies with similar Policies supported by the VNA, in particular Pre-fetching and Auto-Routing and Data Retention/Deletion. With respect to data retention and deletion, Atmos meets the HIPAA technical safeguards standard for data protection and data corroboration, both of which include the usage of check sum, double-keying, message authentication and digital signature to ensure data integrity. Combined with erasure coding, these features enable a configuration of up to 7 nines of availability.

A query of the Atmos Directory for its contents, results in the return of keys containing all of the metadata describing the objects under management. Any VNA can be replaced by any other VNA by simply building the new VNA Directory of patient/study information using the metadata provided by Atmos. Thereafter the new VNA can access the Atmos data and there is no need for a cumbersome Data Migration.

Atmos provides superior performance, featuring Throughput (multi-threaded apps up to 300 MB/sec), Scalability (10 TB to 10's of PetaBytes), and Flexibility (up to 5 ways to attach applications).

An organization can use Atmos in the cloud, or an organization can also have its own Private Cloud inside the enterprise and federate data to an outside public Cloud. Atmos support of multitenancy allows for usage/chargeback models for the IDN configuration.

Atmos can be deployed on-premises as a Virtual Edition or as a Physical Edition…as a Virtual Edition on top of traditional storage models, or as a Physical Edition designed for maximum scale and lowest cost.

Description of EMC^2 Proposed VNA Configuration that is Leveraged with Atmos

Considering the profile of the Early Adopter, there are a number of VNA/Atmos configurations that would provide better performance and feature/functionality than the traditional VNA with File System attached storage.

Atmos Physical Edition – A VNA with all of the appropriate features and functionality listed on page 5, most notably an advanced Tag Mapping Engine and Library, is hosted by eight X-86 servers under a pair of load balancers. The Atmos application would also be hosted by commodity hardware…a combination of 1U servers with multiple NICS, 32GB of RAM, Switch connected to EMC standard Disk array enclosures of 1 or 2 terabyte drives. The DAEs and Rack are EMC hardened with dual power etc. The DAE trays can be single tray of 15 disks or a "double pull" tray of 30 disks. Entry point on the small physical edition is 60 TeraBytes with an upside capacity of 720 TeraBytes in one floor tile. This configuration can sit anywhere where there is power and network. The number of servers varies by model for more performance vs capacity. This would represent the Primary subsystem and a mirrored Secondary subsystem would be located in a second data center. The VNA communicates DICOM data to Atmos via HTTP (REST).

Non-DICOM data can be communicated from Source systems directly to Atmos using any of the 5 supported access methods. The choice would most likely be determined by the Source, and whether the Source would expect Atmos to return to it any of these data objects. Documentum is a consideration for the document management system, and this system would access Atmos via HTTP (REST).

An optional management layer for both DICOM and non-DICOM data would be XDS Registry and Repository with its associated Master Patient Index. These technologies would also utilize HTTP access to Atmos. The XDS option would be driven by the need to resolve multiple medical record numbering systems in the enterprise, accommodate significant volumes of non-DICOM data objects that do not lend themselves to DICOM conversion, or the organization’s desire to participate in a local or broader Health Information Exchange.

The VNA and optionally XDS applications would pass as much metadata to Atmos as necessary to support the extended Information Lifecycle Management Policy, especially the Data Duplication, Tiering, and Deletion Policies.

The UniViewer component of this configuration should ideally be one that features zero download, server-side rendering, and an HTTP access method. The number of servers and load balancers for this subsystem would be determined by the number of concurrent users and thus the servers resources required to meet performance expectations. One of the advantages of the HTTP access is that the UniViewer can draw image data directly from Atmos, thereby reducing the server requirements for the VNA.

The Atmos Physical Edition would be most suitable to organizations who have (or are prepared to establish) dual data centers, and have a preference for managing all of their data on-premises. If this organization has multiple facilities, local Facility Image Caches consisting of an instance of both the VNA and Atmos on small commodity server configurations can be located in each facility, while the Primary and Secondary subsystems that constitute the bulk of the VNA/Atmos infrastructure would reside in the two data centers.

Physical Edition would also be suitable for the larger Independent Delivery Networks (IDN) with capacity requirements above 60TB. In this case, the physical Primary and Secondary subsystems that constitute the bulk of the VNA/Atmos infrastructure would reside in the IDN data centers (the IDN Private Cloud). Each of the individual hospitals would have their own local virtual VNA/Atmos platform including sufficient local storage to meet the performance expectations of the PACS users. Between the PACS and the VNA/Atmos, there should initially be enough on-premises storage to manage the most recent 18 months of image data. This volume has nothing to do with satisfying the UniViewer users, because those users will be the beneficiaries of the UniViewer, which will be able to efficiently stream HTML versions of the images over the internet from as far away as the IDN data center. The local cache(s) will be needed to provide full fidelity DICOM images over the LAN to the PACS Diagnostic workstations in order to populate hanging protocols with priors. This recommended volume of local storage will tend to decrease as affordable bandwidth at the 10 gigabit level becomes available in the data centers enabling low bandwidth streaming to wireless and fixed devices

In this IDN configuration, Atmos multitenancy will enable the IDN to dynamically allocate long-term storage to the individual hospitals, allow each hospital to establish its own ILM policies and monitor its own audit logs, and allow the IDN to accurately define charge-backs for the services.

Atmos Virtual Edition #1 - Both the VNA and Atmos are run in the VMware ESX v4.x environment. The number of servers is close to the number described in the Physical Edition, but the organization has more flexibility in the location of the servers. The XDS Registry/Repository and MPI would also run in the VMware environment, if this technology is to be included in the configuration.

Ideally the UniViewer selected for this configuration is developed from the ground up as a software-only application (does not require a dedicated rendering card), so it too can be virtualized. Of course, this UniViewer also uses HTTP access directly to Atmos to retrieve the image data, thus eliminating the loop through the VNA. This access method also provides the UniViewer with access to all of the data objects being managed by Atmos, not just the DICOM objects submitted by the VNA. Refer to my previous comments on MINT (page 9).

Atmos Virtual Edition #1 would be most suitable to the same Early Adopter organizations with capacity requirements of less than 60TB but also appreciate the efficiency and cost savings of the virtual environment. Once again, if this organization has multiple facilities, VMware will make it much easier to establish those Facility Image Caches that would be located in each facility. Virtual instances of all the applications in this configuration can run on those local servers in the facilities.

Virtual Edition #2 – All of the individual applications run in the VMware environment. This would include: [1] the VNA and Atmos applications, [2] The XDS Registry/Repository and MPI (if included), [3] the UniViewer. All access to Atmos is via HTTP. In this configuration, the primary archive copy of the data managed by Atmos is located on-premises. The Secondary copy and any additional copies are located off-premises, most likely under a contract with a managed services provider.

Virtual Edition #2 would be most suitable to the Early Adopter organizations, who have begun to realize that there is no strong technology argument for managing the back-up copies of their image data on-premises, and realize that there are significant cost savings to be had from operationalizing the management of the back-up copy off-premises. Even the Business Continuity objectives can be met when the synchronous WAN access to the off-premises Cloud Infrastructure is added to the equation.

This Edition should also be very attractive to both Early Adopter and Early Majority organizations that do not have (nor want to invest in) a second data center.

Virtual Edition #3 – In this Virtual Edition of the VNA/Atmos configuration, both the Primary and Secondary archive copies of the image data are moved off-premises, into a Cloud Infrastructure. As described in Virtual Edition #1, there will most likely have to be a smaller local image cache of some size on-premises, wherever there is a PACS that requires full-fidelity priors for comparison. The capacity requirements for these local caches will obviously depend on the WAN bandwidth available to each location. It is recognized that moving the Primary and all back-up archive copies of the data into an off-premises Cloud Infrastructure is a major paradigm shift in medical image management. Imaging departments are particularly possessive of their data, even in the face of overwhelming economic arguments.

That is why I believe that Virtual Edition #3 will probably be chosen in large numbers only when the market is well into the Early Majority phase. Smaller organizations, especially those without second data centers, with limited IT resources and limited funds will be attracted to turn-key solutions supported by large companies, probably under fee-for-service arrangements, simply because this may be their only viable option.

Market Adoption

Virtual VNA/Atmos configurations with the majority of the storage off-premises should hold special appeal to Early Adopter IDNs that appreciate the administrative advantages of the virtual environment. Allowing their individual hospitals to continue building out monolithic silos of data glued to each PACS, often based on disparate hardware, is simply an unsustainable strategy. Most IDNs clearly understand what a VNA is and what advantages it brings to their organization. There are major reductions in cost of hardware, and significant reductions in cost of maintenance. When 10 gigabit networks, HTTP access methods (see MINT on page 9) and virtualized UniViewer are added to the discussion, the arguments for deployment of this Edition of VNA/Atmos are very convincing.

Atmos Physical Edition is a best fit for the larger IDN. In this adoption group it is less likely that all of the imaging departments will agree on the same PACS. Large IDNs have difficulty getting all of their constituents to agree on common solutions as a way to solve their data management problems. The Physical Edition of Atmos combined with VNA enables the IDN to take charge of the data management problem, while allowing the imaging departments to choose whatever department solution they believe meets their needs. In my opinion, the Physical Edition of Atmos will enable the large IDNs to actually adopt the technology at scale.

Organizations of all sizes and complexity, which are characterized by limited IT resources, limited experience with complex multi-vendor systems, and limited funding, are probably not going to adopt VNA technology until the system is presented to them by a large, stable vendor that can cost-effectively manage that system for them. The key to managing as complex a system as an Enterprise data management/distribution system is Virtualization of that system in a Cloud Infrastructure like the VNA and Atmos configurations discussed in this paper. In my opinion, the virtualized VNA with Atmos configuration will play a leading role in the transition of the market from Early Adopter to Early Majority. As off-premise Cloud Infrastructure PROVES itself to be reliable as well as cost-effective, the data possession issues so prevalent in medical imaging will begin to fade away, and even the Early Adopters who have paved the way with Physical VNA configurations, will gradually switch to off-premises Cloud Infrastructure for a majority of their data.

Even if the PACS vendors are slow to adopt MINT and its HTTP transfer protocol, the market shift to off-premises storage for most of an organization's data can still happen, because the VNA, UniViewer, and Cloud Infrastructure vendors will certainly adopt MINT. If PACS vendors chose to delay this major improvement to their systems, so be it.

Enterprise data management and distribution is already on the move out of the department PACS. Virtualized Cloud Infrastructure is the next generation of medical image data management and distribution. It is a transformative technology that has the potential to enable better collaboration through meta data analytics at cloud scale.

About the author…

Mr. Michael Gray is the principal of Gray Consulting, a consulting practice established in 1991 to develop a number of consulting services designed to assist Health Systems and Radiology Practice Groups. Gray Consulting has provided consulting services related to PACS and Enterprise Archiving to over 75 Organizations.

Mr. Gray routinely publishes articles on his Weblog (http://www.graycons.com) on subjects such as workflow design, business case modeling, system deployment strategies, expansion or replacement of data Storage Solutions, development of Data Migration strategies from old to new PACS, and the latest market concepts including PACS-Neutral Enterprise Archiving.

Mr. Gray has a BS in Biology and Chemistry from Washington University, St. Louis; has been awarded three US patents; and has an extensive bibliography in medical image display and electronic information management systems.

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