Technical & Financial Argument for a PACS Vendor-Neutral DICOM Enterprise Archive

A White Paper
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Preface

The Digital Image Archive holds a prominent place in the Picture Archiving and Communications System, holding down the second letter in the acronym, yet the archiving aspect of most PACS has long been relegated to an afterthought, a storage solution and some application software tacked onto the system. Until recently, the archive was thought of as something every PACS included, because it was included. It was simply part of the system. Until recently, the choice of storage solution was up to the PACS vendor, which ended up being whichever media vendor offered the most attractive margin. If the choice of storage media was rarely argued, it is easy to see how the issue of data storage format would not even raise an eyebrow.

The concept of an independent archive has gained some traction as a Disaster Recovery solution, but a relatively small percentage of PACS installations in the US feature an independent main archive. As storage media continues to double in capacity and drop in price, the PACS vendors can easily price the independent archive out of the market. So most PACS continue to be deployed as complete, self-contained systems. As an added bonus, today's customer can usually get their PACS configured with any major vendor's storage media that they prefer. So what's the advantage of having an independent archive?

With the issue of who owns the archive, PACS vendor or Storage vendor, once again resolved, it is easy to see how the issue of data storage format would not even raise an eyebrow. Who cares what data format is used? In a self-contained PACS, there are (conveniently) no inter-system compatibility issues. Life is good with "one throat to choke".

Then along came the era of data migrations.

Turns out changing from one (legacy) PACS to another (new) PACS requires the migration of all of the actual data files. Among a number of reasons for this forced migration is the issue of data storage formats. Despite so-called "DICOM conformance", there is a lot of non-conformance in the way many PACS store their data, and that is a major reason for data migration. It turns out that this data migration is time-consuming, costly, and therefore painful. And it is inevitable.

This White Paper addresses the problems related to the traditional PACS archive strategy, the resurgent argument for a PACS-neutral independent archive, and the new financial arguments in support of this new data management paradigm.

The Problems with the "Traditional" PACS Archive.

The "traditional" PACS archive is a totally owned subsystem of the PACS. Regardless the type of storage media, the PACS application controls access to and from the media, meaning that data destined for storage on the media and data retrieved from the storage media must be processed by the PACS application software and physically flow through

the PACS server hardware. This condition is obvious if the storage media is directly attached to the PACS Server, but it is also true if the PACS server is connected via a network and through a gateway (head) to a NAS storage solution. As long as the PACS server and the PACS application "owns" the storage solution, the data must flow through this bottleneck.

At the very least this means that other application servers like a Cardiology PACS or an EMR must negotiate with the Radiology PACS server for storage commitment, or for any image data it might ask for in return, and the data must flow through the Radiology PACS server on its way to the requesting server or display. In sufficient quantities, these data transfers can negatively effect the performance of the Radiology PACS.

The Radiology PACS server also becomes a bottleneck when the time comes to migrate study data from an old piece of media to a new piece of media. When the time comes to replace that old DLT tape library or CD/DVD jukebox with a new RAID module, all of that data migration from old media to new media must be processed through the Radiology PACS application and pass through the PACS server. Media to media data migration could pull down the performance of a three year old PACS for several months, and occur as frequently as once a year, because the structure of media service contracts argues for media replacement every three years.

As long as the archive is a totally owned subsystem of the PACS, the customer's choice of storage media will be limited, both initially and downstream. At the time of initial purchase, and under some pressure, the vendor may acquiesce to a choice between EMC^2, HP, IBM and NetApp, but what are the choices eighteen months later, when it's time to add more storage? Any vendor lock on the storage system will eliminate any chance of shopping around for storage and effectively eliminate the chance of purchasing at "street prices".

As long as the archive is a totally owned subsystem of the PACS, the PACS vendor is relatively free to use whatever data format suites their purpose. A self-contained PACS would be optimized for internal efficiencies and not necessarily for data exchange with other systems. The Fuji Synapse™ and the Philips iSite™ are examples of self-contained PACS that feature proprietary data storage formats, originally designed to be performance advantages. While it is true that both of these systems can deliver the data in a DICOM format in response to an external DICOM query, the more important issue is that both of these systems are storing years of study data, tens of Terabytes, in a non-DICOM format. The price for any marginal performance improvement using their

proprietary data formats instead of using the DICOM format will come due when the time comes to migrate the data to another PACS.

Another related data format issue has to with do the data header itself. Regardless how the PACS actually stores the study data, the DICOM data header is either stored with the image data or stripped off and stored separately in the PACS Directory. As long as the study data can be delivered to a requesting device with DICOM header attached, the PACS is arguably DICOM-conformant. As long as the archive is a totally owned subsystem of the PACS, the PACS vendor is relatively free to use whatever header format suites their purpose. While DICOM conformance requires the use of Public Tags for most of the key meta data associated with the image data, too many vendors have chosen to bury some key information in Private DICOM Tags, or (worse) in Private Tags using a proprietary Value Representation (the alphanumeric text that describes the information encoded in the Tag). In this case, the "purpose" is almost always PACS vendor lock. A modality vendor's PACS will almost always work better with that vendor's modalities, and vice versa. The chat groups are filled with examples of CT, MR, FFDM, CR, etc. working better with the same vendor's PACS. The use of proprietary header formats (even though they may be construed to be DICOM conformant) means the data is owned by the PACS, not by the customer. The price for this type of proprietary data format is also extracted when the time comes to migrate the data to another PACS.

The archive that it totally owned by the PACS application is also difficult to share with another application, like cardiology, pathology, etc. It is difficult and/or expensive to use the typical, self-contained Radiology PACS archive as an enterprise archive. All of the other applications wishing to share the Radiology PACS archive must pass their data through the Radiology PACS, creating a performance hit on both the Radiology PACS Directory and the server platform. The pass-through problem can be mitigated somewhat if the Radiology PACS is configured to use a partition of a SAN storage solution or is configured with its own NAS server and storage. In these cases, the other application servers can then use their own assigned partitions. But this strategy suggests that the enterprise storage solution is determined by whichever application server is purchased first. Not all application servers in a health system require the same type of storage, demand the same performance, have the same budgetary discretion. In this example, assuming the radiology PASCS is purchased first, the radiology department's choice of storage solutions is being forced on every other department.

As previously mentioned, the archive that it totally owned by the PACS application is usually only marginally DICOM-conformant. The assumption of the self-contained PACS is that there is very little sharing of study data with other systems. The PACS may respond to a remote DICOM query with minimal data, i.e. the original image pixel data and little else. Presentation States, Key Image Notes, and other key meta data objects associated with the images and created by the radiologist during interpretation may not be

forwarded, because the PACS doesn't treat these as DICOM objects, or it places them in Private Tags, or it uses a proprietary Value Representation to encode the information. Self-contained Radiology PACS are typically very stingy when it comes time to give up their data in a data migration process. The vendors really think of it as their data, and now that the radiology department has decided to leave them for another PACS vendor, the jilted vendor may be reluctant to help in the retrieval and migration of all of the data that really belongs to the health system. This translates to expensive and time consuming data migrations.

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The Definition of Vendor-Neutral DICOM Enterprise Archive

In my opinion many of the PACS vendors have been bad DICOM citizens, and their most significant infractions are related to the archive subsystem. Their privatization of the Directory dictionaries and schema, and the way they treat DICOM Headers and many of the key meta data objects associated with the images has directly caused the data migration crisis in today's market.

Many PACS vendors are truly behaving as if the study data belongs to them and not the Health System.

In another White Paper[1] I wrote on the subject this past January, I stated that it was time to reinvent how radiology study data is managed. If the PACS (as we currently know it) cannot manage the complete lifecycle of radiology study data, then the data management and the archive functionality of the PACS must be separated from the PACS and embodied in a new kind of data management system. Today I would add that if the PACS vendors are unwilling to treat all study data and related meta data as DICOM objects, using Public DICOM Tags with a standardized Value Representation that describes the encoding, then it is time to reinvent how the study data will be stored in the Archive.

I firmly believe that the time has come for a Vendor-neutral, DICOM, Enterprise Archive.

As is often the case when it comes to matters related to PACS, semantics is very important, so a careful explanation of the above term is in order.

The term Archive refers to a long-term data storage subsystem. In this context it is the long-term storage subsystem for a PACS. It is tasked with storing image data and the related meta data associated with a medical imaging procedure. A short-term image cache (storage for possibly the most recent 3, 6, or 12 months of study data) might remain a component of the department PACS. The Archive would store study data for at least

[1] Building a Better Medical Image Archive; Michael J. Gray, Gray Consulting; January 15, 2007

the legally mandated term, and possibly store selected studies even longer. Many teaching hospitals are trying to store all of their study data permanently, which would define a very long-term archive.

An Enterprise Archive refers to a long-term storage solution that is capable of managing study data from multiple imaging departments (i.e. radiology, cardiology, pathology, ophthalmology, etc.), and/or multiple imaging facilities (multiple hospitals, hospitals and associated imaging centers, etc.). Rather than deploying individual archives, each dedicated to an associated PACS, the Enterprise Archive consolidates all long-term storage solutions into a single, centralized, shared archive subsystem. At the very least, the Enterprise Archive would simply provide long-term data storage for each individual PACS. Ideally, the Enterprise archive would facilitate data exchange between each separate department or facility PACS.

A DICOM Enterprise Archive refers to an enterprise-wide, long-term data storage subsystem that primarily treats all data objects as DICOM data objects, utilizes Public DICOM SOP Classes for inter-system data communications, and stores all image data and study-related meta data in Public DICOM Tags using standardized Value Representation encoding. In short, this archive would be as DICOM-conformant as possible.

Vendor-neutral applies to both Storage Media neutrality and PACS neutrality. First is the issue of storage media. Media neutrality means that the user would be able to not only choose the storage vendor for the initial configuration of storage, but for all subsequent storage additions, upgrades and replacements. The Media-neutral DICOM Enterprise Archive would feature an open storage strategy, for example a NAS architecture that would allow different types of storage media from different media vendors. No hardware lock-in for the long lifetime of the system.

Second is the issue of PACS neutrality. PACS neutrality means that the user would be able to combine the Enterprise DICOM Archive subsystem with multiple PACS. The key implication here is that the archive would facilitate exchanging data between different PACS. This data exchange would be both serial (as when an old PACS is replaced with a new PACS), as well as parallel (as when multiple PACS simultaneously share the common archive).

Without getting overly technical in this paper, it is necessary to point out that compatibility between disparate PACS would not be a problem, if all PACS were 100% DICOM-conformant. Because there are still numerous proprietary features in many PACS, the archive's ability to exchange data between PACS will require a very special application…Tag Morphing. A simple yet excellent technical description of Tag Morphing is presented in a paper[2] available from Emageon.

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[2] Data Flow…Emageon's Clinical Content Management Solution, Siemens Medical Systems' Magic™ Sienet PACS; Emageon; February, 2007

In short, Tag Morphing is the ability to manipulate the Tags that comprise the DICOM Header. Meta data stored by PACS A in a Private Tag is decoded (if necessary) by the Enterprise Archive into a standard Value Representation and copied into a Public Tag utilized by the Enterprise Archive. This new header is considered the Archive's "Gold Standard". Whenever PACS A requests data managed by the Enterprise Archive, the archive returns the data with its newly created Gold Standard header, which contains both the PACS A version of any Private Tag information as well as the Archive's version of any Private Tag information copied to the Gold Standard's Public Tags. If PACS B were to request study data created by PACS A, the Archive would create a new generation of the Gold Standard header. In this case the new header would include all of the PACS A Private Tag information copied to any Private Tags that PACS B was expecting. This new generation of the archive's Gold Standard now contains meta data contained in Private Tags used by PACS A, a copy of that meta data in the Archive's Public Tags (the Gold Standard), and a third copy of the Private Tag meta data created by PACS A in any Private Tags used by PACS B. It sounds complicated and it is, but Tag Morphing is the only real-world solution to exchanging study data between disparate PACS.

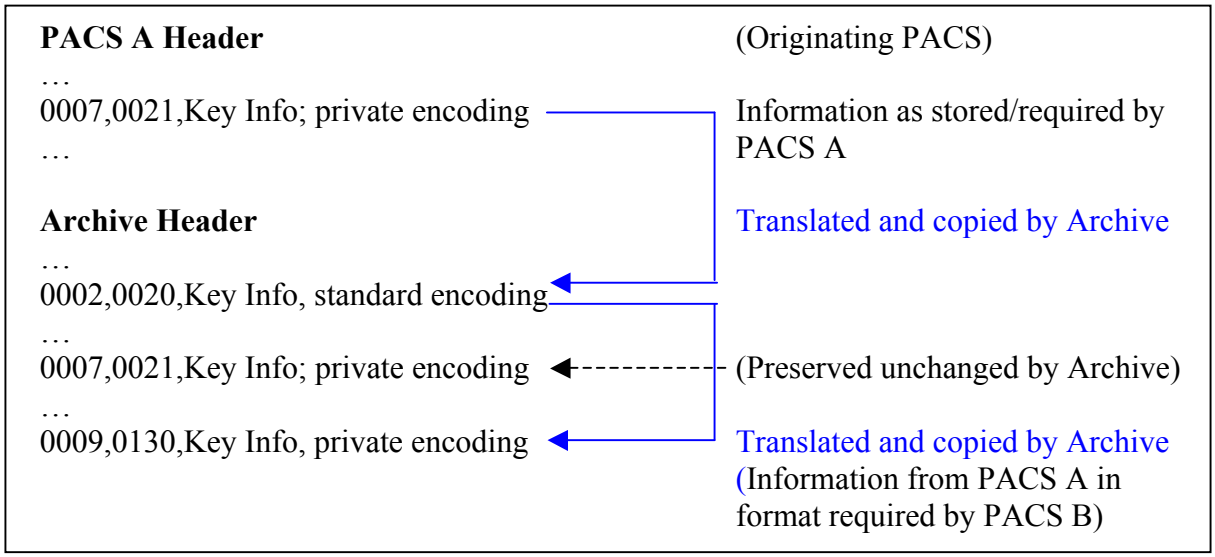

Illustration #1: Translation of Private information created by PACS A into Public Tag for archiving and optional conversation of Private Info from PACS A into Private format expected by PACS B.

DICOM Tag Morphing is a skill-set perfected through trial and error, in the field, during data migrations from PACS to PACS. Ironically the very PACS Archive strategies that created the need for data migration have spawned the technology that will create the Vendor-neutral DICOM Enterprise Archive. The data migration process is typically a Serial process (data is migrated from A to B). In this case, the required Tag Morphing is one direction. The Private Tags used by PACS A are morphed into the Private Tags used by PACS B. Moreover, in a one-time data migration from A to B, there is no need to create a Public Tag version of any Private Tag information created by PACS A, since PACS B wouldn't know what to do with it.

Simultaneous exchange of data between disparate PACS requires the Archive to perform Dynamic Tag Morphing. In this case, the Archive must be able to continuously morph the Private Tags in order to make private information created by one PACS accessible and understandable by another PACS. We will see later in this paper that Dynamic Tag Morphing is well understood by the more sophisticated Archive vendors, and already included in real-world products.

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The Arguments

• Arguments FOR a Vendor-Neutral Archive

There are numerous arguments in favor of deploying a Vendor-Neutral DICOM Enterprise Archive. First and foremost is the desire to eliminate future data migration costs and problems. Once the data has been migrated from the existing PACS to the Archive, there should be no need for future data migrations, each time an old PACS is replaced by a new PACS, either the new PACS will be able to access and utilize all the meta data stored by the archive in the Public Tags of its Gold Standard header, or the Archive will be able to perform Tag Morphing, copying meta data to whatever Private Tags are utilized by the new PACS.

Of course the new PACS would not be aware of all the study data originally acquired by the old PACS, but it would not be necessary to migrate the study data just to populate the new PACS Directory. There are three ways to accomplish this. [1] The new PACS might be capable of automatically issuing a DICOM Query to the DICOM Enterprise Archive, Retrieving the priors and Storing them on its working cache. [2] The DICOM Enterprise Archive supports an open Directory policy and the Archive's Directory schema and dictionary can be copied to the new PACS Directory, thus teaching the new PACS the complete list of patients and studies available on the Enterprise Archive. [3] In the event that the new PACS is incapable of automatic Q/R of a foreign archive, or incapable of learning the Directory of the DICOM Enterprise Archive, the Archive can use the HL-7 Orders to trigger a pre-fetch of relevant priors and auto-route the study data to the new PACS.

In any case, once the facility's historical study data is migrated to the DICOM Enterprise Archive, it would not be necessary to migrate the data each time a new PACS is deployed.

Deploying a Media-Neutral DICOM Enterprise Archive would enable an imaging facility to purchase whatever type of storage solution is most suitable to the IT department. The media neutrality means any vendor and any technology would be compatible and supportable by the Archive. Media neutrality also means that a new vendor or a new type of storage media could be added each time new storage must be added or old storage

needed to be replaced. Each opportunity to add or replace storage means an opportunity to shop for the right solution at the right price, because there is no media vendor lock.

Deploying the PACS-Neutral Enterprise Archive would enable an imaging facility to take control of its study data, preventing it from being held hostage by the PACS vendor. The Archive's ability to create a totally open data format, using only Public Tags and being able to morph Private Tags as necessary eliminates PACS vendor lock. The facility can change PACS solutions whenever it becomes prudent, without the fear of losing data. The facility is even free to chose a PACS solution that is less than completely DICOM conformant, because the Archive can accommodate any non-conformities.

A PACS-Neutral DICOM Enterprise Archive would enable the multi-facility Health System to manage data from each of the facilities on a single, shared Enterprise Archive. Concentrating the independent PACS archives into an Enterprise Archive would reduce cost of ownership and simplify support.

A PACS-Neutral DICOM Enterprise Archive would enable the multi-facility Health System to manage data from different PACS on a single shared Enterprise Archive. Converting each of the proprietary PACS archives into a single Enterprise archive would greatly reduce cost of ownership and greatly simplify support.

Most current generation PACS have very unsophisticated Information Lifecycle Management (ILM) strategies, If they have any ILM strategy. Media migration (movement of study data from one type of media to another), and a purge strategy (IF they have a purge strategy) may simply be based on study date. The Vendor-Neutral DICOM Enterprise Archive would support a very sophisticated user-defined media migration and data purge strategy that would enable the archive to move study data within the storage solution(s) and purge study data based on patient, study age, study type, etc. These sophisticated ILM strategies would use meta data stored in the study's DICOM header to intelligently manage the data over the full lifetime of the data, which for many types of exams will easily exceed the lifetime of any single PACS.

A Vendor-Neutral DICOM Enterprise Archive would be an ideal data repository for the Electronic Medical Record (EMR) system. Interfacing the EMR to the Enterprise Archive is an intelligent alternative to constructing yet another separate storage solution for the EMR, or trying to build and support multiple interfaces between the EMR and multiple department PACS. Some Enterprise Archives already support the acquisition and management of non-DICOM data objects, and adding this features to those that do not, is not a major engineering effort.

It is worth repeating that the deployment of a PACS-Neutral Enterprise Archive would make it easier to change PACS whenever the situation demanded change. The facility and not the vendor owns the data. There is no need for data migration. Only a minimalist PACS configuration is required. The sales situation would be very competitive on a very level playing field.

• Arguments AGAINST a Vendor-Neutral Archive

With so many arguments in favor of deploying a Vendor-Neutral Archive, what's holding up the market explosion? There are numerous arguments against the deployment. First of all there is the relative scarcity of the required technology. As already described, the ability to exchange data between disparate PACS requires special morphing software and custom programming. These key technologies and services are provided by only a few companies. As of June 2007, that list was relatively short and limited to Acuo Technologies, Agfa Healthcare, DeJarnette Research Systems, Emageon, Inc. and partners affiliated with the previous four companies. That's not a lot of choice.

Secondly there is PACS vendor resistance, as would be expected. The PACS vendors do not wish to abdicate their control over the direct-attached archive subsystem. It is more than a matter of hardware margins and software licenses. They do not wish to relinquish ownership of the study data and make it that easy to replace their PACS with another vendor's PACS. They really don't want to make their PACS a commodity.

Next there is the subject of risk. The short list of suppliers is an indication that this is an Early Adopter Market, which means that there is some technology risk. The technologies and methodologies employed by these companies vary considerably, making it necessary to carefully study the subject in order to select the correct long term solution. You wouldn't want to start off on a 15 year archive strategy with the wrong Archive.

Lastly there is the subject of cost. It should be intuitively obvious that the cost of combining a PACS from one vendor with a separate standalone archive from another vendor would be higher than the cost of a combined PACS and Archive solution from the same vendor. There are hardware, software, and professional services overlaps in the two-vendor configuration, and there is the additional cost of the Tag Morphing and Information Lifecycle Management applications. In this White Paper, the additional cost of the two-vendor solution over the single vendor solution is referred to as the **"Premium"**. Later in this Paper we will estimate the Premium for a small imaging department and determine if there is any Return on such and Investment (ROI).

• Counter Arguments

Four companies is not a big choice, but it is a start. The morphing tools and professional services experience exist, ironically a result of years of data migration necessitated by proprietary PACS. There are now a number of companies that possess the know-how to translate even the most proprietary DICOM headers. It isn't that difficult to incorporate these translation tools into the input/output component of the archiving application. The process of translating one DICOM header to another (Tag Morphing) is part of every data migration process. Acuo, Agfa, DeJarnette, and Emageon are simply the first to recognize the opportunities and have added tag morphing to their archive subsystems. Other vendors will be forced to follow as the broad market becomes aware of these issues.

If anyone is foolish enough to ask a PACS vendor's opinion about an independent archive, the response will be all too predictable. The PACS vendors can object all they want, but their objections are hollow, meaningless posturing. When it comes to archiving, the horse is already out of the barn. Most PACS vendors will lead with their favorite media solution, but they are no longer willing to lose a deal over the brand of storage. The margins in the archive subsystem are not what they used to be. Most PACS have been validated against all of the major storage solutions, and with few exceptions (Philips iSite) the user can pretty much have their choice for the archive piece of the system. That $50-70K the vendors now charge to interface to a storage or archive solution purchased from another vendor more than covers whatever margin there ever was in the vendor's "archive" solution. Besides, the archive application software is still a requisite to connect to the archive. What difference does it make whether the data is being physically managed by the PACS vendor's "archive" or another vendor's "archive"? The value of the PACS software package has not been devalued one bit. It always was a matter of hardware margin.

As for who controls the study data, I think the evidence suggests that it is time for the facilities to take charge. It is encouraging to see data migration pre-nuptials negotiated into new PACS contracts, but why should any facility want to continue paying anything for this service every time they decide to change PACS vendors? Unless the "Premium" for a Vendor-Neutral DICOM Enterprise Archive is completely unreasonable, the time seems right to take the "A" out of PACS and reduce the PACS to an image display and distribution software package and eliminate the need for costly data migrations.

As with most technology innovations, the early days are fraught with risks. True innovators are a rare breed in healthcare IT, because failure can be very expensive. It's understandable that a CxO or Department Director would not want to be the first to step forward.

In truth, the PACS-neutral DICOM Enterprise Archive market is not in the innovation stage. The technology and the application of that technology already exists. There are numerous deployments of this technology by Acuo, Agfa and DeJarnette in Europe, and Emageon in the US (Barnes Jewish Community Health System in the St. Louis area and Kaiser Permanente, in Northern California).

As for the cost issues, it is time to take a look at the "Premium" demanded by a standalone Enterprise Archive and determine if there is a positive Return On Investment (ROI) for such a project.

Suggested Return on Investment or How to Offset the Premium

Determining the potential Return On Investment (ROI) on a PACS-neutral DICOM Enterprise Archive project requires the following four pieces of information:

1. The radiology department's volume of study data (both historical and projected) that will have to migrated from PACS to PACS over the next fifteen years and the projected costs of those data migrations.
2. The current cost of a PACS (complete with long-term archive) that is configured to store the volume of study data (both historical and new) projected for the radiology department over the next five years.
3. The current cost of a PACS-neutral DICOM Enterprise Archive configured to store the volume of study data (both historical and new) projected for the radiology department over the next five years.
4. The current cost of the PACS in #3 without the long-term archive.

For the purpose of this discussion, let us examine the case study of a real radiology department using real equipment quotes from real vendors. The names of the hospital and the vendors have been changed to protect their identities.

The radiology department of Somewhere Community Hospital (SCH) is a typical medium-sized imaging facility. All of the imaging modalities are represented, including digital mammography, PET, and a 64 slice CT. In 2002, the department deployed a PACS. There are now approximately 20.7 TB of study data under management. The department estimates that it will perform approximately 50,000 studies in 2007.

Since the PACS is now approaching its fifth year of life, the hospital is planning to replace the system at the end of 2007. In addition to the cost of purchasing and deploying the new PACS, the hospital knows that it must also budget for the data migration from the old PACS to the new PACS. Typically a hospital would not think about the cost of future data migrations, when their next PACS is replaced by yet another PACS, and that PACS is replaced by yet another.

The **Migration Prognosticator**[3] is an excel spreadsheet designed by Gray Consulting to help a Health System predict the time and costs associated with multiple data migrations. This tool requires the input of a few pieces of site-specific data:

1) The approximate volume (TeraBytes) of study data under management by a PACS as of December 31, 2006
2) The projected volume of new studies per imaging modality for 2007
3) The projected annual growth rate for each imaging modality
4) The estimated percentage of all studies that are Pediatric
5) The estimated percentage of all studies that are retained for research or study file purposes

[3] The Migration Prognosticator is available at no cost from Gray Consulting

The Prognosticator includes numerous assumptions that are built into the spreadsheet:

1) Industry average data equivalents (MB/study) for each modality type
2) Industry-average cost per TB to migrate data, and an estimate of the yearly reduction in cost for this service
3) A purge strategy based on long-term retention of Mammography, Pediatric, and Research studies, and retention of all other studies for 7 years
4) An industry-average data migration rate and an estimate of the yearly improvement of this rate as hardware performance improves.

The Prognosticator returns the following key information:

1) The amount of data in TB that would have to migrated from PACS to PACS for any given year through 2021
2) The estimated duration of time it would take to migrate all of the data for any given year through 2021
3) The estimated duration of time it would take to migrate the most recent year of data to a new PACS for any given year through 2021, as this would impact the new PACS go live date
4) The estimated cost of the data migration in any year through 2021
5) The total cost of data migration associated with the next two PACS (assuming a five year lifecycle for each PACS)

The Migration Prognosticator representing data for Somewhere Community Hospital is attached to this White Paper as Appendix A. The cost (in time and money) for the data migration that will be required at the end of 2007 to move the data to the new PACS is summarized below:

1) 25.3 TB of data will be moved
2) It will take approximately 8 months to move all of this data, so the hospital will have to plan on continuing maintenance of the old PACS server and storage solutions well into 2008
3) It will take approximately 2 months to move the most recent year of study data, so the go live date of the new PACS will have to pushed out these two months
4) The industry average cost to migrate the study data acquired through the end of 2007 is approximately $316,747

The case study investigated the configurations of three new PACS, all current generation, all major PACS providers. The systems are not identical but they are reasonably similar in architecture and composition. The table presented on the next page organizes the major components of these three replacement PACS and their related costs.

The table does not include items that were identical for all three configurations, (Document Scanning software and hardware, networked CD/DVD Burner appliance, and the Display station hardware). These items would be purchased separately, so it was unnecessary to include their costs in the ROI model.

Notice that the short-term and long-term storage solutions as well as the five year cost of maintenance for both this hardware and software is broken out. This separation is important, because the ROI model requires that the long-term storage be eliminated from the PACS configuration when a separate Enterprise Archive is deployed.

The cost of the data migration required to move the data from the old PACS to the new PACS is included in the three quotes. The breakout of the Professional Services related to the data migration and the Data Management fees associated with the storage of this historical data on the new PACS is important, as these items can also be eliminated from the PACS configuration if a separate Enterprise Archive is deployed.

All-inclusive Radiology PACS (including long-term Archive)

Categories	Vendor A	Vendor B	Vendor C
Main Server Subsystem			
Hardware	$39,000	$64,000	$76,500
System software	$478,000	$812,000	$390,200
Data management software	incl.	incl.	incl.
Display software	incl.	incl.	incl.
Professional Services	$126,000	$110,050	$104,800
Data Acquisition			
Modality Interfaces	$54,000	$8,500	$20,000
RIS Interfaces	incl.	$58,100	incl.
Short-term storage	$100,700	$66,300	$103,800
Web Server	incl.	incl.	incl.
Archive Server	$22,330	incl.	incl.
Long-term storage	$336,400	$182,650	$26,500
Miscellaneous			
Document Scanning	n/a	n/a	n/a
CD/DVD Burning	n/a	n/a	n/a
Display stations	n/a	n/a	n/a
Data Migration			
Professional Services.	$130,000	$380,000	$207,000
Data Management fees[4]	$165,300	$0	$270,900
5-year Maintenance			
Main Server	$300,000	$340,000	$255,000
Short term storage	$15,000	$17,500	$82,500
Long-term storage	$35,000	$38,000	$160,000
Total	**$1,801,730**	**$2,077,100**	**$1,697,200**

Table 1. Components and costs of an All-inclusive Radiology PACS from three vendors

[4] Data Management fees are assessed for each study migrated from another PACS that will be managed by the new PACS

Now let's look at the major components of a PACS-neutral DICOM Enterprise Archive configured specifically for SCH. This quote will also include the data migration services required to move the historical data from the current PACS to the Enterprise Archive, as well as the Data Management Software license fees to manage the historical data on the Archive, and the software license fees associated with the new studies that will acquired by the new PACS over the next five years (through 2012). The Table representing this information is presented below.

PACS-Neutral DICOM Enterprise Archive

Categories	Costs
Archive Server	
Hardware	$74,800
Software	$325,175
Yr 1 warranty	$40,450
Manufacturing	$19,000
Professional Services	$50,250
Interfaces	
RIS	Included
PACS	Included
Long-term Storage Solution (5 yrs.)	$131,200
Tape Library (Directory back-up)	$20,300
Data Migration	
Professional Services	$200,000
5-year Maintenance	
Main Server	$61,500
Long-term storage	$63,000
Software	$169,000
Total	**$1,154,675**

Table 2. Components and costs of a PACS-Neutral Enterprise Archive

The PACS-neutral DICOM Enterprise Archive presented in this example is configured with a Digital Tape Library to create back-up copies of the Archive Directory. There is no back-up for the image data included in this configuration, simply because there are so many variations possible, from shelf archive of tape cartridges to a fully redundant standalone server/storage solution. Note that the Disaster Recovery Solution was also excluded from the three PACS configurations. For the purpose of this paper, it was unnecessary to include the costs of a DR solution, because the costs of the same type of DR solution would be similar for any of the configurations (PACS or Archive) that will be explored.

The next step is to review the quotes for the all-inclusive Radiology PACs and remove any item that would not be required if the PACS were interfaced to an Enterprise Archive. In most cases, the only items that can be removed are related directly to the long-term archive subsystem. In some cases, an additional interface fee is required to cover the connection of the PACS to a foreign archive. The Table representing the cost of each PACS without its built-in archive is presented below.

Radiology PACS without the Long-term Archive subsystem

Categories	Vendor A	Vendor B	Vendor C
Main Server Subsystem			
Hardware	$39,000	$64,000	$76,500
System software	$478,000	$812,000	$390,200
Data management software	incl.	incl.	incl.
Display software	incl.	incl.	incl.
Professional Services	$126,000	$110,050	$104,800
Data Acquisition			
Modality Interfaces	$54,000	$8,500	$20,000
RIS Interfaces	incl.	$58,100	incl.
Short-term storage[5]	$100,700	$66,300	$103,800
Web Server	incl.	incl.	incl.
Archive Server	Not required	incl.	incl.
Long-term storage	Not required	Not required	Not required
Miscellaneous			
Document Scanning	n/a	n/a	n/a
CD/DVD Burning	n/a	n/a	n/a
Display stations	n/a	n/a	n/a
Data Migration			
Professional Services.	Not required	Not required	Not required
Data Management fees	Not required	Not required	Not required
5-year Maintenance			
Main Server	$300,000	$340,000	$255,000
Short term storage	$15,000	$17,500	$82,500
Long-term storage	Not required	Not required	Not required
Total	**$1,112,700**	**$1,476,450**	**$1,032,800**

[5] The short-term image storage cache utilized by the PACS is still required, although it could be argued that this cache could be down-sized, if the PACS-Neutral Archive can support sufficient transfer rates for priors.

Table 3. Components and costs of a Radiology PACS without the Long-term Archive and fees associated with migrated data.

The deployment of the PACS-neutral DICOM Enterprise Archive means that the new PACS does not have to be configured with its own long-term archive, so the long-term storage can be eliminated from the PACS quotes, as well as the maintenance fess associated with this storage solution. In the case of one of the PACS configurations, this eliminated an archive server as well. The historical data is migrated to and managed by the Enterprise Archive, so the professional services and software license fees associated with the migrated data can be eliminated from the PACS quotes.

The elimination of the long-term storage solution and fees related to data migration removes an average of **$650,000** from each of the PACS quotes.

The pricing information provided in Tables 1 thru 3 can now be combined in a simple table that illustrates the "Premium" associated with deploying a combination of PACS-neutral DICOM Enterprise Archive and a PACS without its traditional long-term archive, rather than a complete PACS solution form a single vendor.

"Premium" associated with a Combined System

Categories	Vendor A	Vendor B	Vendor C
PACS w/o Archive	$1,112,700	$1,476,450	$1,032,800
Vendor-Neutral Archive	$1,154,675	$1,154,675	$1,154,675
Combined System (A)	$2,267,375	$2,631,125	$2,187,475
PACS with Archive (B)	$1,801,730	$2,077,100	$1,697,200
"Premium" (A-B)	**$465,465**	**$554,025**	**$490,275**

Table 4. Premium (extra costs) associated with deployment of a combination Enterprise Archive and PACS.

Table 4 above indicates that the deployment of an Enterprise Archive and a PACS without archive requires a significant premium…an average of **$503,315**. While there are numerous arguments in favor of deploying the PACS-neutral Archive, an average premium of $503K for this strategy might be considered too high a price to pay. Fortunately the biggest argument for deploying the PAC-neutral Archive is the end to future data migrations.

The Migration Prognosticator estimates that the future costs of data migration for Somewhere Community Hospital will be approximately **$1,226,164**. This estimate was based on the assumption that SCH would replace their new PACS in five years (2012) and replace its replacement in another five years (2017). Obviously the sum of these two

future migration costs easily covers the "Premium" demanded by the PACS-neutral Archive strategy. In addition to those estimated hard dollar savings (average $722,849), there are also considerable savings in time and professional services related to go-live costs for each of those future PACS.
In conclusion…

There are several powerful arguments for deploying a PACS-neutral DICOM Enterprise Archive.

- eliminate future data migration costs and problems
- ability to purchase whatever type of storage solution is most suitable
- an imaging facility takes control of its study data
- ability to chose a PACS solution that is less than completely DICOM conformant
- manage data from multiple facilities on a single, shared Enterprise Archive
- manage data from different PACS on a single shared Enterprise Archive
- very sophisticated user-defined media migration and data purge strategy
- ideal data repository for the Electronic Medical Record (EMR) system
- easier to change PACS whenever the situation demanded change

There are several significant arguments against a PACS-neutral Archive strategy:

- relative scarcity of the required technology (special morphing software and custom programming)
- PACS vendor resistance
- some degree of technology risk
- "Premium" cost

For Health Systems that see the advantages outweighing the disadvantages, especially for those that are willing to take the technology risk and become early adopters, the only significant obstacle to overcome is the "Premium" cost. Hopefully the case study presented in this white paper will prove encouraging, as it suggests that the "Premium" associated with the PACS-Neutral Archive strategy is easily overcome by the costs of those future data migrations that will no longer be necessary.

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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 the Integrated Delivery Network, individual Hospital, and independent Imaging Center design, choose and deploy the "right" PACS. Gray Consulting has provided these PACS-related consulting services to over 45 Health Systems.

Mr. Gray's areas of expertise are Market Analysis, Technology Analysis, Strategic Planning, Equipment Utilization, Needs Assessment, Workflow Analysis and Re-design, Business Case Modeling, Vendor Analysis/Selection, and Technical Contract Negotiation. Mr. Gray's unique perspective has proven invaluable to Radiology and Information System administrators planning the introduction of new Image Management technologies into their imaging departments and hospitals. Mr. Gray routinely speaks to both national and local Health Care Organizations on subjects such as post-PACS workflow design, business case modeling, system deployment strategies, expansion or replacement of data Storage Solutions, and development of Data Migration strategies from old to new PACS.

" The foundation of my consulting services is an unbiased and completely ethical approach. It assures that my clients receive the full benefit of my experience and expertise without compromise. You should also know that I personally perform all projects…there is no cadre of "associates".

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

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