



F R O S T & S U L L I V A N

*50 Years of Growth, Innovation and Leadership*

Medical Image Sharing And Management  
Drives Collaborative Care:  
Overcoming Fragmentation To Create Unity

A Frost & Sullivan  
White Paper

---

[www.frost.com](http://www.frost.com)



<b>Image Management Today—Fragmentation and Related Challenges .....</b>	<b>5</b>
<b>PACS Development .....</b>	<b>6</b>
<b>Incompatibility Between PACS and IHE Standards.....</b>	<b>6</b>
<b>Consolidation of Healthcare Organizations .....</b>	<b>7</b>
<b>Growing Volumes and Complexity.....</b>	<b>8</b>
<b>Overcoming Structural Hurdles Without Forklifts .....</b>	<b>10</b>
<i>Lowering Storage Costs and Complexity .....</i>	<i>11</i>
<i>Access Difficulties and Bottlenecks .....</i>	<i>11</i>
<i>Data Migrations .....</i>	<i>11</i>
<i>Lifecycle Management.....</i>	<i>12</i>
<b>Medical Image Sharing—Prerequisite of the Next Generation of Care .....</b>	<b>12</b>
<b>Recent Government Initiatives and Technology Drivers .....</b>	<b>13</b>
<b>Paving a Path for Tomorrow—Growing Importance of Image Management for Providers .....</b>	<b>14</b>
<b>EMC’s Solutions for Image Sharing and Management.....</b>	<b>16</b>
<b>References .....</b>	<b>18</b>

While the medical field has had a long history of stunning innovations and technological advancement, development and adoption of integrated IT solutions have not had the same impact on healthcare as IT has had on other industries. Indeed, compared to other vertical fields such as finance and retail, healthcare remains behind in its leverage of IT.

However, there is now increased global recognition that healthcare has much to gain from harnessing IT solutions. Indeed, the deployment of IT solutions is believed to be a virtual panacea for many of the industry's woes—offering solutions for everything from improving efficiencies and workflows, to reducing levels of medical waste and fraud, to improving patient outcomes through predictive analytics and preventative care. A recent report by the McKinsey Global Institute proclaimed that effectively utilizing healthcare IT could save \$300 billion a year in healthcare costs in the United States.<sup>1</sup> The European Commission has cited a Microsoft case study that indicates annual costs per patient can be reduced by 36.7 percent through the use of healthcare IT solutions.<sup>2</sup>

Forecasts such as these are predicated on a vision of all types of health information being interconnected and therefore empowering if properly harnessed. This vision of collaborative healthcare requires connecting information across different sectors of the continuum of care to improve benefits for both the individual and the healthcare system.

- **Increased efficiencies:** Providers will not have to repeat recently conducted diagnostic tests and will be able to view previous and existing imaging files, for example;
- **Improved safety:** All caregivers will be able to see the patient's current medications, and avoid prescribing new medications that could be toxic or ineffective given the patient's current medications; and
- **Better outcomes:** Caregivers can work together to share information and interact to coordinate the optimal care pathway, given their collective insights.

Despite the undeniable virtues of the interconnected and collaborative healthcare of tomorrow, current health IT systems have not been built to support connected health. Additionally, healthcare organizations now see an explosion in the amount of health data and are struggling to manage the wealth of information produced. While this data is hailed as the means to reduce costs and improve outcomes, the sheer volume and variety of it is so overwhelming that most organizations cannot take advantage of it.

Nowhere is this situation more acute than in medical imaging. Imaging is the biggest contributor—by far—to the issue of “Big Data” within healthcare providers. In Europe, diagnostic imaging procedures are expected to increase by between 10

percent to 12 percent, and Picture Archiving and Communication System (PACS) storage requirements are growing at a rate of 17 percent. In the United States, the rate of growth of PACS storage requirements is even higher, with growth rates exceeding 20 percent annually, and cumulative PACS storage requirements tripling every four to five years.<sup>3</sup>

Most of the image data today is created and managed in departmental silos—fragmented and separated from other departments of the same healthcare system. Overcoming the fragmentation of medical imaging data, and learning to manage it differently, is central to unlocking some of the larger benefits of the vision of collaborative care.

This paper will take a closer look at the world of image sharing and management—where it is today, where it needs to go, and challenges associated with managing the current fragmentation and steering the transition to tomorrow for healthcare providers.

Specifically, we will examine:

- Fragmentation in PACS and image management today
- The infrastructure needed to allow providers to manage, migrate and share their data
- The strategic role of medical imaging in charting the course
- Examples of new solutions that can enable the transition

## **IMAGE MANAGEMENT TODAY—FRAGMENTATION AND RELATED CHALLENGES**

Today, PACS have been deployed in more than 90 percent of hospitals in the United States and hold a similar or even greater penetration in some Western European countries. Yet many of these installed PACS systems will need to be migrated to new systems in the next few years. It is estimated that 14 percent to 20 percent of PACS systems will need to be replaced or upgraded in the coming year.<sup>4</sup>

Despite the now ubiquitous use of PACS, most of the vast stores of imaging data remain locked in silos—contained within proprietary schema erected by different PACS manufacturers. As many clinical departments within a hospital deploy PACS from different vendors (e.g., cardiology, radiology, pathology), much of the medical imaging data may not be able to be easily shared across a single enterprise, much less across different provider networks and regions.

The reality today is that image management is exceptionally fragmented and challenging. Key factors behind this include the “siloes” way PACS itself has developed,

consolidation trends on the provider side, and various migration and management challenges associated with dealing with the massive volume and variety of image data.

## **PACS DEVELOPMENT**

---

Much of the fragmentation of medical imaging today simply reflects the siloed nature of PACS—the way PACS were implemented in the past and then expanded within institutions.

PACS originally developed as a replacement for film and a productivity booster for radiology only—the most image-intensive department by far. Starting in the mid-1990s, similar image management systems, or specialty PACS, emerged for other departments such as cardiology, oncology and orthopedics. Today, most hospitals operate individual islands of image management, with limited connection to any central PACS. These are localized, modality-specific systems or smaller clusters of modalities—operating and managed individually across radiology, cardiology, oncology, and other areas.

Though some hospitals have effectively integrated PACS across different departments throughout their enterprise, they are a minority—estimated by Frost & Sullivan at fewer than 10 percent of U.S. hospitals. There is a higher level of PACS integration between clinical departments in Europe, with countries like the United Kingdom leading with more than 30 percent penetration among hospitals. Italy and Spain are two other countries leading in PACS integration.

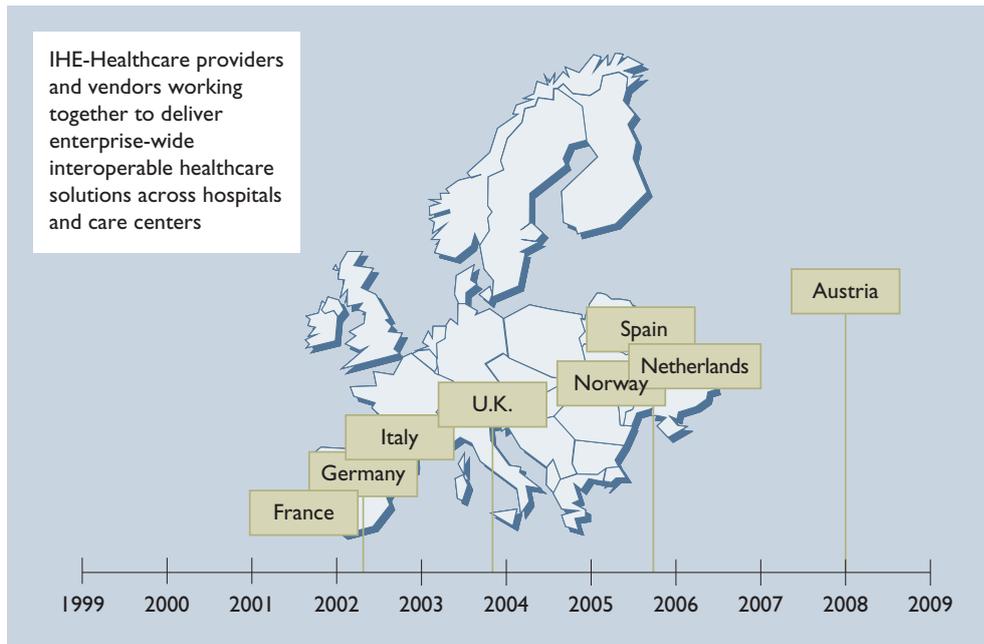
Most of the image data is still created and managed in different departments. Moreover, even the minority of enterprise-wide PACS are not compatible with images from other providers. Fragmentation is deep and exists within and across provider networks.

## **INCOMPATIBILITY BETWEEN PACS AND IHE STANDARDS**

---

The departmental-centric development of PACS would be a relatively minor obstacle to integration and image sharing if not for the limited compatibility between different manufacturers' systems. In the U.S. healthcare system, any enforcement of the use of industry standards in their native format and of the interoperability of any two competitors' systems depends primarily on the providers' own integration efforts and their own commitment to industry standards such as Integrating the Healthcare Enterprise (IHE).

IHE Europe is making an effort to ensure that products from different vendors can exchange information through HL7 and DICOM standards. The project is structured to enable competitive opportunities for European healthcare solution providers, IT manufacturers, as well as small and medium enterprises. European suppliers are able to influence the development of integrated solutions within the technical framework and standards to ensure interoperability between systems and solutions.



Source: IHE, Frost & Sullivan

Most PACS customize the way images are stored and processed. This is done primarily by altering metadata associated with the images, as well as creating new proprietary metadata that are linked to the images. This customization effectively creates a proprietary database, creating a barrier to the sharing of imaging data. Though value-added features are often supported by these proprietary elements (e.g., workflow improvement), the end result is most PACS are self-contained, and therefore relegated to a departmental or network silo.

## CONSOLIDATION OF HEALTHCARE ORGANIZATIONS

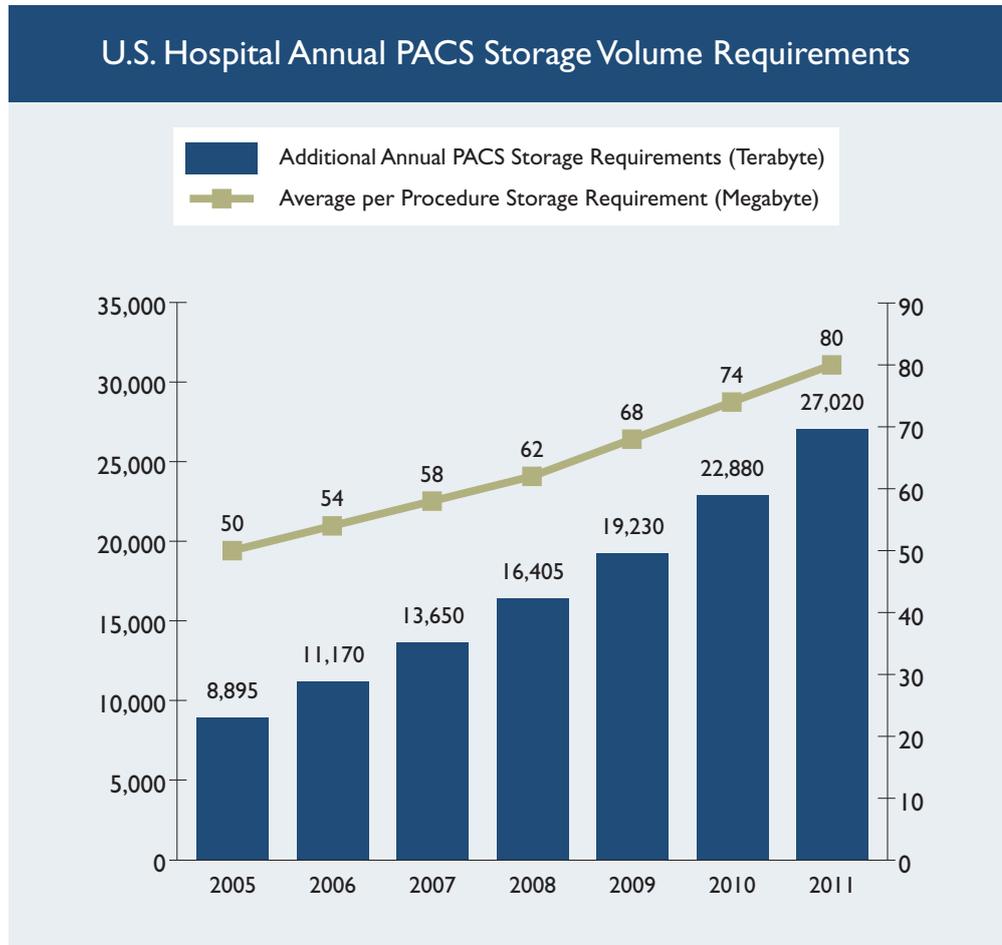
Provider consolidation is another key factor and challenge behind today's fragmentation in image management. When hospitals and imaging centers consolidate, disparate PACS systems from other facilities and departments are absorbed. And in all likelihood these systems come from different vendors, managing different workflows, with different proprietary schema that ultimately are not fully compatible. It is not uncommon today that members of a radiology group end up having to own, maintain, and learn how to operate three or more different PACS.

Hospital M&A transaction volume in the United States tripled between 2008 and 2010<sup>5</sup>, and the number of M&A deals in 2011 kept pace with 2010 deal volume. With continued high rates of consolidation, more and more hospital systems are encountering the problem of the inability of providers, radiologists and cardiologists to view images from the various facilities and departments in these combined hospital systems.

### GROWING VOLUMES AND COMPLEXITY

Another critical challenge with medical image management today is the sheer volume and complexity of the data. Growth in imaging volumes and file sizes has placed an enormous strain on the storage requirements. Though growth has recently slowed in annual procedures on PACS, the amount of additional storage needed continues to grow at an explosive rate.

**Figure 1: U.S. Hospital Annual PACS Storage Volume Requirements**



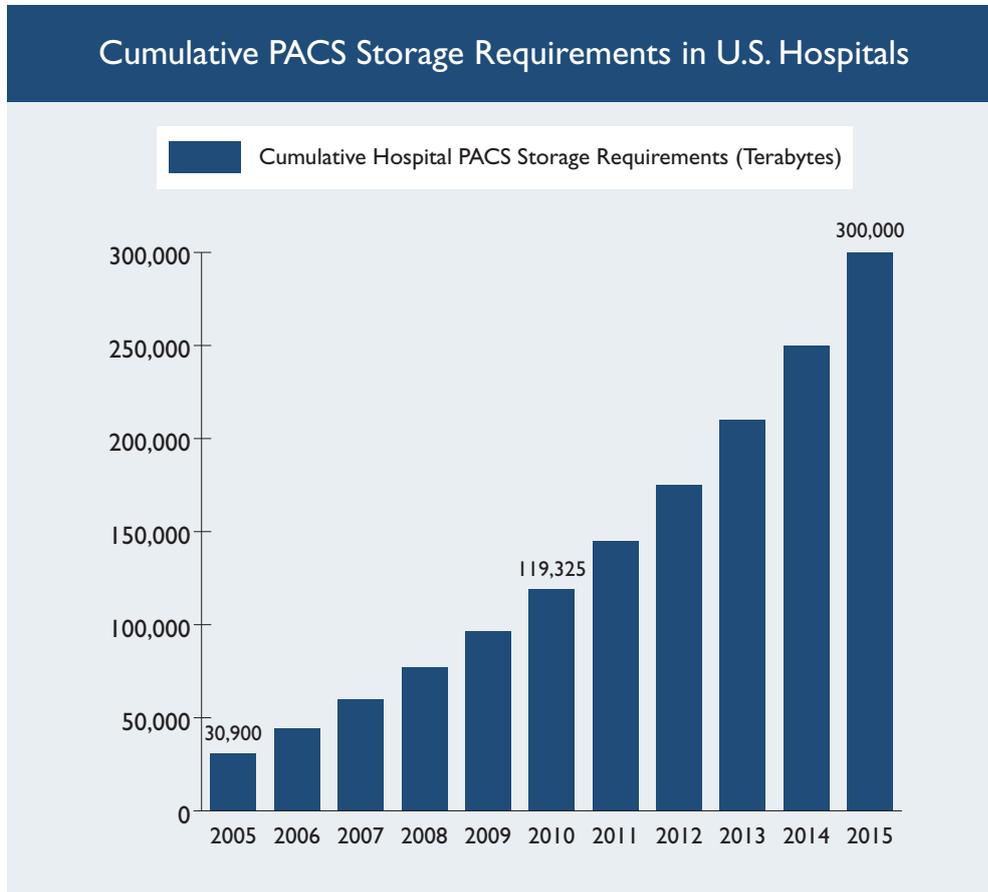
Source: Frost & Sullivan

Additional PACS storage requirements in U.S. hospitals have been growing at more than 20 percent per year, leaping from less than 8,900 terabytes in 2005 to more than 27,000 terabytes in 2011.

This reflects the growing number of procedures of course, but more importantly, the dramatically increasing size of the average study. Due to advances in feature-rich applications and a procedural shift toward more data-intensive modalities, the average

size of an imaging procedure has grown from less than 50 MB in 2005 to more than 80 MB in 2011. This growth is not expected to let up; in fact, storage requirements for imaging data will grow exponentially—driven by factors such as an aging population, adoption of 3D/4D PACS, integration of digital pathology images, and others.

**Figure 2: Cumulative PACS Storage Requirements in U.S. Hospitals**

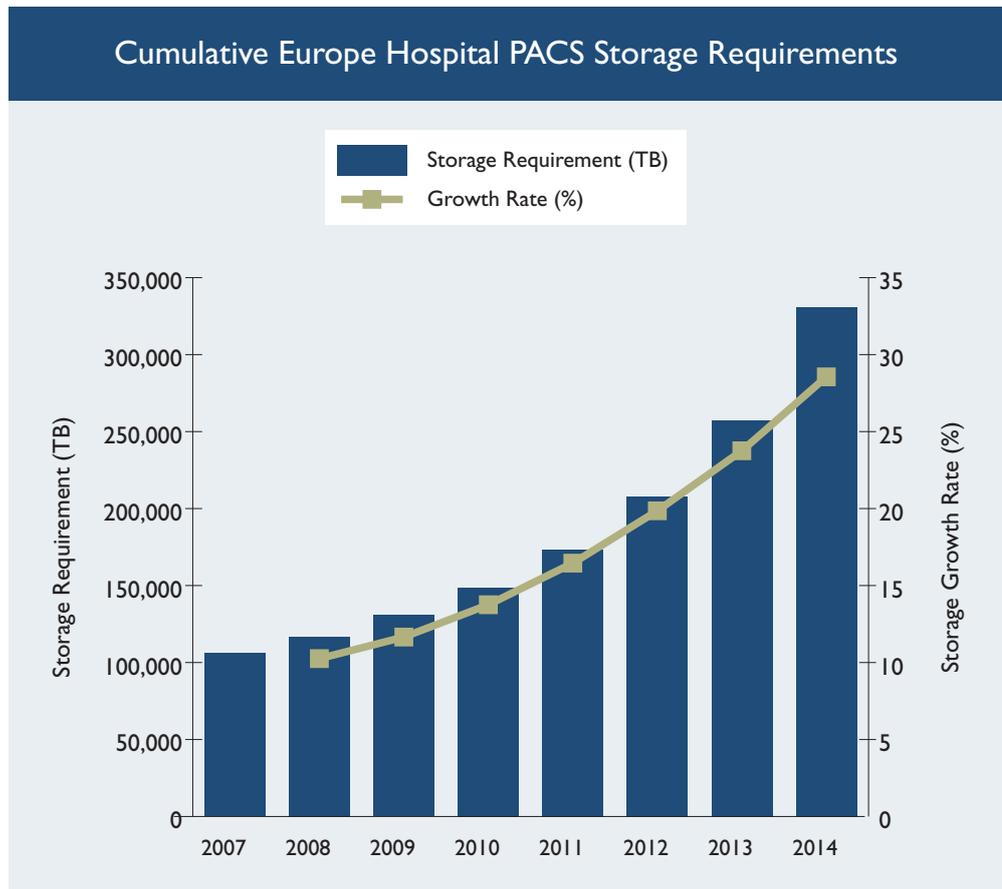


Source: Frost & Sullivan

As shown, the cumulative U.S. PACS storage in 2015 is expected to be 10 times the total storage in 2005. Storage requirements are essentially tripling in size every four to five years. And these estimates are considered conservative, as they account for only the primary copy of the image data. In reality, image data are often replicated as part of disaster recovery and business continuity plans.

Figure 3 indicates the PACS storage requirements in Europe, and shows that growth rates for PACS storage are accelerating at an even higher rate than the U.S. market. Europe can also be said to be more advanced in PACS penetration, and in many cases, in the sharing of information among hospitals within each country.

**Figure 3: Cumulative Europe Hospital PACS Storage Requirements**



Source: Frost & Sullivan

**OVERCOMING STRUCTURAL HURDLES WITHOUT FORKLIFTS**

For all its promises as a foundational piece for the collaborative healthcare of tomorrow, the state of medical image sharing and management today remains fragmented. The departmental focus and proprietary nature of most traditional PACS, along with the trend of provider consolidation and growing swaths of Big Data created and stored on isolated PACS, are all key factors in why and how medical image sharing became so fragmented.

These represent formidable obstacles not only for enabling the type of image sharing needed for tomorrow’s goals of more interconnected and collaborative care, but they also are fueling massive issues in the storage, retrieval, viewing, management and upgrades of image data today.

### **Lowering Storage Costs and Complexity**

Hospital IT executives often mention the increasing complexity of medical image storage as one of the toughest ongoing challenges they face. Storage requirements for imaging are growing much faster than the cost of storage is declining. Moreover, most hospitals operate multiple image archive silos, mostly from different vendors with different databases and database managers, along with different hardware configurations, workflow requirements and service contracts.

In short, the system of image archives a hospital must manage is complex. And as long as the archives are isolated, managing the growing volumes of imaging data across the different islands of PACS silos becomes exponentially more challenging. Ultimately, a provider's productivity level and patient care are compromised.

Applying more scalable solutions from vendors with experience in other industries, such as entertainment, is one approach that is beginning to be applied in healthcare. Solutions that allow for simpler methods of storage growth and tiering—such as utilizing a single file system without stubs, and migrating within arrays, rather than across arrays—should be examined to address this issue.

### **Access Difficulties and Bottlenecks**

Storage silos also make it difficult for clinicians to access patient data scattered across the enterprise. For many providers, images are accessed through departmental PACS, while related patient documents such as lab reports, video files, JPEG images and others are stored in HIS/RIS applications. Typically, data needs to be accessed from each system, which makes the process of collecting and then assembling all the information difficult and time consuming.

Moreover, many of the storage silos are insufficiently scalable, and not up to the task of managing the growing size and variety of imaging data. To eliminate disruptive bottlenecks and efficiency problems, solutions that better support the exponential growth of data and easy movement of files to different storage tiers should be utilized, such as those used by researchers involved in gene sequencing.

To deliver on the vision of collaborative care, images from various sources—along with other patient data—would be accessible via a single platform, allowing efficient access to all patient data and images from across the enterprise.

### **Data Migrations**

Data migrations are another challenge stemming from PACS fragmentation and incompatibility. When users change their PACS vendor, or even sometimes when they upgrade to a new operating system (OS) from the legacy vendor, they are forced to migrate all the data. This entails a very long and costly process, where it is estimated that five years of data can take up to 18 months to migrate from a legacy PACS to a new, or next generation, PACS OS.

Outside of the costs for migration, there are myriad risks, including maintaining the legacy PACS and the new PACS during the transition time, security concerns, and disruptions in workflow. With the traditional model of PACS, providers are forced to endure this whenever they upgrade—and they are often running many different individualized silos of image archives, each from different manufacturers and at different points in the product lifecycle.

### **Lifecycle Management**

Effective lifecycle management demands that storage layers and costs are aligned with operational priorities. Thus, imaging data are distributed across different tiers or layers of storage depending on the clinical urgency, legal and regulatory retention, and value over time.

This is another challenge compounded by the fragmented nature of today's image management market. As image storage requirements continue to grow, imaging data become distributed and more complex with multi-site PACS, multi-department PACS and multi-vendor PACS. This restrains users' ability to deploy effective lifecycle management policies.

Indeed, some sites do not have any lifecycle management strategy, and most have various unsophisticated ones, such as migrating image data across storage media and purging based only on study dates.

## **MEDICAL IMAGE SHARING—PREREQUISITE OF THE NEXT GENERATION OF CARE**

The goal of a more interconnected model of healthcare has been pursued by many visionaries and industry stakeholders for some time. Though this vision varies in the specific technology, standards and forces driving the change, the essential message is strikingly similar: leverage healthcare IT and advances in related fields to overcome information silos and usher in a new era of productivity, collaboration and, ultimately, improved outcomes.

Here, as barriers to sharing are removed and information is exchanged across wide swaths of provider, payer and researcher fields, the power of analytics and collaboration can be released. These then drive significant benefits. The guiding philosophy then changes from collecting and assembling patient data, to assessing and predicting. Meanwhile, the focus changes from department- or enterprise-centric to patient-centric.

Enabling this to occur requires that information to be shared and analyzed. Medical data held in digital format can be transported, but this information sharing is not easy, due to the size of the files and lack of standardized formats and systems used to store and read this data. No substantial part of this vision, or its aspired benefits, gets off the ground unless medical image sharing is enabled. And as evidenced by the

current fragmented state of image management, solutions to medical imaging sharing and management are an area of high importance to realizing the benefits of collaborative care now and in the future.

## RECENT GOVERNMENT INITIATIVES AND TECHNOLOGY DRIVERS

Hospitals increasingly want to be able to follow patients throughout the continuum of care. The adoption of an integrated solution will improve clinical outcomes for physicians as they can view multi-modality images from any department, thus having a more comprehensive view of a patient's history. This enables a more confident diagnosis and effective treatment planning. The workflow benefits of an enterprise-wide image management solution are also clear. The enterprise approach allows cardiologists, who have peripatetic working habits, to access their images from any DICOM-enabled location. This will be especially beneficial during incidences of downtime in the cardiology department. Vendor consolidation is spurring the development of integrated solutions, which is allowing end users to adopt the single-vendor approach and purchase an integrated solution in which all the technologies are compatible and communicate with each other.

Some examples of recent government initiatives that are driving integrated health IT include the Telematics Framework Architecture, which gives the functions and general conditions for the upcoming telemetric infrastructure for the German healthcare system, through which systems such as HIS, RIS, PACS or other application systems connect to the telematics infrastructure through the connector installed at each base, which may be either a standalone system or be integrated within an information system. On the back-end of the infrastructure is a set of resource providers that maintain the data stores and external services that can be accessed through the network.

Another example is the Helsinki Medical Imaging Centre, which has implemented a multi-site Picture Archiving and Communications System across the hospital district of Helsinki and Uusimaa (HUS). The HUS district is the largest hospital district in Finland, covering more than one-third of the population. More than 200 radiologists and thousands of PACS-using clinicians work at the HUS to produce almost 1 million radiology examinations annually.

A digital image management proposal is being adopted by the French government, with the goal of achieving widespread adoption and cost savings over current practice. The proposal would include the creation of a national image archive. In addition, hospitals without PACS could gain access to a Web-based PACS through a common regional PACS deployed via a software-as-a-service model. It is estimated that more than 70 million Euros would be saved through the program.

A Web-based solution called Image Exchange Portal (IEP) has been deployed in U.K. since 2010. The portal enables the transfer of digital images between NHS organizations and independent health providers.

Beyond the growing financial and competitive pressures, providers in the United States now are driven by aspects of the American Recovery and Reinvestment Act (ARRA) to demonstrate various criteria for “meaningful use” of healthcare IT. These include standards relating to the EMR and data-sharing.

Though the original language of the ARRA did not specifically call out imaging and PACS, subsequent releases by the Centers for Medicare and Medicaid Services clarified that cross-provider data sharing, including diagnostic test results, is required. This means that hospitals and providers are now highly incentivized to find solutions to bridge the gap.

The market is still working out many of the details regarding what specifically must be demonstrated to qualify as a meaningful user under various criteria. Of course, vendors with all sorts of different technologies are angling to fill this void. The problem is that there are many different ways to demonstrate some level of image sharing, but most amount to only Band-Aid solutions to the issue of PACS silos.

For example, sharing images by burning CDs, routing through the Internet with encryption software, or transferring from one site to another via a Virtual Private Network (VPN) all accomplish the task of image sharing to some degree. But these do not address the issue of compatibility between different PACS. So when one site tries to view images from another site, key features and clinical context will not be available, even though both PACS are DICOM-compliant.

These methods might provide some temporary benefits to providers. But in the larger picture they are half-measures because they don’t tackle central challenges linked to PACS. A broader solution to reach Meaningful Use targets of information availability, accessibility and use to improve outcomes is the true goal.

### **PAVING A PATH FOR TOMORROW—GROWING IMPORTANCE OF IMAGE MANAGEMENT FOR PROVIDERS**

It is no secret that the PACS purchasing lifecycle has become more involved and lengthy in recent years. PACS purchases are no longer tied to a few stakeholders and a modality installation, such as computed radiography. Decisions about new and upgrade PACS now involve more stakeholders and collaboration across the system. This is because PACS occupy an increasingly central role in a hospital enterprise, and because, in a world driving toward collaborative care, how a provider expands or upgrades its image management infrastructure is a strategic issue for the healthcare enterprise.

In order to survive in this environment, hospitals need to adopt solutions to image management infrastructure that enable, not hinder, related goals. In particular, hospitals need to be able to provide or address the following:

- Freeing images from their siloed PACS vendor solutions to support easy image sharing
- High-performance access to large image files within a cost-effective and scalable storage infrastructure
- Image storage and access solutions need to support cost-efficient infrastructure and application system migration
- With data files growing exponentially in size, solutions need to support image lifecycle management and cost-efficient retention policies
- Image sharing needs to leverage the information interoperability of document sharing solutions
- Medical image sharing and management solutions need to support analytics, enabling research and care provision

On at least one level, these unmet needs have stimulated new responses and solutions from healthcare solution suppliers. Offerings have begun to emerge that more strategically address some or all of these needs.

Advances and interest in areas such as vendor-neutral enterprise archives, cloud computing, as well as the tie-ins to broader applications around analytics, enterprise content management and sophisticated lifecycle management are driving a number of more forward-looking solutions.

In short, the market has begun to realize that image sharing and management resides at the center of many enterprise-wide issues. It should now be understood that how a provider addresses the issue of PACS silos and growing storage requirements is of the utmost strategic importance.

After all, the bigger picture of interconnected and collaborative care is no longer just an abstract vision—providers are now under competitive, financial and regulatory pressures to make concrete steps toward this goal. This year has mostly been about getting providers to use electronic health records; but the next several years will be about exchanging data, having communities of information sharing, and enabling the analytics and benefits in health outcomes promised at the end of this journey.

## EMC'S SOLUTIONS FOR IMAGE SHARING AND MANAGEMENT

EMC is a global leader in information infrastructure with a broad healthcare portfolio and an extensive track record in providing solutions to Big Data management challenges in the medical industry. Within healthcare, the company has dynamically grown its capabilities along the arc of emerging strategic needs; in particular, the needs around PACS archives and the bigger picture of image sharing and management in conjunction with leading ISV PACS partners.

The EMC Medical Image Management with Document Sharing Solution leverages a vendor-neutral image archive and various EMC technologies to allow standards-based (DICOM, HL7) clinical image and document management across the healthcare enterprise, and at a regional or national level.

The EMC Medical Image Management with Document Sharing Solution enables the normalization of multiple versions of medical data standards, making data sharable by users in different locations using different image viewers. The Documentum Content Server manages the storage, retrieval, updating, archiving, and lifecycle management of disparate patient content stored in a federated repository.

This solution allows providers to capture a 360-degree view of the patient, including not only images and metadata associated with those images, but also other structured and unstructured data, from medical records to financial records. All types of patient content across the range of medical applications utilized within a healthcare organization can be stored, shared and viewed securely, and managed intelligently based on business rules and policies.

In a world where access to patient data needs to be instantaneous and secure, and needs to be ubiquitous outside the walls of a single department or provider facility, solutions that support the ability to access, view and manage a wide range of patient data from a wide range of sources meet the current needs of a single enterprise and the coming needs demanded by collaborative care models. To deliver to the present and future of collaborative care, the following are needed elements in a medical image management solution:

- Support the capture, search, retrieval and management of structured and unstructured data from a variety of sources
- Aggregate and reconcile content of various types and formats in a patient-centric repository
- Facilitate communications between systems from multiple vendors
- Apply intelligent business rules and policies to content management, secure access and audit controls
- Provide a current ROI and a future-proof infrastructure that meets security, compliance and data expansion requirements

EMC is able to do this by very effectively leveraging the variety of products and solutions within the EMC portfolio. Building on its traditional strength in image storage and management for healthcare organizations, and utilizing an unmatched combination of strengths in content management, Big Data and analytics, and cloud storage solutions, EMC has the combination of knowledge, experience, skills, solutions and partners to enable healthcare organizations to meet their need for collaborative care today, along with the changing demands of the future.

## REFERENCES

---

- <sup>1</sup> McKinsey Global Institute. 2011. "Big data: The next frontier for innovation, competition, and productivity." [http://www.mckinsey.com/Insights/MGI/Research/Technology\\_and\\_Innovation/Big\\_data\\_The\\_next\\_frontier\\_for\\_innovation](http://www.mckinsey.com/Insights/MGI/Research/Technology_and_Innovation/Big_data_The_next_frontier_for_innovation) (May 2011).
- <sup>2</sup> Microsoft, 2007. "Hospital of the Future Adopts OneIT to Deliver Improved Patient Care, Efficiency Savings, and Productivity Gains."
- <sup>3</sup> Frost & Sullivan, 2011. See Figure 1 and Figure 2.
- <sup>4</sup> DiagnosticImaging.com citing a report by KLAS Research, "KLAS: New Wave of PACS Replacements is Coming," <http://www.diagnosticimaging.com/conference-reports/rsna2011/content/article/113619/2000916> (December 2011); and Carestream Health, <http://blog.carestreamhealth.com/2011/07/18/replacement-pacs-rules-of-engagement/> (July 2011).
- <sup>5</sup> American Health Lawyers Association, [http://www.healthlawyers.org/Events/Programs/Materials/Documents/AMI11/fishman\\_neumann\\_owens\\_slides.pdf](http://www.healthlawyers.org/Events/Programs/Materials/Documents/AMI11/fishman_neumann_owens_slides.pdf)



**Silicon Valley**  
331 E. Evelyn Ave. Suite 100  
Mountain View, CA 94041  
Tel 650.475.4500  
Fax 650.475.1570

**San Antonio**  
7550 West Interstate 10,  
Suite 400,  
San Antonio, Texas 78229-5616  
Tel 210.348.1000  
Fax 210.348.1003

**London**  
4, Grosvenor Gardens,  
London SW1W 0DH, UK  
Tel 44(0)20 7730 3438  
Fax 44(0)20 7730 3343

**877.GoFrost • [myfrost@frost.com](mailto:myfrost@frost.com)**  
**<http://www.frost.com>**

## ABOUT FROST & SULLIVAN

Frost & Sullivan, the Growth Partnership Company, partners with clients to accelerate their growth. The company's TEAM Research, Growth Consulting, and Growth Team Membership™ empower clients to create a growth-focused culture that generates, evaluates, and implements effective growth strategies. Frost & Sullivan employs over 50 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from more than 40 offices on six continents. For more information about Frost & Sullivan's Growth Partnership Services, visit <http://www.frost.com>.

For information regarding permission, write:

Frost & Sullivan  
331 E. Evelyn Ave. Suite 100  
Mountain View, CA 94041

Auckland	Dubai	Mumbai	Sophia Antipolis
Bangkok	Frankfurt	Manhattan	Sydney
Beijing	Hong Kong	Oxford	Taipei
Bengaluru	Istanbul	Paris	Tel Aviv
Bogotá	Jakarta	Rockville Centre	Tokyo
Buenos Aires	Kolkata	San Antonio	Toronto
Cape Town	Kuala Lumpur	São Paulo	Warsaw
Chennai	London	Seoul	Washington, DC
Colombo	Mexico City	Shanghai	
Delhi / NCR	Milan	Silicon Valley	
Dhaka	Moscow	Singapore	