LOADBALANCER | DesAcc

WHITE PAPER

The pivotal role of the load balancer in PACS migrations

Considering the impact on network architects and operations staff

Picture Archive and Communication System (PACS), Vendor Neutral Archiving (VNA) and Enterprise Imaging (EI) technologies are essential in modern health care, enabling organizations to process, view, share and store medical images such as x-rays, ultrasounds and CT scans. These technologies are used by clinicians to diagnose patient conditions, determine treatments and monitor recoveries, and therefore they need to perform reliably 24 hours a day, every day.

Implementing such a critical IT systems is not a straightforward undertaking. However, there are many reasons why health care organizations decide to step up to this challenge and migrate to a PACS platform, or migrate a copy of their data to an EI solution such as a Vendor Neutral Archive (VNA). Many want to take advantage of new advanced technology and features such as Artificial Intelligence and Machine Learning (AI/ML), to improve the quality or efficiency of patient care. Others need to address scalability concerns, technical challenges with their existing platforms or want to take advantage of externally hosted service offerings

Larger health care groups may decide to create a standardized platform across multiple facilities and sites to reduce costs and improve the efficiency of patient-centric workflows. Sooner or later, though, all users of technology will need to upgrade, if not replace, their platforms, as vendors only support and maintain their technology for a finite number of years.

> *Critically, load balancers help to prevent downtime in the new system, not only during the migration phase but throughout its operational lifetime.*

Some organizations hold twenty years' worth of imaging data and want to migrate it in a year or less. This means that data must be extracted from the outgoing system twenty to forty times faster than it was originally ingested, and delivered to the new system at the same rate.

While the technical and change management challenges that organizations will face during a system replacement project will inevitably vary from organization to organization, there are three key risks that all organizations should be concerned about: slow data migration, lost patient data and unacceptable downtime.

Using load balancers can significantly improve the efficiency and reliability of the data migration process, which is commonly recognized as one of the most challenging aspects of implementing a new system. By placing a load balancer in front of the new system health care organizations can direct images and patient data to multiple nodes, rather than just one, reducing bottlenecks and eliminating unnecessary disruptions and delays in the data migration process.

Your choice of migration provider is also crucial if bottlenecks and pitfalls in data extraction are to be avoided and data delivered efficiently to the new PACS/VNA/EI system.

The use of load balancers can also help health care providers to reduce the risk of lost images and patient data for new data, by improving the integration between image capture equipment, such as CT scanners, and the new system. Load balancers can automatically encrypt data from old imaging devices that do not have encryption capabilities so that they are not rejected by the new platform.

Critically, load balancers help to prevent downtime in the new system, not only during the migration phase but throughout its operational lifetime. They can be configured to perform multi-layer health checks on the system storage systems and associated databases to ensure that all components of this critical system are performing optimally. If issues are detected, the load balancers can seamlessly direct user traffic to alternate services, keeping the system up and running.

End to End Imaging environments and data formats are incredibly complicated, particularly in large multi-site health care trusts and groups. So for this reason, organizations should take particular care when selecting providers for migration. Choose one who understands both the source and destination systems well – and ideally independent of both. The success of a migration project is also significantly enhanced by working with a load balancer vendor that has strong experience of delivering and supporting load balancing solutions in the medical imaging field.

Knowledgeable advice at the outset and experienced support on an ongoing basis will help health care providers to give their clinicians the reliable 24/7 service they depend upon to save lives.

> *Today's PACS is no longer just a 'bucket' but a critical, enterprise-wide system which drives clinical workflow and underpins many patient pathways.*

PACS, VNA and Enterprise Imaging 101

What are PACS, VNA and Enterprise Imaging?

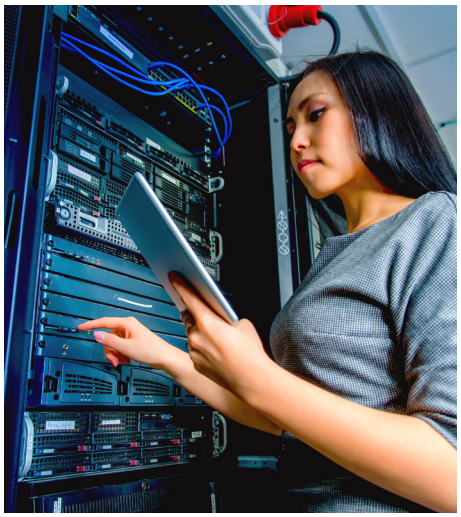
Picture Archiving and Communications Systems (PACS) and its successors, VNA and EI are essential in modern healthcare organizations, enabling them to process, view, share and store medical images such as digital x-rays, ultrasounds and CT scans. It is used by clinicians to diagnose patient conditions, determine treatments, and monitor recoveries.

Their origins were often as single-solution workstations attached to a single scanner or sub-department of a hospital. These "mini PACS" within imaging departments have been totally replaced by departmental PACSs, and in many countries, the printing of film has been almost totally eradicated.

A key enabler for this is the Digital Imaging and Communications in Medicine (DICOM) protocol, a network-based protocol which allows scanners, storage systems and workstations and applications to exchange data. A PACS will support a rich range of DICOM import and export capabilities, as well as supporting DICOM and other interfaces which are used to trigger various steps in imaging workflow and patient pathways.

As a result, today's PACS is no longer just a "bucket" but a critical, enterprise-wide system which drives clinical workflow and underpins many patient pathways. The PACS sits at the center of large, connected infrastructure of dozens, if not hundreds of networked devices. Some of these capture the X-rays and scans, some of these further process exams to provide additional means to interpret and visualize the data in them. Some devices may even be external to the healthcare provider and support research or patient transfers to specialist centers.

To recognize this centrality, many PACS have evolved into Enterprise Imaging (EI) systems, often underpinned by a Vendor Neutral Archive (VNA). These platforms store more than radiology images, take advantage of infrastructure at scale and may consolidate the function of specialist PACSs from several departments by including exams from specialties like cardiology and ophthalmology. Such EI systems now frequently hold clinical documents in addition to considerable other metadata.



Load balancer 101

What is a Load balancer?

A load balancer, sometimes known as an application device controller (ADC), distributes application and network traffic between clusters of two or more servers.

Load balancers are commonly used by organizations with business-critical web and mobile apps that experience high usage, either through the volume of data, or a high number of users (for example employees, or customers – or both).

In these scenarios, organizations will need more than one server in their networks to handle the high number of concurrent connections. The load balancer sits in front of these servers to share the load between the different physical or virtual machines. It balances traffic equally across all available servers, so that users experience the same, consistently fast performance.

Furthermore, if one server should fail, the load balancer intelligently reroutes the traffic to an alternate server in the cluster, ensuring the application's availability, and avoiding costly downtime.

Available for hardware, virtual and cloud environments to best suit your existing (or planned) application infrastructure, load balancers are most commonly deployed as active-passive pairs, providing business continuity by redirecting traffic to the secondary device in the event of a failure.

A load balancer also enables organizations to dynamically add more servers to respond to growing user numbers or anticipated peaks in demand, without interrupting their services or having to reconfigure the other servers in the cluster. And scheduled maintenance can be performed without taking applications offline – IT technicians can disconnect, patch, upgrade and reconnect servers without any disruption for users.

Reasons to migrate

There are several different reasons for considering replacing your current PACS or Enterprise Imaging (EI) system, and more than one of the following priorities is likely to be driving a typical health care organization.

New capabilities

Many hospitals and health care organizations migrate to new PACS platforms to enable them to take advantage of the advanced functionality that is now embedded in the latest generation of PACS solutions. They want to be able to generate and view 3D images and use state-of-the-art visualization tools to improve their understanding and diagnosis of patient conditions.

The reach of PACS is now larger. Newer PACS are now positioned as Enterprise Imaging systems (see What is PACS?), recognizing a role that includes storing, managing and display content from departments beyond radiology and content types including documents, waveform data (such as ECGs) and scanned images as well as the more usual medical images.

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Existing shortcomings

One recent study published in the Journal of Digital Imaging lists a number of common limitations in current PACS installations, including image transmission problems, network and hardware issues and difficulties changing settings[1]. Rapidly diminishing storage space is another pressing challenge for many organizations, as large, higher resolution image files consume more megabytes of space. Such technical issues lead to user frustration, lost efficiency and additional costs and generate a strong impetus for moving to a completely new PACS platform.

End of life

For some organizations, the need to deploy a new system will simply be determined by the age of the existing technology. There is some disagreement within the industry about the expected life of a system, but whatever the time-span, all systems will need to be replaced, or at least upgraded, at some stage.

In these days of heightened cybersecurity risk, continuing to use a PACS platform where the application is no longer supported by the supplier or the operating system is no longer patched by the vendor is now a risk that few health care organizations will be prepared to take.

It is worth noting that even with the same vendor, some upgrades to new platforms require a full-scale migration.

Improving efficiency

Migrating to a new PACS or EI platform allows an opportunity to consolidate multiple systems into one. This improves efficiency by migrating to a single PACS solution that can serve all clinicians across multiple facilities and multiple sites. Hospitals can also take advantage of economies of scale in the provision and management of storage and server resources, saving money on IT support, as well as improving the efficiency of the patient journey all the way from referral through to diagnosis and treatment. This rationale for a PACS migration often seen when organizations have recently undertaken a merger, as there is usually a need to consolidate systems and integrate processes.

1 Alhajeri M, Shah SGS. Limitations in and Solutions for Improving the Functionality of Picture Archiving and Communication System: an Exploratory Study of PACS Professionals' Perspectives. J Digit Imaging. 2019 Feb 1;32(1):54–67.

Innovation

Health care enterprises also want to apply Artificial Intelligence and Machine Learning (AI/ML) to speed up their processing and interpretation of data and they want to make it easier for clinicians to view medical images from any location and any device. Both these goals are more easily achieved with a platform which stores data at scale and which provides a range of modern, interoperable interfaces to enable secure data exchange.

Cloud and storage migration

Some migrations may not involve any system replacement or consolidation but involve a change to storage systems or locations. Many organizations are moving all or part of their imaging archives into the cloud. Whilst not always involving the DICOM protocol, these migrations still generate considerable network traffic and may well benefit from routing, encryption and load distribution capabilities of a load balancer.

Data retention drivers

When a migration is being considered, it's essential to preserve at least some of the data in the outgoing system. There are three key reasons for doing this.

Clinical need

Clinicians may need to look back at x-rays and scans taken many years in the past in order to compare 'before' and 'after' images and see the emergence or spread of a disease or medical condition over time.

PACS/VNA/EI platforms do not just hold medical images; they also hold databases of patient records and associated metadata, such as when and where each image was taken. All this supplementary information needs to be transferred from the legacy system to the new system, alongside the images, or otherwise, clinicians will not be able to identify which image relates to which patient, how to contact the patient and when the image was taken.

Legal duty

If this sensitive patient data were to be lost during the data migration process, health care services would be significantly disrupted and there could be a risk of litigation or fines for data privacy violations. Health care organizations in most countries have a legal duty to retain medical images for a specific period and make them available on-demand. The retention timescale often exceeds the lifespan of a single system, so data must endure even when the systems that originally created it have retired.

Data-driven Innovation

Increasingly, organizations also want to be able to 'learn' from their data. Many have moved from applying purge rules to a 'retain everything' strategy, because they want to be able to use de-identified medical images and related to content to 'train' emerging Artificial Intelligence and Machine Learning (AI/ML) applications to spot new insights and patterns in existing data. These applications could help with the diagnostic workload, clinical trials and even ultimately lead to new treatments and cures.

Images held in the legacy PACS can, therefore, not simply be abandoned.

> *"From the moment that a new PACS or EI solution comes online, it needs to deliver 24/7 uptime to enable clinicians to provide a high quality of service for patients."*

Migration risks and complexity

It is widely recognized that "The transition between PACS has the potential to derail the operations of a radiology department.[2]" Because radiology diagnoses underpin so many patient pathways, a poorly planned and implemented imaging migration project will jeopardize operations far beyond the radiology department and hamper the delivery of patient care throughout the organization.

It is therefore essential for health care providers to embark on PACS and EI migration projects with a realistic understanding of the challenges they will face. These will vary depending on the existing IT environment, state of the infrastructure and data centers housing it. And as with all large IT replacement projects, there will be important change management issues to address, relating to cost control, training and communication.

There are three key risks that all health care organizations will inevitably be concerned about and which will be a critical consideration in all PACS migrations.

1. Slow data migration

Data migration is one of the largest challenges faced by organizations transitioning to a new system[3]. Yet, as we saw above, there are clinical, ethical and legal reasons for retaining data.

A legacy system that has been in use for many years will hold millions of individual images and can now easily hold billions. Furthermore, these image files can be huge, with a single CT scan taking up 300-500 kbytes of storage space and a single digital mammography 2D image requiring 20-25 Mbytes

2 Berkowitz SJ, Wei JL, Halabi S. Migrating to the Modern PACS: Challenges and Opportunities. RadioGraphics. October 2018; 38(6):1761–72.
3 same as reference 2

of space, even when compressed. This gets considerably worse with large 3D mammography tomosynthesis datasets, where a single breast image can be 500 Mbytes in size.

Consequently, migrating all images from a legacy system to a new system can be an incredibly time-consuming process, particularly when avoidable bottlenecks slow the process. When the data migration is not completed promptly, clinicians will have an extended period of disruption, when current and historic images are saved on different systems.

Replacement projects are normally scheduled to take a year or less. Yet organizations can easily hold twenty years' worth of data. This means extracting data out of an outgoing system and delivering it to a new system at a rate twenty to forty times faster than it originally went into the outgoing system.

One of those avoidable bottlenecks is the use of the DICOM protocol to extract data in bulk from the outgoing system. Whilst DICOM enables standards-based data exchange across the world, its request and fetch capability (DICOM Query/Retrieve) was designed to serve up the imaging history for a single patient, or a handful of similar exams for several patients. It was never designed, nor is it fast enough for data migration at the scale now required to deliver the terabytes of data stored in a way which meets timescales for all but the smallest migration projects.

2. Lost patient data

As we saw above, the system manages part of most patient's medical record. The risk of a large-scale data loss is small in well-managed projects. However, individual images can easily get lost during and following a PACS or EI migration.

Integration or legacy data encoding issues may mean that x-ray images taken in the radiology department may not be transferred properly into the new PACS or EI system, resulting in this image being lost. This might require a new x-ray needing to be taken, or mean that historic data is lost forever. Health care providers would have the additional cost of having to repeat x-rays and other scans when the original images are lost, and patients could experience potentially life-threatening delays in their treatment, or have an important part of their clinical history rendered unavailable, even though it could shed light on their present condition or treatment.

3. Unacceptable downtime

From the moment that a new PACS or EI solution comes online, it needs to deliver 24/7 uptime to enable clinicians to provide a high quality of service for patients. This high availability can be challenging to achieve, especially at the outset when the platform may be simultaneously receiving new images from hundreds of connected imaging machines and historic images which are being migrated from the old PACS.

If data migration is not yet complete, each patient's record may still be fragmented between the outgoing and new systems. This results in clinicians needing to look in two places for the patient's full history. It also means that

the outgoing system must be kept running and available, so the additional load which migration imposes must be managed so that clinicians can still refer to the outgoing system and access scans and information in a timely fashion.

Undoubtedly, there is no room for 'teething problems' in a new PACS platform. Even a small amount of downtime will be unacceptable. In many industries, 99% uptime in a key IT system would be considered good. However, in a hospital, a PACS system that offers 99% uptime will be offline for 3.5 days a year, which is completely untenable. Even a system that is available 99.99% of the time will be offline for nearly an hour (53 minutes) per year[4].

> *"Load balancers can play a pivotal role in migration projects by helping organizations to mitigate the three significant risks of slow data migration, patient data loss and downtime."*

Avoiding migration bottlenecks: direct-from-media migration

The DICOM protocol is essential for the integration of scanners, X-ray and ultrasound machines, workstations and AI/ML applications to a PACS or Enterprise Imaging (EI) system. It is also the best format for ingest into a new PACS, Vendor Neutral Archive or Enterprise Imaging system.

However, as stated above, although it can serve up images and associated data on an outgoing PACS, the limitations of that system's hardware and software platform mean that DICOM is not fast enough. Because a migration places too much load on the DICOM interfaces and particularly the PACS database, most DICOM-based migrations have to take place in 'quiet' time outside core clinical hours. This extends the migration project timescales.

Even assuming a migration could run 24/7, 100 terabytes of data (approximately 2.5 million exams) migrated at 40Mbits/s would take 8 months to migrate. That's only 10,800 exams per day!

There is an alternative: Rapid migration using Direct-from-Storage.

This approach doesn't increase the load on the outgoing system's database, operating system or servers because data is copied directly from the source system's storage. This is usually disk but it's also possible to read from tapes, DVDs and optical disks.

Data is converted into DICOM format before sending and this also presents an opportunity to ensure the patient demographics inside the DICOM are up-to-date as well as providing the opportunity to cleanse or even re-map patient identifiers, exam codes, study descriptions and standardize data elements with varied data quality such as Institution Name and elements which frequently contain non-standard values, such as body part.

End-to-end migration rates can now reach 2,000 - 5,000 Mbits/s, with the limiting factors now being the performance of the storage hardware on the source system and the rate at which the new destination PACS/VNA can receive and process data. A migration of the same 100 terabytes from earlier will take 22 days to complete instead at 500 Mbits/s. This is approximately 135,000 exams per day. Some of the new systems which DesAcc work with have been able to ingest at 600,000 exams per day.

4 Liu, Yu and Wang, Jihong. PACS and Digital Medicine, Essential Principles and Practical Guidance.

What role do load balancers play in imaging migrations?

Load balancers can play a pivotal role in migration projects by helping organizations to mitigate the three significant risks of slow data migration, patient data loss and downtime.

Available as a virtualized solution or as a hardware appliance, load balancers can be placed between the legacy system, existing image capture equipment and new platform, facilitating integration and streamlining the flow of traffic. They can significantly simplify the migration process, whether the project is being led by the organization's own in-house IT team, a PACS vendor or a specialist medical imaging services consultancy.

High availability during the data migration process

DICOM is the protocol for integrating medical imaging and associated devices to a PACS or EI system. DICOM is also essential for populating a new PACS, VNA or EI system with data.

When a direct-to-media migration is used, DICOM data can be delivered much faster than when a traditional DICOM-based extraction approach is used. Data is therefore delivered in much greater volumes to the new system.

Sitting between the migration engine and the new platform, load balancers stream DICOM data to multiple nodes simultaneously, rather than one, which reduces the likelihood of ingestion bottlenecks and allows the data migration process to proceed efficiently and reliably. When a load balancer is not used, if a receiving node becomes overloaded or goes offline, the entire data migration grinds to a halt.

With a load balancer, if one node becomes overloaded, data migration will automatically switch to other available nodes and the process will continue.

Smooth PACS transition

During a system replacement project, an organization may have a legacy and a new system running simultaneously. Both systems will be delivering services for users while at the same time handling the additional load of the data migration activity, and all scanners and X-ray equipment will still be acquiring new data for patients.

Using a load balancer to reduce bottlenecks should optimize response times on the new PACS and help to deliver a better experience for users while the data migration takes place. It can also allow scanners and X-ray equipment to seamlessly transition from sending new exams from the outgoing system to the new system.

Changing destination IP addresses on scanners and X-ray machines often requires a chargeable engineer visit. However, if a load balancer is used to be the virtual destination IP, and the load balancer's address can be changed on the X-ray or scanner equipment during a periodic maintenance visit, the need for a separate call-out fee to change the IP address can be avoided. The implementation and timing of changing scanner-to-PACS routing during migration starts to come under the control of the healthcare organization rather than the equipment vendor.

High availability and flexibility after the migration

Load balancers can help to ensure the high availability of the new PACS or EI platform throughout its entire lifetime. Newly balance newly acquired exams across servers in the platform. This ensures that no single server is overloaded and deliver high performance for every user. Some load balancers can undertake multi-layer health checks, verifying not only that the system is available, but also that the storage systems and database are available. It this way, they can help ensure the availability of the entire service for clinicians.

> *"From the moment that a new PACS or EI solution comes online, it needs to deliver 24/7 uptime to enable clinicians to provide a high quality of service for patients."*

The use of load balancers also makes it far easier for organizations to scale up their PACS platform. The load balancers can easily direct traffic to additional servers, as usage increases and file storage is consumed, preventing degradation in performance over time.

Effective system integrations to prevent data loss

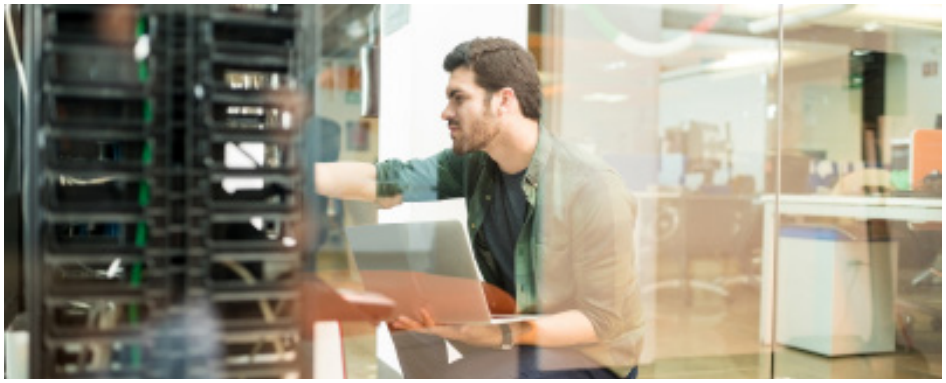
Load balancers can also help to simplify the integration of existing X-ray and scanner equipment devices with the new PACS or EI platform, by standardizing the use of security protocols. For example, if an existing CT scanner does not encrypt traffic but the new PACS or organization policies about cross-network

flows require all incoming patient data and images to be supplied in Transport Layer Security (TLS) or, less commonly now, Secure Sockets Layer (SSL), a load balancer can automatically encrypt it, enabling the two systems to connect smoothly and preventing avoidable data loss.

Which load balancers are most suitable for imaging migration projects?

There are a large number of load balancer vendors and all of them have products that could be used in conjunction with medical imaging solutions. However, not all of them will have been road-tested with the leading PACS systems and not all of the vendors will have specialist expertise in this field.

Important criteria that organizations should consider when selecting a load balancer include:



> *"Given the compexity and risks associated with PACS, VNA and EI migrations, having a step by step guide for how to optimize the use of a load balancer can be invaluable."*

Track record with chosen PACS/EI

Given the criticality of PACS and EI platforms for delivering patient care, health care providers cannot afford to take chances with any part of their new infrastructure, no matter how small. It is therefore important for organizations to look for load balancer vendors that have specialist expertise in this industry and load balancer products that have a proven track record for supporting the chosen PACS technology.

No throughput limits: One thing all health care providers can be certain about is that traffic to their PACS or EI platform will expand over time, to accommodate more images and bigger images. Some load balancers have restrictive licensing agreements, which impose artificial limits on throughput, and these kinds of products can become costly or even obsolete in just a few years. Organizations should, therefore, seek products without throughput limits and size them to take into account the likelihood of rapid, significant data growth.

Product-specific deployment guides

Given the complexity and risks associated with PACS, VNA and EI migrations, having a step-by-step guide for how to optimize the use of a load balancer can be invaluable. Load balancer vendors who are leaders in the medical imaging field should be able to provide detailed deployment guides, specifically for the chosen PACS platform. By using this guide, organizations can get up and running more quickly and confidently.

Support from medical imaging experts

If questions or issues arise during the migration, the project team will want to be able to speak with load balancer vendors who understand medical imaging systems, know how to set up load balancers with DICOM devices and have experience of resolving technical challenges. Health care providers should, therefore, ensure that their shortlisted load balancing vendors have specialist experience of deploying load balancers with leading PACS platforms and can provide a responsive, knowledgeable support service.

Selecting a data migration vendor

There are many data migration choices; using your outgoing vendor to push exams using DICOM, using an in-house migration team from your new PACS/VNA/EI system vendor to pull exams using DICOM Query/Retrieve or employing a data migration specialist such as DesAcc.

However, there are several factors you should consider when looking at medical data migration.

> *Having a vendor who is independent of both outgoing and new system vendors and who undertstands the anomalies and unique characteristics of both systems is crucial.*

Track record with both the outgoing and new systems

Given the criticality of existing and new PACS platforms for delivering patient care, health care providers cannot afford to take chances with any part of their old or new PACS/VNA/EI infrastructure.

Having a vendor who is independent of both outgoing and new system vendors and who understands the anomalies and unique characteristics of both systems is crucial. They can help arbitrate and resolve problems in the event of incompatibilities – and can help you avoid pitfalls in the first place.

No throughput limits

Your organization has made a considerable investment in the new PACS, VNA or EI system and wants to start realizing the benefits as quickly as possible. Project timescales are often curtailed as end-of-life or contractual deadlines in the outgoing system are looming. Look for a vendor who can deliver data in a standard DICOM format as quickly as possible.

Medical data experts

Important clinical data often resides within proprietary structures in the outgoing system. A good example is annotations and markups. Look for a vendor who knows how to extract data and convert it into DICOM or another standards-based format such as Portable Document Format (PDF).

Experienced in clinical workflow and data exchange

If questions or issues arise during the migration, the project team will want to be able to speak with migration who understand medical imaging systems, understand how departments work and who can talk to your clinical staff. Health care providers should, therefore, ensure that their shortlisted vendors are not only aware of health data migration, but have specific experience in handling medical imaging data at scale.

Deployment considerations

Migration imposes loads on a new system and load balancer which the new system may not face again during its lifetime. Accordingly, you need to size your load balancer to allow the capacity for migration ingestion as well as potential simultaneous ingestion of newly acquired exams.

Organizations may wish to augment physical load balancers by using virtual load balancers to provide additional traffic-handling capacity during migration and then decommission the virtual load balancers and their associated virtual machines when the migration has completed. Choosing a vendor such as Loadbalancer.org who uses the same technology for both virtual and physical technology helps reduce training costs and means involving one load balancer vendor in your project, rather than two.

Regardless of your load balancer deployment strategy, you should ensure that both the load balancer and ingestion tier of your new PACS/VNA/EI system have been sized to deal with the peak loads which migration imposes.

About Loadbalancer.org

Loadbalancer.org's mission is to ensure that its clients' businesses are never interrupted. The load balancer experts ask the right questions to get to the heart of what matters, bringing a depth of understanding to each deployment. Experience enables Loadbalancer.org engineers to design less complex, unbreakable solutions - and to provide exceptional personalized support.

About DesAcc

DesAcc is experienced with the challenges of handling healthcare data at scale. Using our deep understanding of how data is created and stored within health IT systems, we extract, standardise, and move data between systems worldwide. We use this knowledge to create innovative solutions for machines and humans which makes data more available to help drive patient care and research.

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