



Medical Imaging on AWS

Cloud-based platform for
storage, sharing, and analysis



INTRODUCTION

Amazon Web Services (AWS) and our partners have solved image management, for X-rays, CT scans, MRIs, and ultrasounds, in the cloud with four primary pillars that work in unison to benefit the healthcare system and its patients. In this eBook, dive deep on the AWS solution for storing and sharing medical images that has transformed how healthcare systems deliver patient care.



PILLAR #1

Accessing enterprise imaging solutions on AWS

Priority

Outdated file-sharing methods significantly and unduly burden medical professionals and patients

Before 1895, physicians could not see inside a patient's body without an invasive medical procedure. That year, German mechanical engineer Wilhelm Conrad Roentgen discovered what he called X-rays while experimenting with electron tubes. Roentgen used the new technology to photograph his wife's hand, [revealing its skeletal structure](#). Medical professionals peered inside the human body for the first time, [and the field of medicine transformed](#).

Now, nearly 130 years later, the field of medical imaging has evolved incredibly. CT scans create computerized, 360-degree images of the human body in incredible detail within minutes. Many different types of medical images, ranging from X-rays to CT scans, play a critical role in patient health outcomes, including wellness visits, disease prevention, early detection, diagnosis, prognosis, treatment, follow-ups, and research. But the technology for image sharing has not kept pace with the technology for image capture.

Many clinicians, including radiologists and cardiologists, rely on Picture Archiving and Communication Systems (PACS) to view, share and reference images for various procedures and to determine treatment plans. [PACS is a digital system for storing and sharing medical images and reports.](#) Unfortunately, PACS is often unavailable or difficult for physicians to access, forcing them to find workarounds to obtain the information they need to do their jobs. Some hospitals still burn CDs in order to make images available to interventionalists, and many patients find themselves acting as a delivery service, driving to imaging centers to pick up copies of CDs and hand-delivering them to their specialist or PCP. Too many patients and physicians live and work as if the year is 1990. Patients sometimes end up getting multiple rounds of the same imaging—and the associated exposure to radiation—simply because specialists struggle to gain access to previously captured images held at different locations. This results in lost time and money; it also adds unnecessary radiation exposure. In fact, multiple institutions say they will only consider vendors with cloud solutions because their patients and physicians demand it.

Solution

PACS on AWS benefits patients and healthcare systems by lowering infrastructure costs, increasing accessibility, and allowing for remote access.



Enterprise Imaging on AWS is

- ◆ **Accessible**, featuring remote interpretation of images and patient access.
- ◆ **Full-stack**, featuring viewer, workflow, and VNA. Our Partners utilize AWS services such as Amazon HealthLake Imaging, Amazon Simple Storage Service (Amazon S3), Amazon Elastic Compute Cloud (Amazon EC2), Amazon EC2 G4 instances, and Amazon Elastic Block Store (EBS) to build PACS/VNA solutions in the cloud
- ◆ **Fast**, with sub-second image delivery, streamed on demand; the system setup is also easy and installs within days
- ◆ **Flexible**, deploying as software as a service (SaaS) or self-hosted, whichever your facility prefers
- ◆ **Scalable**, to support local, regional, and national health systems; clients can use [elastic compute and storage](#) resources as needed, paying only for what they use
- ◆ **Secure**, leveraging robust AWS security controls and enterprise-ready, read-only deployment architectures to protect against ransomware
- ◆ **Multimodal**, enabling comprehensive clinical depth with diagnostic and enterprise viewing and mobile imaging

No more forcing patients to hand-deliver images to their healthcare providers. It is the 21st Century.



Case study

Visage Imaging & California-based health system

A large, California-based health system decided to replace its diagnostic medical imaging applications across all five of its academic medical centers with a single-vendor solution running in the public cloud. They chose to implement Visage on AWS after product tests showed average study load times for simulated radiologists of 0.267 seconds per study, 44 percent peak CPU usage on the backend server, and 37 percent max memory usage on the render server. Visage Imaging offers a cloud-based, ultra-fast, fully-managed PACS-as-a-service that enables you to go live securely with incredible scale and performance.

PILLAR #2

Fast access and disaster recovery (DR) of medical histories through VNA

Priority

Bespoke, on-premises data centers leave healthcare communities at risk for data loss through natural disasters, technical failures, and human error, and limit access to medical records, effectively making data internal-use only.

Digital security entails a number of measures, and information must be protected against unauthorized access, system overload, cyber-attack, and physical vulnerabilities. The challenge of maintaining and updating data storage to safeguard against disaster with a rapidly expanding image set goes beyond physical storage capacity. Replacing and expanding hardware isn't just expensive and time-consuming—it creates additional risk. Every time you replace or copy hardware, you make your data vulnerable to loss, which decreases patient trust, damages your brand, and leads to serious legal and HIPAA ramifications. Additionally, recovery can take hours or days when data loss occurs, which is significant in the medical field, where every second counts.

Healthcare providers need easy, assured access to patients' medical histories and data at all times, which means protecting providers against blocked access due to inefficient systems. When historical imaging data is lost or inaccessible, it leaves physicians unable to track health conditions over time, which can result in medical oversight and error.

The best systems protect data while simultaneously ensuring access for those who need it. Fast and secure access to healthcare records across facilities and teams improves patient outcomes due to comprehensive, coordinated care. Patients also support accessibility, with 81 percent of adults in favor of increased access to health information for patients and providers.

In short, storing data in a single, on-premises location puts it at increased risk of loss and fails to prioritize fast recovery and authorized, easy access.

When facilities store medical images using nonstandard file types and software, it creates time-consuming and frustrating obstacles for physicians outside the initial organization who need to access them. For example, another block to access that occurs with on-premises systems is asynchronous data viewing. With many on-premises systems, a single party logging in and accessing patient medical files prevents any other party from accessing it simultaneously. Meanwhile, the best healthcare requires a medical team.





A VNA, or vendor-neutral archive, clears this obstacle. VNA is a system in which medical professionals archive images and data in a standard format for easy access across systems. When this system was implemented at a large healthcare network in Ohio, the impact was remarkable. The process was associated with more than 10 percent cost savings, a 30 percent reduction in storage costs, superior support for disaster recovery, and an 80 percent decrease in unscheduled outages. All these were achieved despite a 120 percent increase in archive retrieval needs and a 40% growth in image production.

Furthermore, cloud-based VNA storage with AWS can consist of a data lake in which all data is stored in a centralized location. By consolidating data in one place, an AWS data lake serves as a starting point for large-scale analytics of big data in high-performance computing environments, as well as artificial intelligence (AI) and machine learning (ML). Using a data lake thus enables AI and ML to gain efficiencies and insights, improving the overall system. We'll explore that a little later in Pillar 4.

Solution

VNA and cloud storage is the modern data architecture that enables your organization to protect and access data, improving patient lives, optimizing operations, and boosting clinician satisfaction.



AWS disaster recovery

[Amazon HealthLake](#), the AWS data lake for healthcare, is a managed service protected by AWS global network security procedures. AWS's global infrastructure is built around AWS Regions and Availability Zones. AWS Regions provide multiple physically separated and isolated Availability Zones, which are connected with low-latency, high-throughput, and highly redundant networking. With Availability Zones, you can design and operate applications and databases that automatically fail over between zones without interruption. Availability Zones are more highly-available, fault-tolerant, and scalable than traditional single or multiple data center infrastructures.

Amazon HealthLake helps you keep pace with evolving disaster recovery (DR) strategies without costly physical updates and reduces downtime and data loss with its fast, reliable recovery. AWS DR services can decrease your [recovery point objective to seconds and your recovery time objective to just a few minutes](#). You can quickly recover operations after unexpected events, such as software issues or data center hardware failures.



Case study

King Hamad University Hospital (KHUH)

KHUH and Bahrain Oncology Center is a 600-bed hospital in Bahrain. Over the years, KHUH faced constraints with the exponential growth of their on-premise digital storage needs, particularly with the medical images housed by their picture archiving and communication system (PACS).

Storage upgrade activities tied up IT personnel and took efforts away from KHUH's core healthcare business and patient-centric focus. As a result, KHUH wanted a long-term archival solution that could grow and adapt automatically. Furthermore, the solution required minimal changes to the existing PACS system, as an independent software vendor (ISV) provided the PACS system, and changes to the software code base required too much time to implement.

KHUH turned to AWS to find a solution, leveraging [Amazon S3 File Gateway](#) and [Amazon S3 Glacier](#) to store medical images in the cloud for long-term archiving without making changes to the existing PACS. In their new storage architecture, only medical images generated within the last four years are kept on-premises, while the remaining data is archived with AWS.

At KHUH, medical imaging data is now both securely stored and available to authorized professionals using VNA. In the event of a disaster, their database and recovery systems will enable fast access to medical histories, prioritizing the patients at the center of their mission.



PILLAR #3

AI-based medical imaging research

Priority

AI- and ML-based medical imaging research requires incredible data storage capacity and load time, typically unavailable in traditional data storage centers.

Medical teams rely on pathologists to examine bodies and body tissues for various reasons, including disease prevention, early detection, diagnosis, treatment plan development, and research. Pathologists are responsible for analyzing massive amounts of image data, and inevitably, the potential for human error increases with fatigue, stress, and workload. As researchers have searched for ways to optimize image analysis, AI and ML offer great potential.

In recent years, medical teams have implemented artificial intelligence (AI) and machine learning (ML) to analyze medical images that can identify patterns and characteristics to support diagnosis and prognosis, improve care, and aid research. Using this technology enables the medical field to process massive amounts of data without the fatigue or potential for error of human eyes, and with incredible attention to detail, [according to recent studies](#).

Solution

AWS offers the storage space, speed, and power to implement AWS AI/ML capabilities effectively in clinical and research use cases.

The AWS solution allows users to

- ◇ Accelerate their research
- ◇ Set up reproducible workflows
- ◇ Scale infrastructure up and down
- ◇ Set up multimodal ML pipelines
- ◇ Gain financial flexibility
- ◇ Benefit from research funding programs



AWS AI/ML offers many opportunities to level up.

- ◇ Our AI/ML services enable users to explore more architectures, hyperparameters, and hypotheses than what is possible with just static on-prem infrastructure, which supports accelerated research.
- ◇ Services such as [Amazon SageMaker](#) allow software engineers to create, program, and deploy machine-learning models in the cloud.
- ◇ AWS can help you set up reproducible workflows. This is important if you need to undergo an approval process to bring your model into a clinical production environment.
- ◇ Our underlying infrastructure standardization means you can scale your operation up and down as research requires.
- ◇ With AWS, you can set up scalable ML pipelines for multimodal data, allowing you to examine medical imaging in the context of other EHR data for better patient outcomes. This is ideal for precision medicine teams who are increasingly handling heterogeneous workloads.
- ◇ The pay-as-you-go pricing model allows you to trade capital expenses for variable expenses, an option many finance leads opt for as OPEX approvals are often easier to get.
- ◇ You can benefit from different precision medicine and data-sharing funding programs and the architecture best practices we provide.



Case study

Grand Challenge at Radboud University Medical Center

Radboud University Medical Center in the Netherlands partnered with AWS to launch [Grand Challenge](#), a platform that allows users to build, test, and deploy imaging algorithms using ML. Currently, more than 70,000 researchers and clinicians are registered globally, with over 300 challenges and 1,000 algorithms deployed. Since they migrated the platform to AWS, it features scan time to load at <10ms latency. This functionality accelerates medical innovation by allowing developers worldwide to collaborate securely on research using AI and ML.

PILLAR #4

Enabling a single, comprehensive view for safer, more efficient healthcare

Priority

The proliferation of multiple copies of the same image datasets across clinical and research organizations, complicates operations, puts patients at risk, and costs facilities time, money, and other resources.

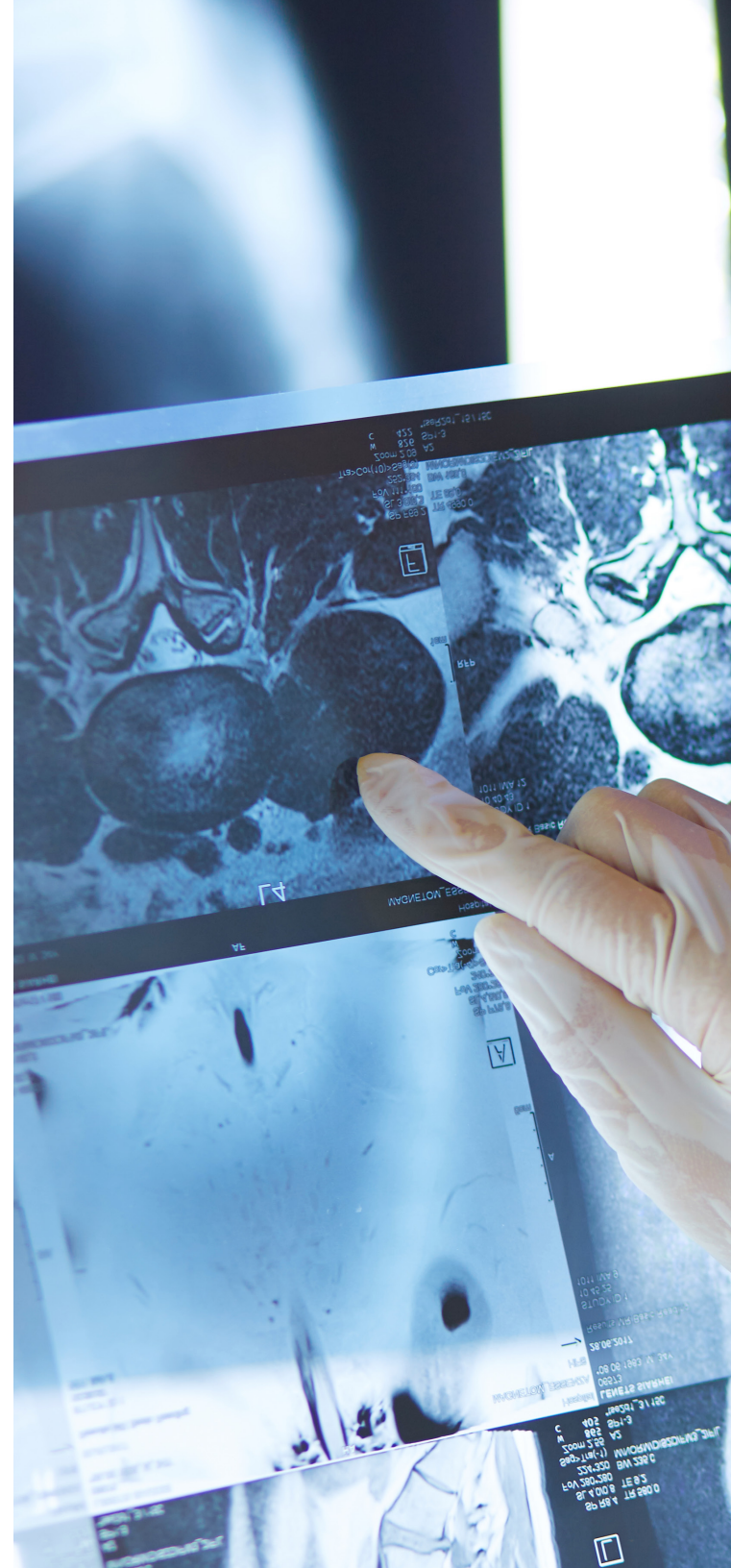
The medical field conducts over 5.5 billion imaging procedures annually, and this number continues to grow. Over the past decade and a half, the workload for radiologists in the United States has almost doubled—from 58 to 100 assignments per day. On top of that, image study size averages have reached 150 MB, further increasing the work and time required to analyze images. The issue with volume and mass is exacerbated by the insufficient systems used by many medical centers.

A single copy of patient imaging data in the cloud

Reduce the cost of medical imaging storage by up to 40 percent with HealthLake Imaging. We started working backwards from our customer's needs around medical imaging, we discovered that there were multiple copies of the same procedure being stored on premise. For example, a 1GB CAT Scan procedure might be stored on the CT Scanner, Radiology PACS, Cardiology PACS, VNA, image sharing system, disaster recovery system and other specialty workstations. These copies are the side effect of the legacy DICOM protocol – now almost 30 years old – which uses a store and forward architecture. Not only do these extra copies increase storage costs, but they also increase the complexity with keeping everything in sync. AWS has a strong history of building highly scalable services and it became clear to us that we could eliminate these extra copies by providing scalable and fast access to image data. Amazon HealthLake Imaging enables you to store one copy of the image data and can reduce your TCO by up to 40 percent.

Sub-second image retrieval from anywhere

HIPAA-eligible and GDPR compliant. But cost is not the only consideration: Our customers also told us that clinicians must be able to view images as fast – or better – than they currently do with their on premises systems. Amazon HealthLake imaging contains additional innovation that can deliver sub second image access from anywhere in the world in under a second, even on a smart phone. This is possible thanks to state-of-the-art lossless image compression technology and the high-speed low latency AWS global network infrastructure. Amazon HealthLake Imaging contains numerous innovations that enable to deliver images as fast – and in many cases faster – than existing PACS solutions.



Multiple PACS systems create silos of information for a patient's team of doctors, with specialists accessing different pieces of information and a limited scope of the patient's entire health view. Imagine a patient's cardiologist accessing a CT scan of the patient's brain to look for signs of a possible stroke, but their neurologist doesn't have the same access. How can a team of doctors work in tandem to treat a patient without equal access to their health information? This negatively impacts patient outcomes, as we know the systems of the body and their distinct organs and tissues are not disconnected but instead, parts of an integrated whole. Doctors need shared access to comprehensive, updated medical histories to best treat patients.

Whether you're a hospital system providing clinical care or a research organization solving social health challenges, a data platform is at the center of your data-sharing and storing solution. Medical professionals across the globe continue to ask for a single view of the patient.

Of course, granting access across teams and facilities raises the question of security. With AWS, only authorized users can access data. AWS meets all compliance regulations of both HIPAA and GDPR.

Solution

Amazon HealthLake Imaging allows medical professionals to store, access, and analyze medical images in the cloud, at petabyte scale.



Take advantage of AWS's cloud-native imaging data platform for both clinical and research needs to unify silos of data

Amazon HealthLake Imaging allows customers to build the next generation applications for enterprise imaging such as PACS and advanced visualization tools. For AI/ML use cases, customers can build solutions to build cohorts over their entire archive in hours – something that currently takes them weeks on premise. Amazon HealthLake Imaging also integrates with Amazon SageMaker for training and inference of medical imaging AI models, QuickSight for operational dashboards, and Amazon Redshift for analytics.

[Amazon HealthLake Imaging](#) solves many of the obstacles that are faced while developing medical imaging solution, by helping to make the process of uploading, storing, and accessing images automatic and effortless. To achieve this, the application converts and optimizes images for rapid retrieval on the web, desktop, and cell phone. Petabyte-scale cloud capacity means software systems can operate at increased scale while keeping the bottom line tight. Medical imaging storage costs up to 40% less with Amazon HealthLake Imaging thanks to the enablement of its single, comprehensive, and up-to-date view of patient data. Amazon HealthLake Imaging also features image retrieval latencies of under a second and application interfaces operating in the cloud. In short, Amazon HealthLake Imaging offers a low-cost, high-performance and scalable solution to easily access medical image across the care continuum. Nothing is sacrificed, and patient care remains the priority.

Summary of benefits:

- ◇ Enables a single view of patient history and imaging
- ◇ Creates one image data source for better clinical and research workflows
- ◇ Features 40% lowered TCO
- ◇ Boasts sub-second image access
- ◇ Automates infrastructure management
- ◇ Offers robust partner network
- ◇ Allows for enterprise imaging, AI/ML research, and long-term image archival





CONCLUSION

AWS for medical imaging transforms the ways healthcare systems care for patients with solutions for storing, sharing, and analyzing medical data.

AWS is the imaging data solution that offers medical teams the access, speed, and functionality high-quality care requires. Remote, simultaneous access with built-in disaster recovery and powerful AI/ML support means that patients get uninterrupted, comprehensive, 21st-century healthcare. AWS in the cloud is also compliant with Health Insurance Portability and Accountability Act (HIPAA) and General Data Protection Regulation (GDPR) compliant, so patient data is secure and controlled.

Across each of the four pillars detailed above, AWS prioritizes patient health outcomes and healthcare operations while offering the most cost-effective pricing. With tiered storage tied directly to usage, you only pay for what you use, which reduces storage costs and makes scale limitless. AWS handles storage and processing power so medical facilities can focus on patient health.

Contact AWS to discuss your medical imaging transformation project.

