NetApp

NetApp Verified Architecture

Epic on modern SAN
NetApp Broadcom healthcare solution
NVA design

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Abstract

This NetApp® Verified Architecture was jointly designed and verified by NetApp and Broadcom. It uses the latest Broadcom technology solutions and NetApp all-flash storage, which sets a new standard for enterprise SAN storage and data protection to meet today's demanding Epic electronic health record (EHR) workloads.

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Executive summary

A NetApp Verified Architecture describes systems and solutions that are designed, tested, and documented to facilitate and to improve customer deployments. These designs incorporate a wide range of technologies and products into a portfolio of solutions that NetApp has developed to help meet the business needs of customers.

This NetApp Verified Architecture provides a solution that modernizes your SAN storage with Gen7 64Gb NVMe over Fibre Channel (NVMe/FC) and cloud connectivity options, giving your company the fastest cloud-ready solution for mission-critical virtualized Epic EHR workloads.

Test results are provided to validated design and configuration recommendations for Epic EHR deployments. The results highlight why Epic gives the NetApp ONTAP® storage platform a high comfort level for operational, analytical databases and NAS and how the rich data management capabilities of ONTAP data management software make it the clear choice for deployments.

Together, NetApp and Brocade have engineered this EHR solution to address the many data management challenges. This document addresses the following:

- Optimizing IT spend by consolidating, simplifying, and adding efficiency to your organization
- ONTAP data management capabilities helping customers succeed
- Transitioning to a world-class modern SAN verified reference architecture that easily scales to any size deployment
- NetApp's fully automated data management solutions for Epic
- Transforming Healthcare IT to drive data management innovation and improve patient outcomes
- Securing and protecting patient records
- Addressing the challenges that healthcare organizations face today with data management and infrastructure
- Introducing future technology nondisruptively, avoiding forklift migrations and business disruption
- Building a private cloud on the industry-leading modern SAN solution

Results summary

The results of this NetApp Verified Architecture solution can be summarized as follows:

- The NetApp AFF A800 single high availability (HA) pair can achieve an aggregated 730K IOPS and scale out to over 4M IOPS on a single 12-node cluster.
- Provides 17 times lower latency than the minimum Epic requirements.
- With storage integration, you can reduce environment refresh up to 720 times, from 24 hours to 2 minutes.
- You can reduce cost on compute with NVMe/FC.
- ONTAP runs one of the fastest enterprise storage controllers in the world with low latency and low price per gigabyte.

NetApp distinguishes itself by having a dedicated, specialized team with a singular focus on healthcare. This NetApp healthcare team consists of former healthcare CIOs, COOs, radiology technicians, and architects who are passionate about healthcare and have real-world experience caring for patients and running healthcare institutions. We are transforming healthcare delivery through innovative technology solutions.

Program summary

Healthcare provider organizations remain under pressure to maximize the benefits of their substantial investments in EHRs. Healthcare organizations face multiple challenges:

- Prolonged delivery times
- Low budgets
- Lack of IT specialists
- Inefficient silos (data, infrastructures, application, and team)
- Increased threat from ransomware attacks
- The need to move from fire-fighting mode to business partner on the IT Maturity scale
- The need for a comprehensive strategy to leverage emerging technologies, such as AI and the cloud

Users with aging legacy infrastructures that are ready for a refresh can now benefit from an innovative technology solution. NetApp and Broadcom enable customers to deploy a solution that increases IT agility, provides seamless scalability, reduces the cost and complexity of data center operations, delivers consistent SLAs, and improves patient outcomes.

For example, with NVMe/FC support, Red Hat Enterprise Linux (RHEL), Broadcom Gen 6 and 7 FC Fabrics, and NetApp AFF A-Series arrays, we are ready to enter a new era of wider adoption of NVMe in production environments like an EHR. This is possible today only with NetApp solutions and the industry's first end-to-end NVMe/FC platform.

Target audience

The target audience for this NetApp Verified Architecture document includes the following groups:

- **The Healthcare CIO, CTO, and CFO,** who can benefit from the executive summary, use case examples, return on investment (ROI) and TCO information, and information about future strategies.
- **Business information officers,** who can learn new ways to serve line-of-business owners with benefits from modern technologies.
- **Architects, administrators, and solutions engineers,** who are responsible for designing and deploying infrastructure for enterprise mission-critical applications.
- **Database administrators (DBAs),** who require new data management capabilities and performance to serve evolving data requirements.
- **Application owners,** who need real-time, lower-latency data to feed current and newer generations of applications.
- **Virtualization architects and administrators,** who are responsible for designing, deploying, and managing virtualized enterprise mission critical environments.
- **Data architects,** who require platforms that are designed to enable more real-time analytics and to serve the AI and machine learning requirements that new workloads need.
- **Cloud architects,** who must harness the power of the hybrid cloud and leverage core and cloud-native solutions.
- **Backup administrators,** who must protect data and leverage new innovations to make data protection seamless and nondisruptive to the business.
- **Service delivery managers,** who must meet SLAs and service-level objectives (SLOs) that require IT infrastructure and solutions that promote consistent and predictable results.

EHR challenges

This section highlights the major challenges for healthcare when implementing a critical EHR solution. This section is followed by solutions to these challenges.

Data silos

In a typical healthcare-delivery organization such as a hospital, an imaging center, or ambulatory surgery center, there are dozens to hundreds (even thousands) of applications running in production, often on their own data infrastructure. These data silos exist throughout healthcare IT. This traditional way of delivering IT services to the business can lead to a negative impact on patients and caregivers alike. To improve performance, Epic also recommends having multiple pools of storage for different components. And a completely different solution is required for SAN and NAS, adding to cost and complexity.

Figure 1 shows the growing silos in healthcare.

Figure 1) Growing silos in healthcare.
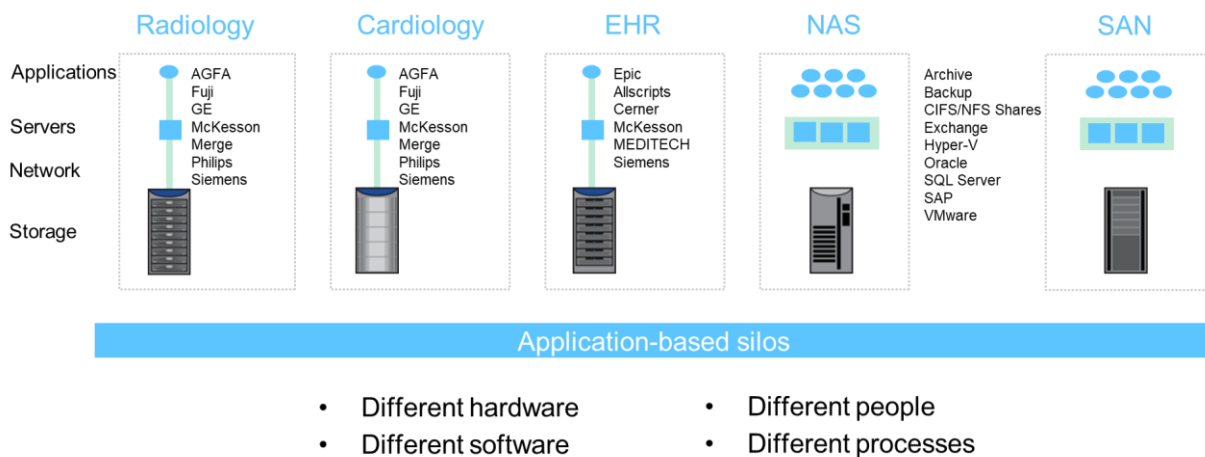
Environmental management

Environmental management is part of every Epic deployment, as shown in Figure 2. Epic DBAs are tasked with building a backup solution that requires multiple refresh copies of production to manage upgrades and provide test environments. Typically, Epic DBAs build custom scripts to manage these operations. These scripts not only touch the Epic production database, but they also manage the storage, VMware hosts, and OS. This requires multiple resources to deliver a solution for Epic.

Figure 2) Environmental management for Epic.
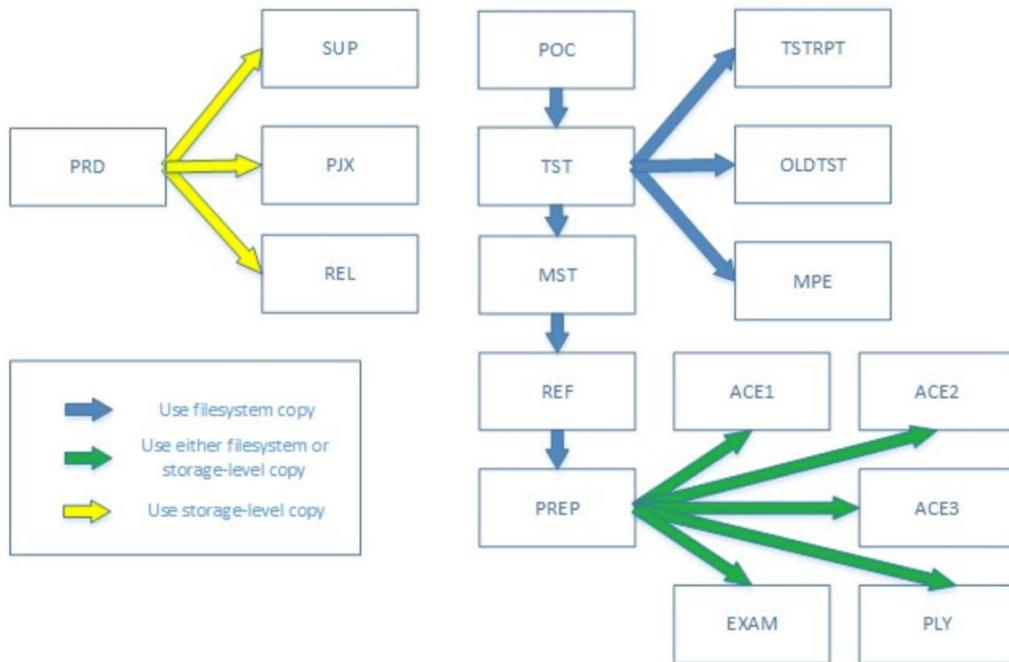
In 2020, Epic added the new 3-2-1 backup recommendations:

3: You must have **three** copies of Epic ODB.

2: One copy of ODB must be archived to a **second** storage platform once a week.

1: **One** copy of ODB must be in a disaster recovery location.

Epic recommends a weekly copy of Epic ODB to a secondary storage operating system. Customers can easily meet this new recommendation with NetApp StorageGRID, a software-defined, object-based storage solution that supports S3 API.

Scalability

The one constant with EHR systems is that data never shrinks and grows approximately 20% annually. Other unknowns, such as acquisitions, make data growth projections unpredictable. This unpredictability has a larger impact on healthcare organizations. Some larger organizations are additionally attempting to consolidate onto a single Epic instance. The need to have a seamless scale up, scale out, and scale to the cloud solution is critical. A solution is needed with flexibility to meet the requirements of healthcare organizations as they grow and need to scale.

Security

Healthcare is the number one target for ransomware attacks and security is of top importance with healthcare leaders. Patient data is considered as valuable and sensitive as financial data; both must be always available and properly secured from unauthorized access. Hospitals can potentially be taken offline putting patients at risk. Other external pressures with compliance, data governance, and a desire to move to the cloud make selecting the right storage platform for the future critical.

Reliability

Deciding what storage platform to run your most valuable clinical applications on is a decision not to be taken lightly. Most storage vendors can offer some level of performance, efficiency, and availability, but

what else? Healthcare organizations are looking for vendors that understand healthcare, want to partner with customers, and bring real value.

Future-proof

Typically, Epic environments are sized for three years, and hardware refreshes require careful planning. New innovative technology is introduced faster than ever. Cloud has become central to health data management strategies, but the path to the cloud is a journey. Selecting the right platform that is flexible, nondisruptive to operations, and can seamlessly scale to meet future performance and storage requirements is important.

Cloud

One of the major challenges with the journey to the cloud is that some enterprise applications are not designed to run on native cloud storage. Native cloud is lacking the performance, reliability, and data management capabilities required to effectively manage enterprise applications. For that reason, all major cloud providers have partnered with NetApp to provide healthcare customers the ability to run production, disaster recovery, backup, and tiering on NetApp in the cloud. NetApp provides a data fabric with the flexibility to move data in and out of the cloud and enables your data to always move at the speed of your business.

Most healthcare organizations have a cloud strategy for various reasons, including to reduce cost, get out of the data center business, and focus on patient care, expose data to the extensive services offered by the cloud, and improve disaster recovery, to name a few. How do you deploy, migrate, monitor, maintain and mange services in the cloud? NetApp Cloud Data Services can help start that journey.

Next-generation SAN

The NetApp solution for Epic is very performance and latency sensitive and benefits from a modern SAN solution. Moving to the industry-leading next generation Gen7 64Gb SAN is critical to delivering and maintaining an Epic solution. This is the focus of this NetApp Verified Architecture.

NetApp solution for Epic

This document describes a modern Epic solution reference architecture, reviewed by Epic and designed by industry leaders, Broadcom and NetApp. This is a first-to-market enterprise NVMe/FC solution. NetApp and Broadcom, together, provide an end-to-end NVMe-powered solution, from host to storage controller, that enable the promise and the benefits of NVMe technology. With a system that yields the fastest access, management, and use of critical data, customers can accelerate their time to innovation and provide solutions to meet all Epic recommendations:

Consolidation

ONTAP is the only storage platform with an Epic high-comfort rated solution for both NAS and SAN. ONTAP is also the only solution that enables customers to consolidate all Epic environments (SAN and NAS) and pools of storage on a single, unified platform, as shown in Figure 3. Epic gives the NetApp ONTAP storage platform a high comfort level for operational, analytical databases and NAS; see the latest Epic SPaTS document for reference. With NetApp's unique ability to consolidate, customers are able to eliminate data silos, simplify data management, reduce their data center footprint, and optimize IT spend.

Figure 3) Environment management for Epic.

Scale & Simplicity for Healthcare
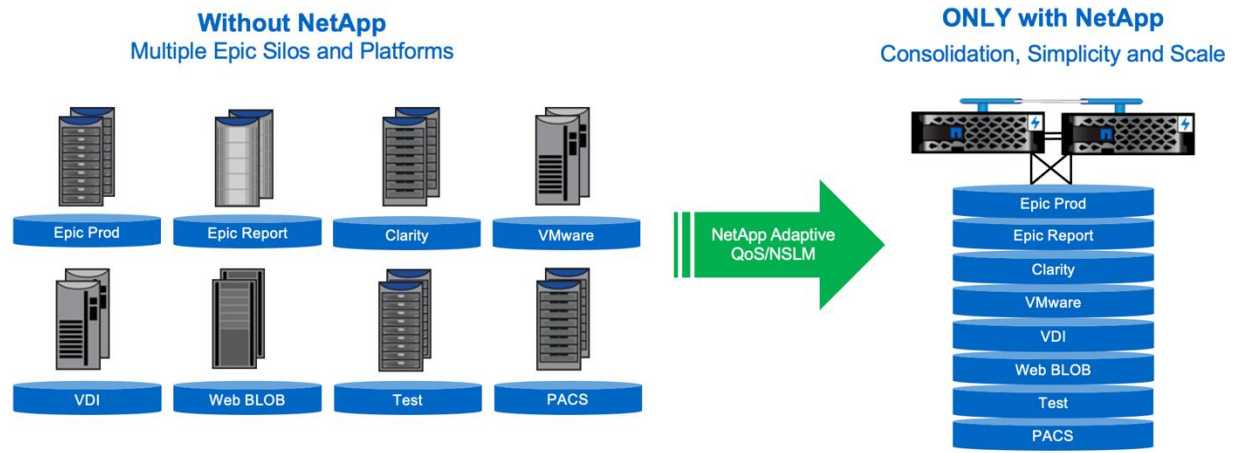
In the Epic Hardware Configuration Guide, Epic defines workloads in pools of storage. Each pool must be isolated from other workloads. This isolation is required to protect critical workloads from contention with others. NetApp Active IQ® Unified Manager has NetApp Service Level Manager (SLM) software that quarantines each workload performance level. By locking in-floor level performance levels for each workload, pools are not required for NetApp and you can consolidate onto a single data management platform.

SLM automatically monitors and selects service-level policies for each workload to consistently deliver on this, day one to year six. Performance is automatically allocated as your data grows based on IOPS/TB. This storage management methodology eliminates performance issues seen in legacy silo systems where the only way to delivery is to over provision and throw money at the problem rather than technology.

Data management: Automation

Leverage purpose-built data management automation to streamline your IT operations and focus on what matters most—delivering world-class patient care. NetApp has developed a data management and automation solution that enables DBAs to streamline operations by using integrated storage snapshots, clones, and replication. Reduce deployment time, operation time, and complexity with NetApp's fully automated backup, restore, and refresh solution for Epic deployed by NetApp.

NetApp has built a data management solution for all Epic workloads: ODB, Cogito, VMware, Hyperspace, and WebBLOB. The NetApp data management solution for Epic helps Epic DBAs have the tools they need to manage Epic and reduce deployment time and operations. Each solution is customized to meet Epic recommendations and customer patient-care needs.

Scale

This NetApp Verified Architecture demonstrates that ONTAP can seamlessly scale beyond an aggregated 4M IOPS on a single 12-node cluster. ONTAP data management software enables scaling up and out with no disruption to the business, whether on-premises or in the cloud.

As Epic and InterSystems continue to increase the scalability limits of a single instance, some organizations are looking to consolidate multiple instances.

For more information, see "Performance measurements."

Security

A critical point of concern and risk for healthcare providers is their exposure to cybersecurity threats. These threats include malware, ransomware, data spillage, data theft, and insider threat. Year over year there is a significant increase in the threats against healthcare and the impacts are felt acutely by providers and patients alike. EHR downtimes can cost providers millions of dollars in revenue and liability and, worse, introduce risk of loss of life for their patients because information sharing all but halts when the EHR is impacted.

With the advent of the EHR, the digitalization and consolidation of sensitive patient data has become a significant target for cyber criminals and a significant point of concern for accidental dissemination by employees. The ramifications of data loss (no matter how it happens) can be severe, ranging from identity theft, to missed treatments, and even death of patients.

NetApp and Brocade offer network and hardware protections that augment and complement existing cybersecurity protection programs. Introducing additional network controls (Brocade) and storage-level (NetApp) capabilities can help identify and prevent attacks and accelerate remediation and restoration if there is a time it is needed. Protecting your mission-critical assets like EHR requires a tiered proactive and reactive approach that NetApp and Brocade deliver at the top of the market, minimizing risk and elevating confidence in the safety and security of the EHR.

NetApp ransomware solutions include:

- **NetApp FPolicy—Zero Trust engine**. Stands alone or seamlessly integrates with your Security Information and Event Management (SIEM) tools.
- **NetApp Cloud Insights**. Actively and proactively monitors your files across your data landscape; and easily identifies anomalous and intuitive indicators to detect ransomware.
- **NetApp Snapshot™ copies.** Read-only copies taken at the speed of business ensure rapid, focused recovery and remediation after detection.
- **Zero Trust and ONTAP.** Hardened, Zero Trust environment provides layers of protection beyond typical security solutions—critical to ensuring patients are not compromised, and providers have continuity in the care they provide.
- **NetApp SnapLock®.** Write once, read many capabilities with expiry time ensures file Snapshot copies are immutable: rogue admins or intruders with elevated credentials cannot delete backups— meets SEC and CFTC regulations.

  Adopting the security capabilities from Brocade and NetApp when deploying Epic is recommended from day zero as part of the deployment. Due to the individual requirements of each organization, a single recommendation as to configuration is not made here. However, the flexibility in the deployment and configuration of the NetApp and Brocade security components ensures that the right configuration for your organization will be implemented. We suggest that these considerations be discussed and decided upon during the architecture and design phase of your Epic deployment, to provide optimal performance and protection.

At the end of the day, leveraging these capabilities together in conjunction with the other components in your security strategy reduces risk, enhances protection and detection, and minimizes downtime. The combined security capabilities of NetApp and Brocade provide a significant improvement in the overall protection of patient data in the enterprise.

Reliability

EHR reliability is core to the business of healthcare. The NetApp solution provides customers the reliability and performance to accelerate the Epic application. The core solutions include:

- ONTAP nondisruptive operations. With NetApp, customers can perform nondisruptive operations on a system by having its partner take over the system's storage, performing maintenance, and then giving back the storage. Aggregate relocation extends the range of nondisruptive capabilities by enabling storage controller upgrade and replacement. This includes nondisruptive aggregate relocation, failover, LIF migration, operations, upgrades, volume moves, and so on.
- Active IQ proactive monitoring that automatically resolves 97% of issues.
- Industry-leading security portfolio to protect patient data against ransomware attacks and immutable backups.

Future proof

With NetApp, you get virtually unlimited seamless scalability, and cost-effective movement of data across on-premises and cloud locations. ONTAP is designed to seamlessly introduce new next generation technology as NetApp continues to lead and innovate in modern SAN and in the cloud, as shown in Figure 4. Customers never have to migrate data again and are empowered to deliver always-on patient care. ONTAP seamless scale is like changing the tires on the highway at 90 miles an hour.

Figure 4) Seamlessly scale and introduce next generation technology.
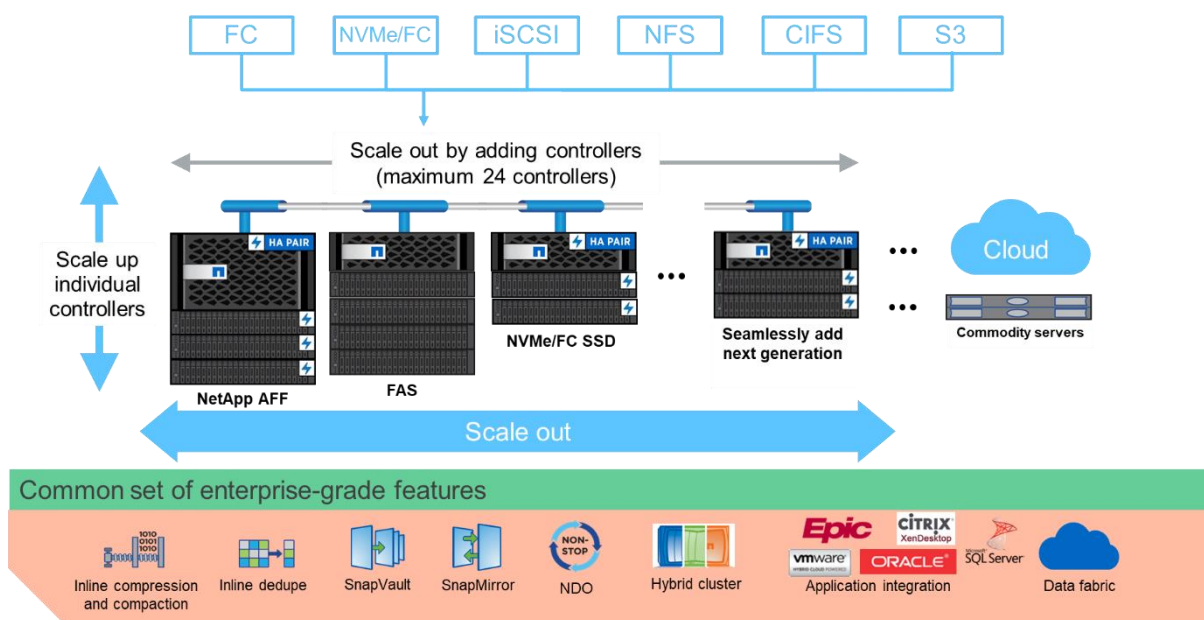
Cloud

This NetApp Verified Architecture is focused on best-in-class SAN performance, so why is there a section on Epic in the cloud? One increasingly critical data management capability is being cloud connected. NetApp has been an early innovator in the cloud and began partnering with Amazon Web Services (AWS), Azure, and Google, as far back as 2014. NetApp software-defined storage provides the data management capabilities to run such applications to the cloud. As healthcare organizations begin their journey to the cloud, the NetApp industry-leading solutions enable customers to run enterprise applications in their cloud of choice, while also reducing the risk of vendor lock-in. Figure 5 illustrates the NetApp approach to overall data management. Adapting cloud is not about where you run your data, it is about how you consume and manage data. Move your data at the speed of business to anywhere in your data fabric.

Figure 5) Run Epic anywhere in data fabric powered by NetApp.
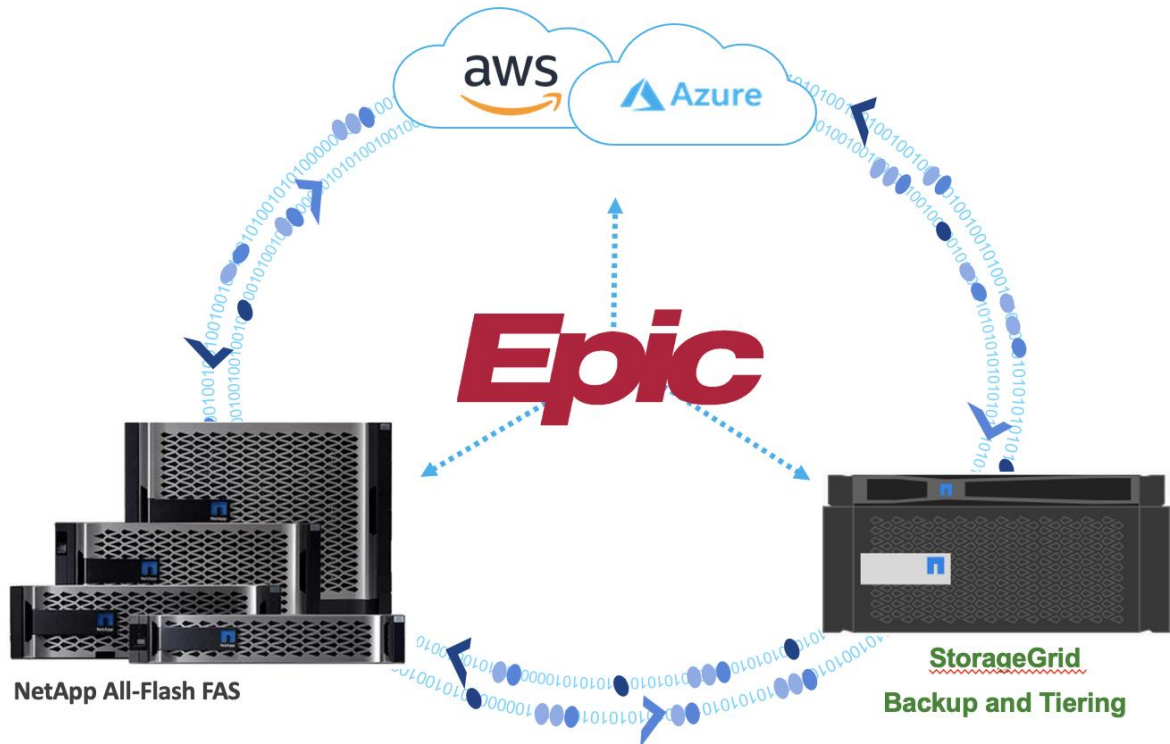
Cloud Volumes ONTAP

Epic's storage platform, ONTAP, is software-defined storage and runs in the cloud of your choice called Cloud Volumes ONTAP. Cloud Volumes ONTAP has a high comfort approval rating by Epic because it is the same ONTAP as on-premises. Use NetApp SnapMirror® or database replication to replicate data between on-premises and the cloud or between clouds and manage your data by using the same consistent set of tools. The benefits of Cloud Volumes ONTAP include:

- Inline efficiency and tiering can save up to 70% of the storage cost.
- Snapshot copies, cloning, and replication for backup and the many near instant refresh environments.
- The suite of tools such as Cloud Manger, Cloud Backup, Cloud Insite, Spot, Cloud secure, and much more.

NetApp Cloud Manager enables you to manage your data the same way regardless of where it resides in the data fabric.

Figure 6) Running Epic DR in the cloud.
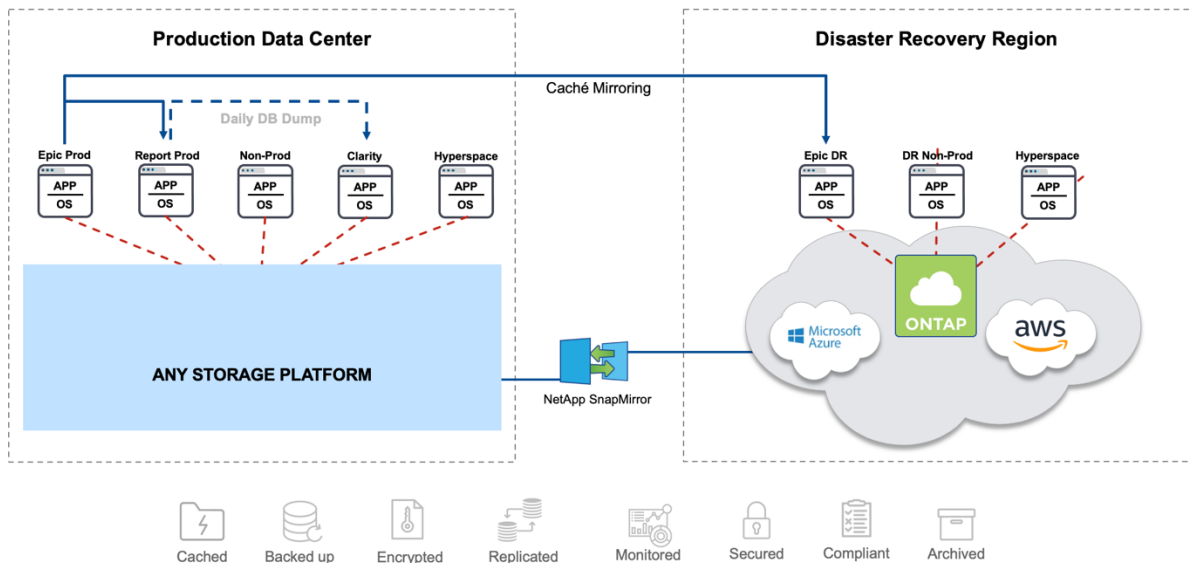
Azure NetApp Files

Azure NetApp Files is a powerful enterprise file-storage service powered by NetApp and sold and supported by Microsoft. Migrate and run complex SMB, NFSv3, NFSv4.1 file workloads in Azure with on-premises performance and enterprise class data management needed for applications such as Epic ODB (NFS) and Clarity (SMB).

For most customers, the cloud currently lacks performance scale to run an Epic environment, or will exceed it in a few years. Most cloud solutions lack scale and most customers are either at that size or exceed it after a few years. Azure NetApp Files addresses performance and data management capabilities. Azure NetApp Files provides true on-premises performance, submillisecond latency, enterprise data management, and increased reliability.

InterSystems Caché and IRIS can run on NFS, and Clarity SQL can run on SMB and is approved by InterSystems and Microsoft. These NAS protocol environments might be new to people familiar with running Epic on SAN over FC..

Note: FCP is not available in the cloud.

For more information, contact the NetApp Epic Alliance team at epic@netapp.com.

Figure 7) Epic on Azure NetApp Files architecture overview – cloud only.
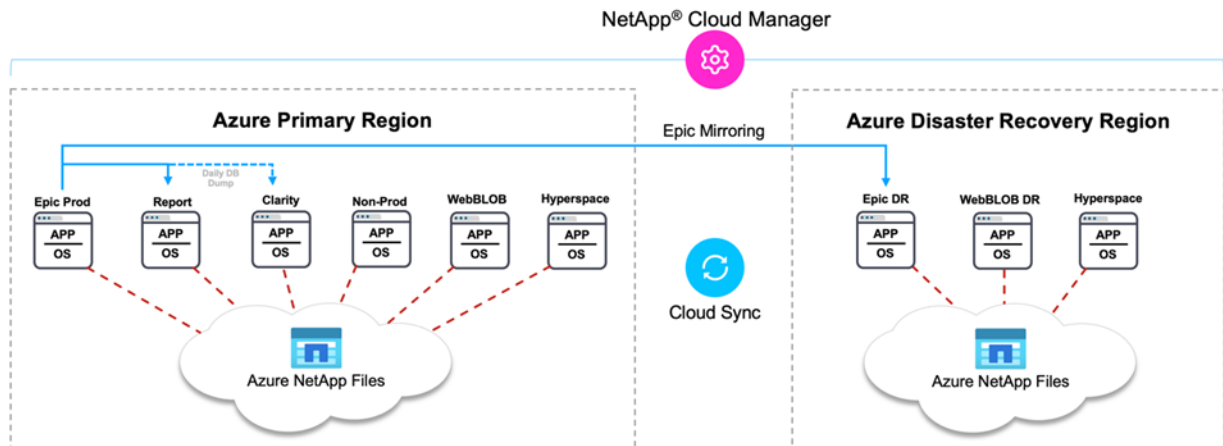
The architecture

This NetApp and Broadcom modern SAN NetApp verified reference architecture for Epic includes the following key NetApp and Broadcom technologies: FCP or NVMe/FC, and seventh-generation host and fabric technology. The performance benefits accrue as you adopt these technologies. Adopt all of them and get game-changing performance benefits with end-to-end visibility through Fabric Vision technology.

This section details the Epic on NetApp architecture and technology developed by NetApp and Brocade that significantly contributes to successfully delivering patient care with Epic.

Scale out architecture

The results of this NetApp Verified Architecture testing clearly proves how ONTAP can scale performance to any size Epic customer in the world. What does it look like to start with a large cluster or scale out over time? The following describes a typical deployment for small to medium customers. See TR-3928: NetApp Best Practices for Epic for more detail about Epic best practices on NetApp, sizing, and architecture options.

You can consolidate all Epic workloads and protocols to a single HA pair. Workloads are balanced evenly across the HA pair. DR shows the minimum workloads required in the Epic HCG, but some organizations do failover to disaster recovery and back regularly and optionally match production and disaster recovery. In Figure 8:

- Green lines show DB replication from production to report and DR.
- The green dotted line shows daily ETL to Clarity.
- Yellow lines show backup options using native NetApp or integration with a backup application. For more information, see "The backup process (yellow)"...
- Blue lines show cloning used to create full near instant copies of Epic ODB for test environments such as SUP, REL and PJX. For more information, see "The backup process (yellow)".

Figure 8) Epic consolidated architecture on NetApp.
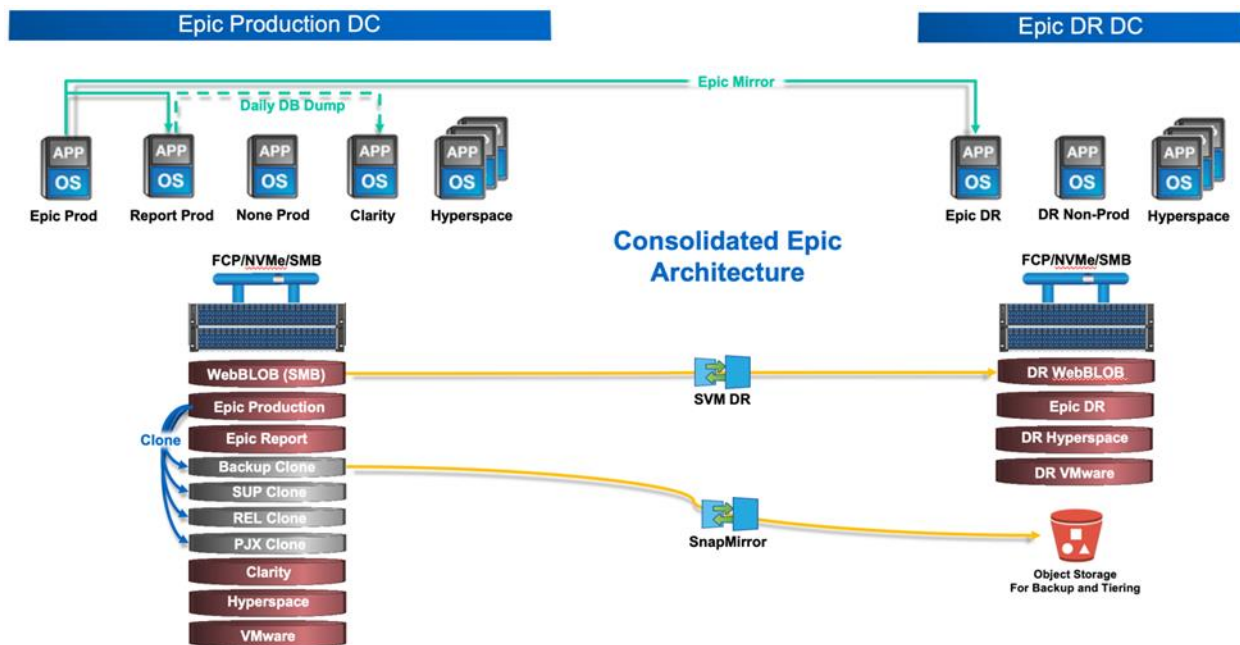
One of the key benefits of ONTAP is the ability to scale up and out nondisruptively. Customers that start with an AFF A400 or A800 HA pair can add a second HA pair to the cluster and balance the workloads, as shown in Figure 9. This design offers a good balance of capacity and performance.

You can move NAS and SAN workloads from node to node within the cluster as needed. No disruption to patient data access, no planning sessions with the various business units (BUs), no operational disruption to backup or test refresh processes.

Figure 9) Epic scale out Architecture on NetApp X-Large.
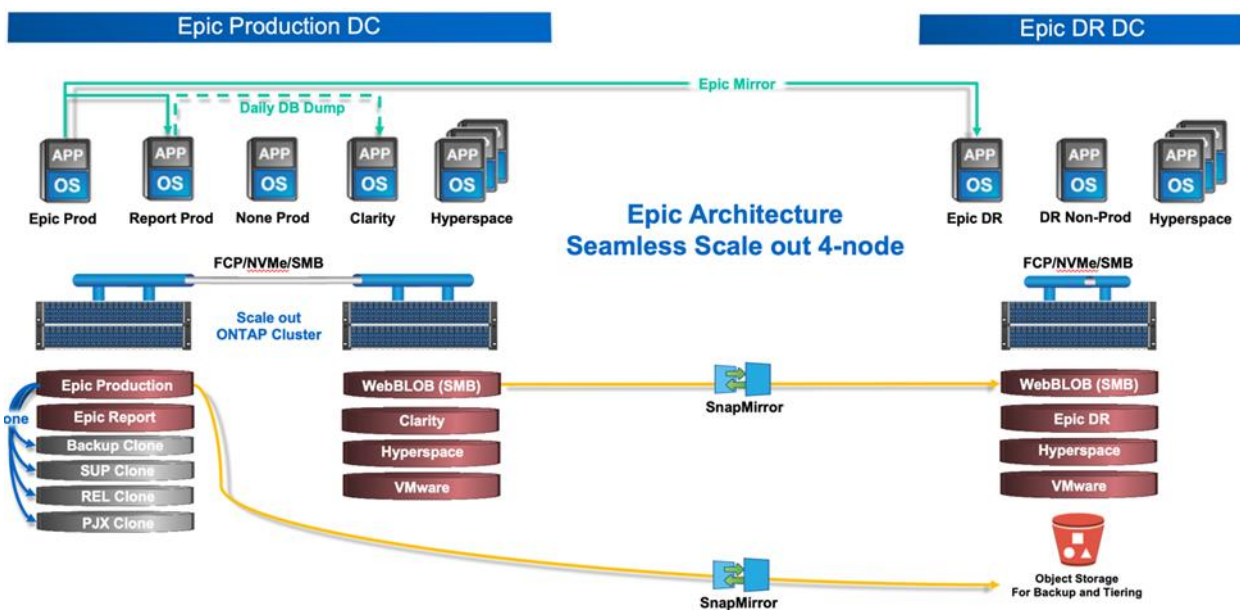
The architecture in Figure 10 has a dedicated HA pair for Epic and reporting/testing. Again, you can start with a 2-node to 4-node cluster and grow to this 6-node cluster architecture without business disruption.

Figure 10) Epic scale out Architecture on NetApp XX-Large.
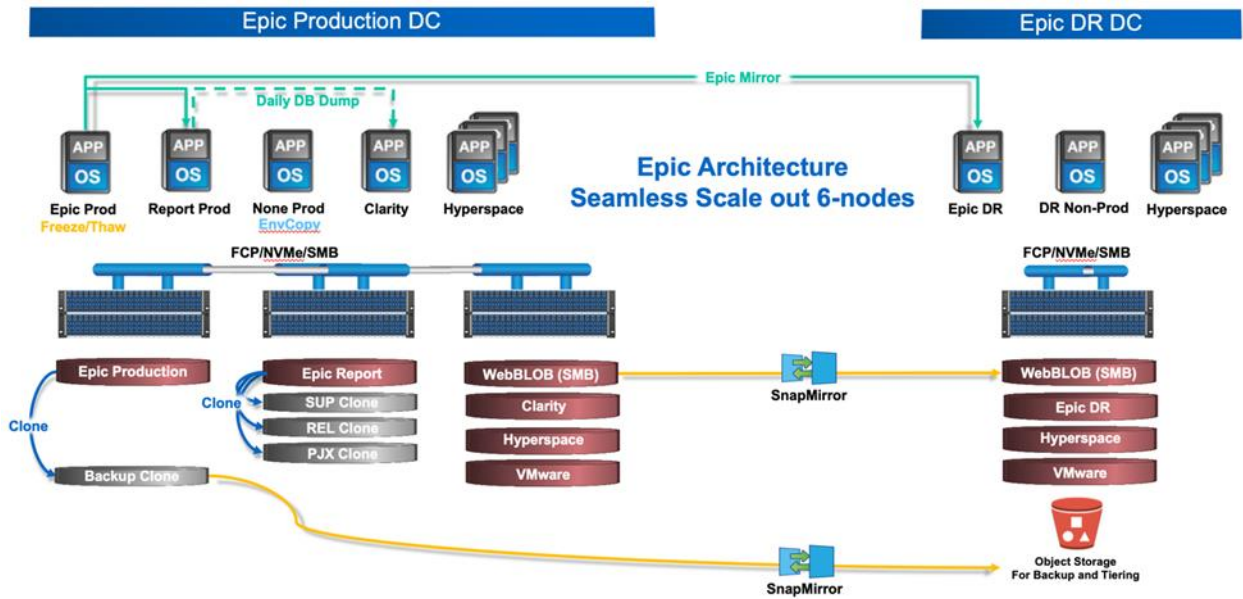
ONTAP scales to 24 nodes for NAS only and 12 nodes for NAS and SAN clusters. ONTAP can provide a single scalable data management framework to meet all of healthcare needs beyond just Epic.

Epic automated backup and environment refresh

First, NetApp ONTAP is the most capable data management storage software available today, with almost 30 years of continuous innovation. Game changing technology such as Snapshot copies, clones, deduplication, NetApp SnapLock® software, to name a few, were all developed first by NetApp along the way. With ONTAP and all of its applications, integration is ideally suited to run enterprise solutions such as Epic.

Epic needs much more than traditional storage vendors offering just simple, reliable, and fast block storage—you can easily end up with multiple storage platforms and third-party applications. What was once simple can suddenly become complex, expensive, and inefficient. This is the very thing healthcare leaders want to avoid.

ONTAP is easy to use and solves the most challenging data management requirements with just the tools that come in the ONTAP bundle.

Figure 11) Which tool do you want your healthcare team to have?

Easily solve patient care with NetApp

Simple		Easy
Adjectives • Plain or basic • Unsophisticated	versus	Adjectives • Not hard or difficult • Requiring minimal effort

The answer should be easy. This section demonstrates how you can use these ONTAP tools to exceed Epic requirements and improve patient care.

It is important to note that the NetApp team implements the fully automated backup and environment refresh solution for Epic by using Ansible. Typically, after GenIO testing is complete, NetApp delivers host side scripts, role-based access control (RBAC), and full stack infrastructure automation. With NetApp, Epic DBAs do not need to spend time building custom scripts for Epic data management. Given that the database sizes are anywhere from 5TB to 250TB, storage integration with Snapshot copies and clones is the only practical way to backup and refresh these environments and save on operational time and storage efficiency.

NetApp provides multiple automated approaches to deliver a full data management solution for Epic on NetApp:

- Ansible
- NetApp SnapCenter®
- NetApp Cloud Backup service
- Any third-party backup application.

 Figure 12 illustrates each of these options. Note that for the first two options, no additional license is required. Cloud backup is a NetApp licensed product and third-party applications comes at a cost.

Figure 12) Epic data management with Ansible.
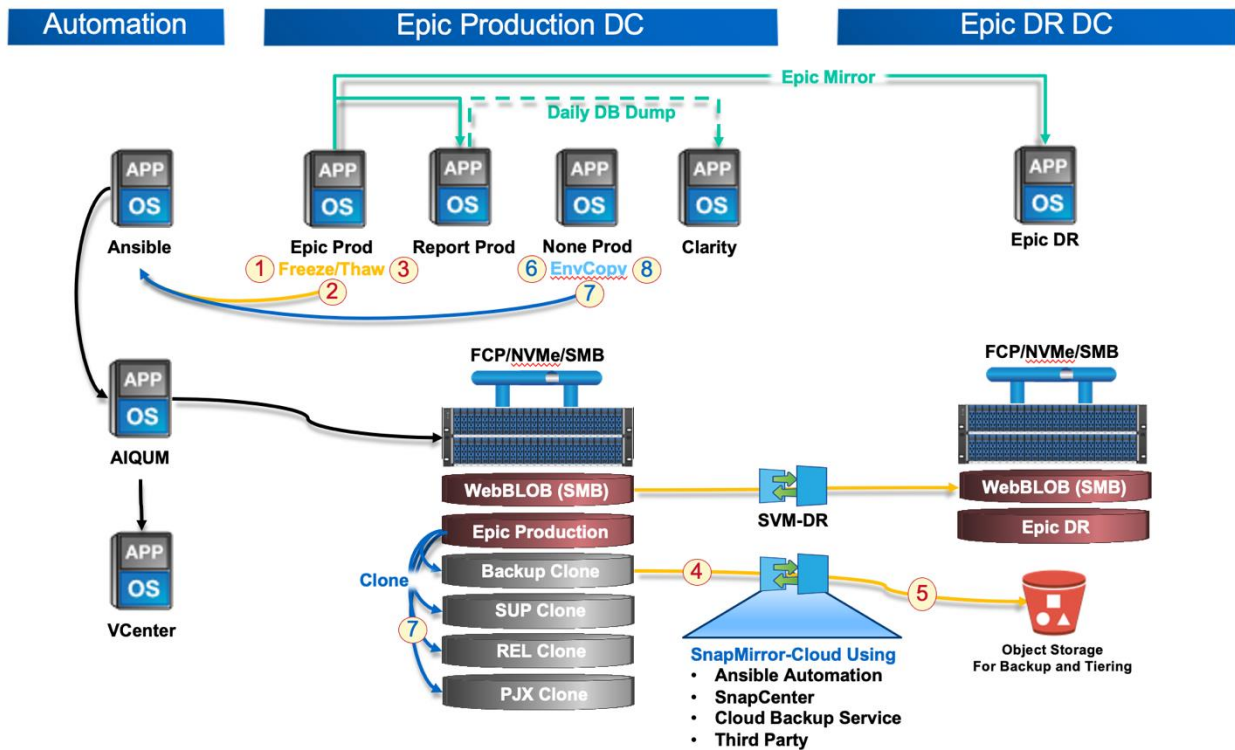
Ansible

NetApp has two Ansible workflows for Epic: one for a backup and one for a refresh using clones. The numbers and colors below match with the diagram.

The backup process (yellow)

The backup process includes the following tasks:

1. From the host, initiate a freeze of the database.
2. After the freeze is acknowledged, issue an API call to Ansible to NetApp Snapshot all volumes.
3. After the Snapshot copies are acknowledged, initiate the thaw.

   Notes:
   - The default auto thaw timer is 10 minutes. Some DBAs might reduce that value. The Snapshot copy process is very quick and is usually less than a minute between freeze and thaw.
   - With block level backups, preserve all the storage efficiencies and replications so that there is less data for you to transfer, less performance impact on the production, lower backup windows, and more reliability for you to meet your SLA.
   - Optionally, use consistency groups.
4. Initiate a SnapMirror cloud-to-object storage on premises or in the cloud.
5. Acknowledge the SnapMirror-cloud storage has been initiated.

The refresh process (blue)

The refresh process includes the following tasks:

1. For DBAs on a nonproduction host, initiate the envcopy scripts to start the refresh process. For example, SUP:
   a. Thaw the SUP environment.
   b. Save environment variables.
2. Envcopy hook to host side scripts to complete the following tasks:
   a. Manage volume groups
   b. Perform an API call to the Ansible workflow to do a single-file NetApp SnapRestore® of all the LUNs.
   Note: This is a near instant LUN restore process. There is no need to unmount and remount LUNs or add devices, or for RHEL remove/add disk devices to VM in VMWare. This reduces the number of steps, complexity, and time to refresh an environment data down to about 70 seconds.
3. After the data is refreshed, the envcopy scripts complete the refresh by copying back env variables and thawing the database.

SnapCenter

Backing up an Epic environment is much more than just Epic ODB. You have other Epic workloads that include VMware, SQL Server, and an Oracle database that SnapCenter can back up, restore, and clone today. SQL and Oracle DBAs all need the same tools to back up each database and create copies for test and development operations. The SnapCenter plug-in for Epic ODB allows a single solution for all Epic workloads. The SnapCenter Plug-In license comes with the NetApp bundle.

SnapCenter Epic plug-in performs the same steps that are described in the Ansible section; however, the Ansible solution focuses only on Epic ODB. SnapCenter can be used to perform the same data management tasks with SQL Server, Oracle, and VMware, and still meet the Epic requirements—all while reducing cost and avoiding the need for third-party applications.

To meet the 3-2-1 requirements, configure a SnapMirror relationship from ONTAP to object storage and SnapCenter should then perform a SnapMirror update to object after each backup.

Cloud Backup service

The Cloud Backup service solution is the same as the Ansible solution, except that steps 4 and 5 are done by Cloud Backup service.

Cloud Backup service is a unique offering in the market. It is a quick and efficient snapshot-based, block-level backup solution managed by NetApp Cloud Manager. If you back up to the cloud, skilled manpower is not required to implement or maintain the backup. With just a few clicks, the backup can protect an entire Cloud Volumes ONTAP or on-premises cluster. Just select the cluster you need to protect, then select the required retention. It's that easy.

Cloud Manager creates a SnapMirror-like replication directly from the ONTAP volumes to the customer-owned object storage. Cloud Manager creates the bucket automatically as well, so the customer doesn't need to do even that.

Cloud Backup service preserves all the storage efficiencies and replications on a block level, which means there is less data to transfer, less performance effect on the production, lower backup windows, and it's more reliable in order to meet your SLA.

Backup Snapshot copies are independent from the source cluster, which means that even in the event of the source cluster being deleted (intentionally or unintentionally), you can recover the data. This feature makes this a great solution for long-term archiving for Epic and meeting the 3-2-1 requirements.

What about restores? A backup is not valuable if you can't restore the data. Cloud Backup service supports volume-level restorations and restores them to a different system. You can restore at the file level or LUN level by using SnapRestore data recovery software.

Figure 13) Epic data management with Ansible and Cloud Backup service.
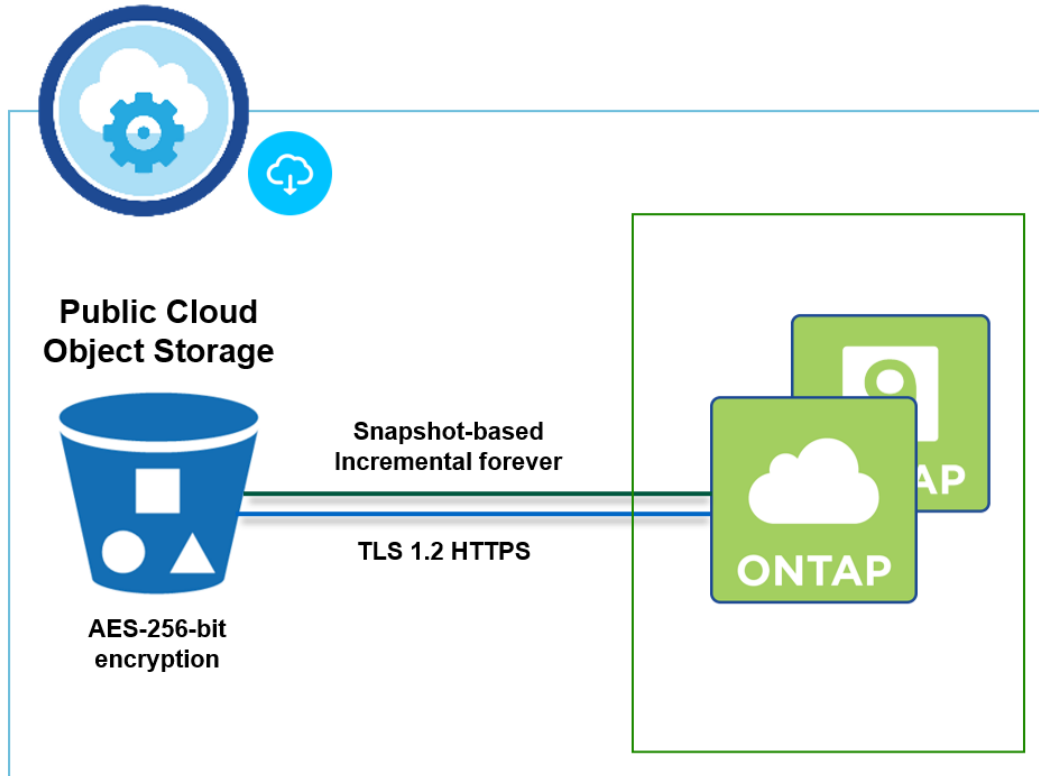
NetApp third-party solution

Figure 14 shows the high-level backup solution using a third-party backup application such as Commvault, Rubrik, or Veeam. The backup and refresh workflows are identical to the Ansible workflows, except for steps 4 and 5 shown in Figure 14:

1. Mount the last backup on the media server:
   a. Unmount the old clone from the media server.
   b. Delete the clone.
   c. Make a new clone from the last Snapshot copy.
   d. Mount the clone on the media server.
2. Perform a streaming backup by using third-party backup application.

This is the most widely deployed Epic data management solution. Ansible workflows are designed to easily integrate with any backup application using steps 4 and 5 shown in Figure 14. NetApp still performs the majority of the automated backup and refresh operations of the Epic ODB, which leaves the backup application to simply perform streaming backup jobs—it's that easy.

Figure 14) Epic data management with Ansible.
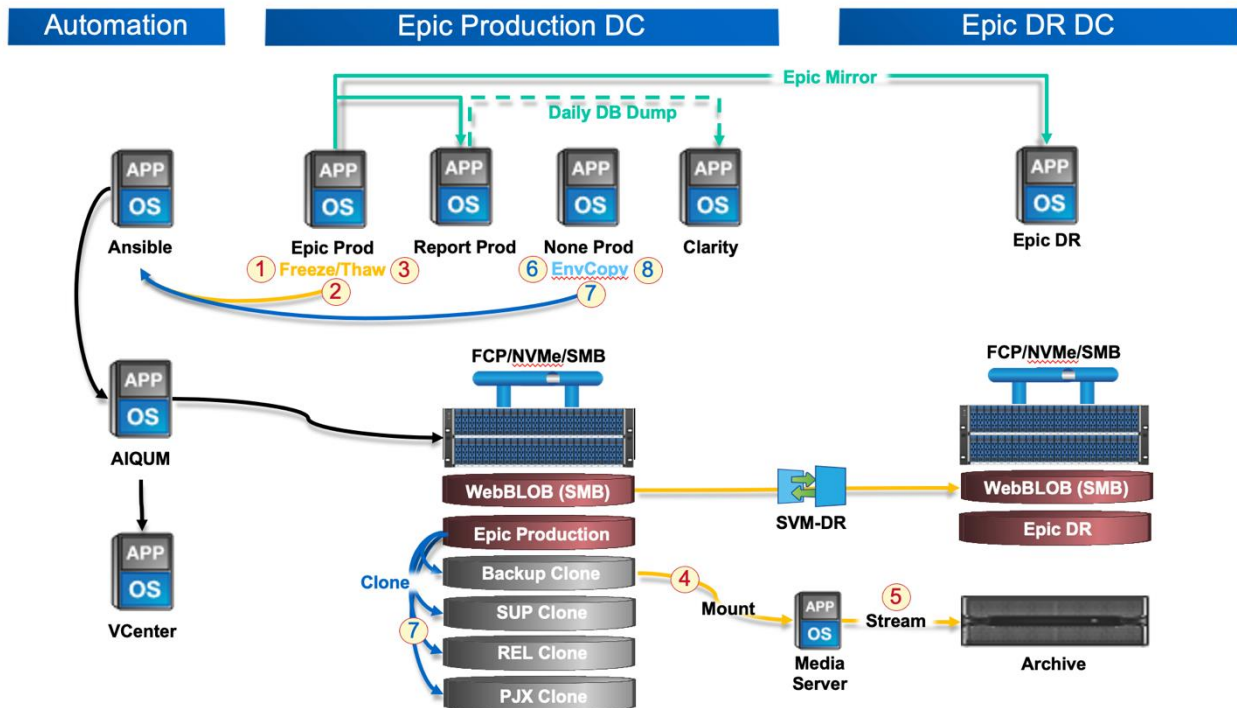
Performance

Performance is a major focus of this NetApp Verified Architecture for Epic. Other independent test results such as SPC-1 also show NetApp enterprise storage as one with the highest performance, lowest latency, and least $/GB. However, there is much more to performance. With the exception of larger customers, most all-flash arrays are fast and reliable enough to run Epic. Why is performance so important when you have all flash? There are many resulting benefits linked to performance. The following list of performance benefits work together—it is difficult to discuss one benefit without the other. The first benefit, performance results, is the main topic of this NetApp Verified Architecture.

- **Performance results.** Numbers do not lie. The results of this NetApp Verified Architecture prove that NetApp is one of the most performant, lowest latency, most scalable, lowest $/GB data management platform in the world.

- **Consolidation.** ONTAP is the only high-comfort data management software that can consolidate all Epic protocols and pools. With increased performance, you can do more with less while delivering more reliable service levels.

- **Reduce cost.** Consolidation leads to reduced spending on hardware, software, and rack space. Healthcare organizations become more efficient with a single data management platform for all healthcare needs. The ONTAP suite of data management tools allow you to achieve Epic requirements without purchasing multiple, expensive third-party add-ons.

  Note: The amount of performance density per node is listed in the "Results summary" section. You can consolidate more workloads with less hardware.

- **Easy.** Imagine a single data management strategy for all your healthcare needs on prem and in the cloud. Add new workloads and push the controllers to higher limits while confidently knowing all workloads will continue to perform consistently based on recommended policy. The SLM constantly monitors and analyses each workload and reports status to a single dashboard in Active IQ Unified Manager.

- **Upgrades.** Every upgrade of ONTAP comes with proven increased performance and better efficiencies. Epic is typically sized for three years of growth and most customers do not have to replace the storage and can extend to 5-6 years by simply upgrading ONTAP.
- **Future innovation.** Upgrades provide new features that impact performance. Some examples of the features that customers have benefited from include:
  - **FlexGroup volumes.** Scale NAS across the cluster and illuminate issues with performance, high file count and scale. WebBLOB, HomeDir and User Profiles have been impacted by such issues causing major outages for all storage platforms. FlexGroup technology has illuminated this as a problem.
  - **FabricPool.** Automatically tier backup data and cold data off you all flash array to object storage like Storage Grid or the cloud.
  - **NVMe/FC.** This NetApp Verified Architecture shows how the industry's first end-to-end NVMe/FC solution increases performance on the storage while reducing CPU consumption on compute.
- **Reliability.** Yes, performance issues are seen as outages and disruptive to patient care. Solutions like Epic EHR comes with mixed workload tiers that most storage platforms have no ability to manage. The ability to deliver consistent services levels is critical. NetApp Services Level Manger actively monitors and reports on performance issues in the Active IQ Unified Manager dashboard, automatically recommends performance policies based on machines learning analysis and illuminate's performance issues.
- **Scale.** The one constant is exponential data growth and with-it performance head room. What happens when you need bigger controllers of to add move controllers. ONTAP at the core is built for non-disruptive operation. Seamlessly scale up and out as need. Never do a migration again and rebalance workloads across the cluster as needed with no disruption to patient care.

NAS

NAS is just as critical as SAN for Epic and needs to be on true enterprise class storage. Issues with WebBLOB, Homedir, or profiles can affect access to patient data. A common issue with such shares is high file count, high directory count and metadata processing can cause data access issues. NetApp provides key capabilities for NAS that addresses Epic needs.

- **FlexGroup volumes.** NetApp recommends using FlexGroup volumes for large shares such as WebBLOB, Homedir, or profiles. FlexGroup volumes distribute performance and metadata processing for shares across multiple volumes across multiple nodes. FlexGroup volumes can scale a single namespace to 24 nodes.
- **FlashPool.** Unstructured data like WebBLOB usually do not have high data reduction. However, in the case of WebBLOB its 95% cold. FlashPool can automatically tier snapshots and cold blocks to lower cost object storage on prem or in the cloud. This allows you to free up capacity from the all-flash performance tier to less expensive object storage automatically with no impact to the applications.
- **SVM DR.** Shares like WebBLOB are typically replicated to DR as part of the failover process to DR. SVM DR enables you to replicate the identity, network configuration of a NAS SVM to DR, and automatically fail everything over with a single command.

For more information about best practices on NetApp for Epic, see TR-3928: NetApp Best Practices for Epic.

SAN

Broadcom Emulex Gen 6/7 FC HBAs

Broadcom Emulex FC host bus adapters (HBAs) are designed to meet the demanding performance, reliability, and management requirements of modern networked storage systems that use high-performance and low-latency SSDs. The Emulex LPe32002 FC HBAs with Dynamic Multi-core

architecture deliver unparalleled performance and more efficient port usage than other HBA by applying all ASIC resources to any port that needs it. Compared to the previous generation, Emulex Gen 6 HBAs deliver two times greater bandwidth—12800MBps (two ports 32GFC, or four ports 16GFC, full duplex), less than half the latency, and support an industry-leading 1.6 million IOPS per adapter. The quad-port LPe32004 delivers up to 3.2 million IOPS per adapter.

The latest Emulex LPe35002 FC HBAs with Dynamic Multi-core architecture deliver an industry-leading 5 million or more IOPS to any port that needs it, providing high performance when and where it is needed. The LPe35002 series delivers 12800MBps (two 32GFC ports) full duplex, and three times better hardware latency.

Emulex Gen 6 and Gen7 HBAs also support NVMe/FC and SCSI FCP concurrently, providing investment protection and allowing data centers to transition to end-to-end NVMe over FC SANs at their own pace.

The secure firmware update feature protects and ensures the authenticity of device firmware. Emulex Gen 6 FC HBAs are NVMe/FC enabled, delivering up to 55% lower insertion latency for NVMe/FC than SCSI FCP. And for investment protection, these FC HBAs also support both NVMe/FC and SCSI FCP concurrently.

Brocade Data Center Gen 6/7 switches

Broadcom's Brocade has been the leading provider of storage networking solutions worldwide for more than 20 years, supporting the mission-critical systems and business-critical applications of most large enterprises. Brocade networking solutions help organizations achieve their critical business initiatives as they transition to a world where applications and information can reside anywhere. Today, Brocade is extending its proven data center expertise across the entire network with open, application-optimized, and efficient solutions that are built for consolidation and unmatched business agility.

Brocade Gen 7 provides the accelerated foundation that modern data centers need to fully realize the benefits of the latest storage technology today and possibly for the next decade.

The seventh generation of FC is aimed at satisfying the needs of growing deployments of flash storage, hyperscale virtualization, and new high-speed data center architectures run twice as fast as the current Gen 6 standard's 32Gbps and has 50% lower latency.

Brocade's Gen 7 platforms are equipped with higher-performing hardware to unleash NVMe technology, and they can discover and produce comprehensive telemetry data across the fabric. They analyze and take actions based on that data to optimize the storage network automatically.

The self-learning and self-optimizing capabilities of Brocade Gen 7 automatically ensure that storage performance and other SAN-related activities are optimized. The collected telemetry data is composed of millions of data points. The Brocade technology leverages it automatically to learn application flows, and then create a baseline of each application's performance from end to end across the fabric to detect when something is abnormal. With Virtual Machine Identification (VMID) tagging, telemetry data is collected on a frame-by-frame basis to the VM. The Brocade systems then provide I/O profiles at the application level, rather than simply on a port basis. The analysis happens within the ASIC integrated circuit to ensure that performance is not impaired.

Brocade's IO Insight and VM Insight

Brocade IO Insight is the industry's first integrated network sensor tool that proactively and nonintrusively monitors real-time storage I/O health and performance statistics for both SCSI and NVMe traffic from any device port on a Gen 6 or Gen 7 FC platform. IO Insight then applies this information within an intuitive, policy-based monitoring and alerting suite to quickly identify the root cause of problems at the storage or VM tier. This level of granularity enables quick identification of degraded application performance at the host VM and storage tiers, reducing time to resolution. IO Insight proactively monitors individual host and storage devices to gain deeper insight into the performance of the network to maintain SLA compliance. It also obtains total I/Os, first response time, I/O latency (Exchange Completion Time [ECT]) and

outstanding I/O performance metrics for a specific host or storage device to diagnose I/O operational issues. Lastly, it enables the tuning of device configurations with integrated I/O metrics to optimize storage performance. You can define preventative actions, such as admin notifications and port fencing to avoid greater negative impact.

The NVMe/FC feature supports both NVMe over Fabrics (NVMe-oF) and SCSI FCP concurrently. Your organization can seamlessly integrate Brocade FCI networks with the next generation of low-latency flash storage, without a disruptive rip and replace.

Furthermore, Brocade VM Insight further extends IO Insight by enabling visibility of I/O statistics at the level of the individual VM. By applying the interpretation of FC standards based VM identification to IO Insight analysis, VM Insight enables the storage administrator to pinpoint issues not just on a physical server, but down to the specific VM workload. VM Insight further enables I/O profiles for individual VMs to be baselined and monitored over time with Fabric Vision MAPS for continual performance monitoring and optimization.

Virtual environments have many additional challenges. VM datastore volumes are often shared between many VMs. Brocade's Flow Vision can point to a problematic physical host, but then it is up to the server support team to determine which VM is causing the problem. Brocade's ASICs VMID built-in function adds the capability to read VMID tags and bring Brocade's extended monitoring capabilities down to individual VM levels. This, in turn, enables an end-to-end quality of service (QoS), with the ability to apply specific levels of QoS on a per-workload basis, to direct FC traffic from a specific VM through the fabric and onto the end storage device.

- VMID gives the vSphere administrator discrete visibility to the application performance, not just the data store.
- VMID gives the vSphere administrator the ability to determine how to balance the VM stack based on CPU, Memory AND I/O Profile preventing the bully/victim cycle.
- VMID lets the vSphere administrator intelligently decide which VMs/applications are the best candidates for migration to NVMe over Fabric in vSphere 7.

For example, to view the initial I/O statistics for a single VM, start by looking up the VMID for the VM. This can be done by finding a switch port that is used by the ESXi host's initiators.

One of the ESXi host's initiators is located on N Port ID 331000 on the G720 switch. Running the `appserver` command on the switch for this port returns the VM entity IDs (VMIDs) assigned to each VM by the host's initiator. In this example, only one VM guest is running on the ESXi host, so only one VMID is displayed (Figure 15).

Figure 15) One VM guest running on the ESXi host.

Using the VMID, the LUN ID of the datastore (on the NetApp system where the VM's VMDKs are stored), and one of the N_Port IDs for the NetApp SVM that hosts the datastore, you can see the statistics for this single VM by using the `flow --show` command (Figure 16). The statistics include latency and I/O for both reads and writes for this VM guest.

Figure 16) Statistics for a single VM using the `flow --show` command.

```
                    :admin> flow --show sys_flow_monitor -srcdev 331000 -dstdev 332101 -lun 0 -srceid "52 d9 1f b0 ef cb c3 13-e7 83 f0 e1 e6 15 a5 c0"
=================================================================================================================================
Name              : sys_flow_monitor
Definition        : SrcDev(331000), DstDev(332101),LUN(0),SEID(52 d9 1f b0 ef cb c3 13-e7 83 f0 e1 e6 15 a5 c0)
Port Speed        : SrcDev(32G), DstDev(32G)
Active Flow       : 1
Timebase          : 6Hrs
Protocol          : NVMe

Port: (16)
---------------------------------------------------------------------------------------------
Monitor Time      : | Wed Jun 23 22:14:43 GMT 2021 |
Elapsed Time      : | 4h:14m |
--------------
I/O Latency |
---------------------------------------------------------------------------------------------
|        Metric        |         Max         |         Avg         |
|                      | Current   /   All   | Current   /   All   |
---------------------------------------------------------------------------------------------
|RD Completion Time    |     10.05m/    11.29m|      477u/     1.318m|
---------------------------------------------------------------------------------------------
|WR Completion Time    |     506.7m/    506.7m|     1.082m/    1.105m|
---------------------------------------------------------------------------------------------
|RD 1st Response Time  |     10.04m/    11.28m|      472u/     1.140m|
---------------------------------------------------------------------------------------------
|WR 1st Response Time  |     9.596m/    10.06m|      299u/      311u|
---------------------------------------------------------------------------------------------
|RD Pending IOs        |       57 /      57  |        9 /       9 |
---------------------------------------------------------------------------------------------
|WR Pending IOs        |       64 /      64  |        7 /       7 |
---------------------------------------------------------------------------------------------

-------------
I/O Performance |
---------------------------------------------------------------------------------------------
|        Metric        |Avg IO Size |     Avg(IOPS)      |      Avg(BPS)      |      Total IO      |     Total Bytes      |
|                      | Current    | Current   /   All  | Current   /   All  | Current   /   All  | Current   /   All    |
---------------------------------------------------------------------------------------------
|RD IO                 |     7.999K|    809 /    579 |   6.323M/   4.584M|   7.102M/   9.419M|    54.19G/    72.80G|
---------------------------------------------------------------------------------------------
|WR IO                 |     8.000K|    280 /    195 |   2.188M/   1.530M|   2.458M/   3.186M|    18.75G/    24.30G|
---------------------------------------------------------------------------------------------
=================================================================================================================================
              admin>
```

Brocade security

Because meeting security requirements is a major challenge for healthcare providers, Brocade is accelerating the secure digital transformation of healthcare services. Brocade products support a wide range of authentication, encryption, and management tools to protect fabrics and data from unauthorized access:

- **Authentication.** Authentication protocol support includes CHAP, DH-CHAP, FCAP, IKE, IPsec, RADIUS, TACACS+, and P-EAP/MS-CHAP for RADIUS.

- **Encryption (AES/3-DES).** Brocade provides AES-128 and AES-256 encryption and 168-bit 3-DES encryption for IP links on extension products and management connections. Brocade also supports AES and 3-DES with IPsec. These solutions provide high-performance encryption and compression.

- **In-flight encryption over Inter-Switch Links (ISLs).** Brocade X6 with Gen 6 Fibre Channel port blades, Brocade X7 with Gen 6 or Gen 7 Fibre Channel port blades, and Brocade G720, G630, G620 switches support in-flight encryption for traffic over ISLs to minimize the risk of unauthorized access to data within the data center and over long-distance links. Data-at-rest and data-in-flight encryption are complementary technologies that serve different purposes, and each might be required to achieve regulatory compliance.

- **Secure boot.** A switch validates the integrity and authenticity of the Fabric OS (FOS) boot image to establish a hardware-based root of trust through the manufacturing supply chain.

- To an attacker, multiple layers of challenge provide the best protection against all types of threats.

Brocade's SANnav

To monitor, visualize, and automate processes in Brocade SAN fabrics, Brocade provides a new modern SAN management software, Brocade SANnav Management Portal and SANnav Global View. SANnav provides comprehensive visibility, actionable information, and simplified processes into SAN fabrics consisting of Brocade Fibre Channel switches. SANnav is the management software that replaces

Brocade Network Advisor. The new modern SANnav is a browser-based management tool that can be deployed on a single node server, multinode on bare-metal servers, or from a VMware OVA package.

Figure 17 shows the SANnav interface.

Figure 17) SANnav interface.
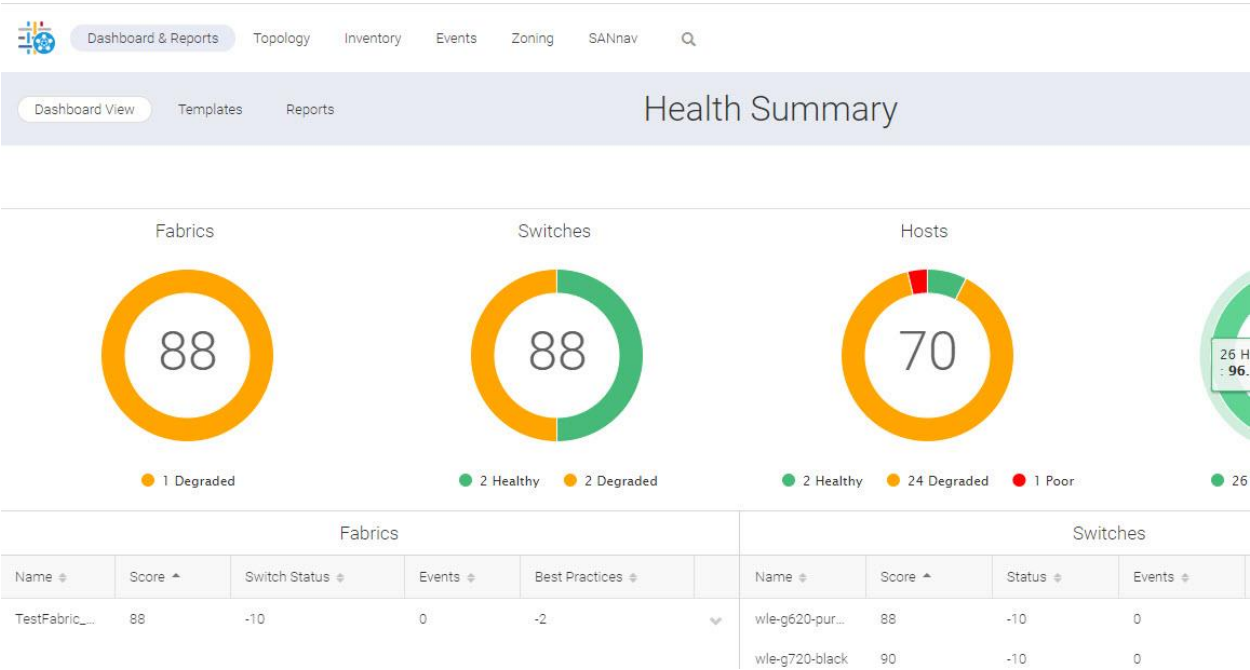
SANnav was developed to provide the following requirements of a modern SAN management tool:

- **Modern user interface.** Web-based client (no bulky Java client).
- **Global visibility.** Single pane of class of all fabrics in a data center and across multiple sites to view health, performance, and inventory; view global events and violations; seamlessly drill down for granular details; and receive alerts from SANnav and through the NetApp Active IQ support portal.
- **Actionable insights**. Gathers IO Insight data, VM Insight data, and other network-integrated sensor data from all switches to enable analytics and deliver actionable insights to troubleshoot and/or optimize the SAN environment.
- **Scalability.** Scale-out architecture.
- **Automation.** Automated monitoring of configuration policies. Automate administration tasks such as deploying new switches and fabrics and automate the collection of data and report generation.

In summary, SANnav can help increase operational efficiency with 75% less time spent on inventory tasks, speed up troubleshooting by 50%, proactively identify potential issues in seconds instead of hours, and increase visibility by 100% by providing a global view instead of viewing one fabric at a time.

The solution

This NetApp Verified Architecture describes systems and solutions that are designed, tested, and documented to facilitate and to improve customer deployments. This section provides the details of the specific solution that used to showcase the first-in-class performance measurements of the EHR workloads.

Note: The performance measurements reported in this document might be different in your environment as a result of your specific use cases and system configuration.

Table 1 and Table 2 describe the hardware and software requirements for generating minimally acceptable performance measurements.

Hardware requirements

Table 1) Hardware requirements for the joint solution.

Hardware
Storage   NetApp AFF A300/A700/A700s/A800 HA pair with 32Gb FC target ports and at least 24 SAS 960GB SSDs
Switches   Brocade X6 Directors, G630, G620, G610 switches, 8510 Directors, 6520, 6510, and 6505 switches
Fibre Channel HBAs   Emulex LPe32002-M2 32Gb FC

Software requirements

Table 2) Software requirements for the joint solution.

Software	Version
NetApp ONTAP	9.1 or later
Brocade Fabric OS (FOS)	8.1.0a or later
Emulex Firmware	FV11.4.204.25 or later DV11.4.354.0 or later

Technology used during testing

This section describes the specific technology used for this NetApp and Broadcom NVMe/FC verified architecture. Table 3 and Table 4 describe the hardware and software details of the system components used for the solution.

Table 3) Hardware used for the joint solution.

Hardware	Quantity
Storage NetApp AFF A800 HA pair with four 32Gb FC target ports and 36-1.75TB SSDs	2
Switches Brocade G720 64Gb FC Switch	2
Fibre Channel HBAs Emulex LPe32002-M2 32Gb FC	8
Workload servers	8

Table 4) Software used for the joint solution.

Software	Version
NetApp ONTAP	9.8
Brocade Fabric OS (FOS)	9.0.1a
Emulex Firmware	FV11.4.204.25 DV11.4.354.0
Server software	RHEL 8.2

Software	Version
	Windows Server 2019

For testing purposes, we deployed eight workload generating servers, two Brocade G720 switches, and two NetApp AFF A800 HA storage controllers. As shown in Figure 18, the complete test bed fit well within a single rack.

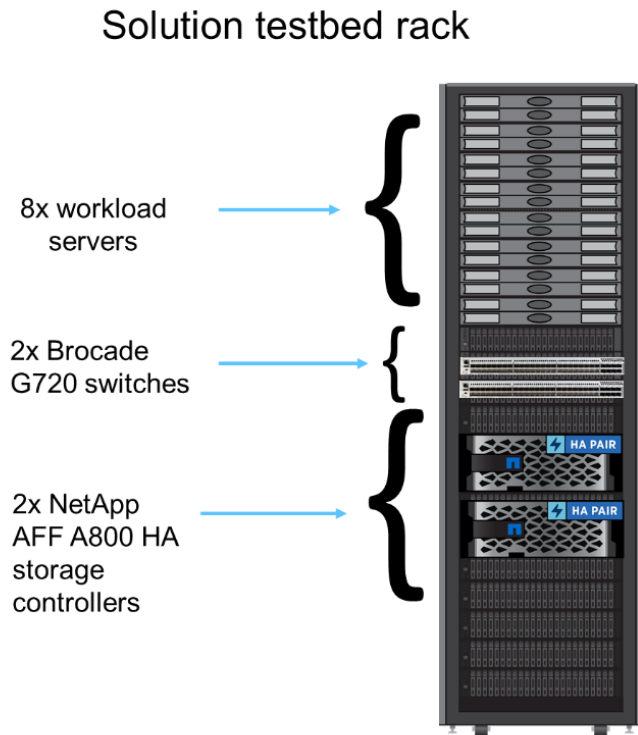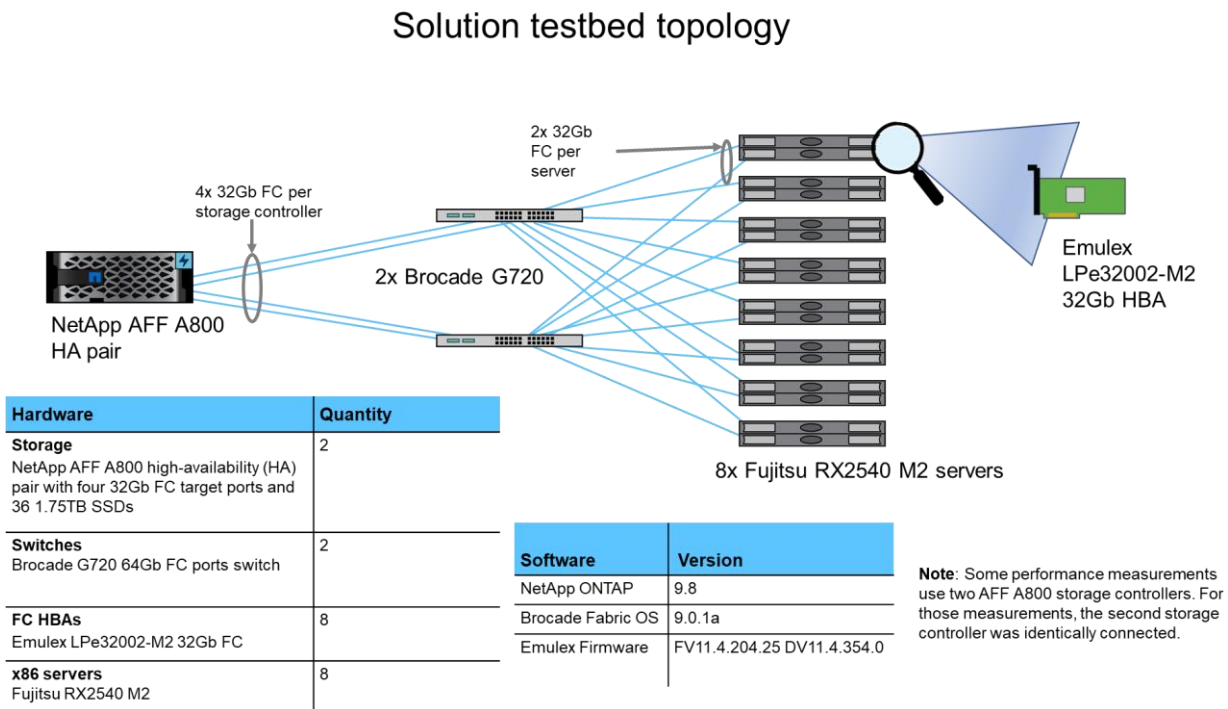**Figure 18) NetApp and Broadcom validated architecture rack view.**

Solution testbed rack

8x workload servers

2x Brocade G720 switches

2x NetApp AFF A800 HA storage controllers

Figure 19) Epic hardware and software testbed topology.

Solution testbed topology

Hardware	Quantity
Storage NetApp AFF A800 high-availability (HA) pair with four 32Gb FC target ports and 36 1.75TB SSDs	2
Switches Brocade G720 64Gb FC ports switch	2
FC HBAs Emulex LPe32002-M2 32Gb FC	8
x86 servers Fujitsu RX2540 M2	8

Software	Version
NetApp ONTAP	9.8
Brocade Fabric OS	9.0.1a
Emulex Firmware	FV11.4.204.25 DV11.4.354.0

Note: Some performance measurements use two AFF A800 storage controllers. For those measurements, the second storage controller was identically connected.

As shown in Figure 19, multiple 32Gb FC networking was used to connect the compute, switching, and storage components of the test bed. To ensure that there was adequate networking bandwidth, and in accordance with best practices, we deployed four 32Gb FC connections to our storage controller; two connections to one Brocade switch and two to the second Brocade switch. Similarly, two 32Gb FC connections were deployed to each workload server; one to each switch.

Performance testing was conducted by using servers without virtualization for all test cases. At no point in the testing did the network connectivity create a bottleneck in the performance measurements.

Two aggregates and four storage virtual machines (SVMs) were created on each A800 HA storage controller. Within each SVM, we create eight volumes, and one LUN/namespace per volume, for a total of 32 LUNs/namespaces. Additionally, four LIFs were created per SVM. Each volume was 1.25TB and each LUN/namespace was 1.0TB.

Solution verification

This section of the NetApp Verified Architecture describes the details of the tools used to measure the performance of the solution, the workload design, solution testbed design, testbed creation, test methodology, and performance measurement. For all areas in this process, we targeted to align our configuration and testing with best practices to ensure real-world outcomes.

Workload design

To ensure that we accurately measured the capability of the solution, we used performance measurement tools that best simulated real-world workloads. To best meet these conditions, we used Epic GenIO and FIO to conduct performance measurements and to verify our solution.

GenIO is Epic's IO generation tool that simulates real-world Epic storage workloads. It is used to validate that storage is production ready. This test focuses on performance by pushing storage to its limits and

determining the headroom, or remaining available resources, on the storage controllers by ramping up the workload until the requirements fail.

We conducted GenIO tests to measure storage headroom. We used eight servers with GenIO loaded to drive I/O on the storage controllers. Four servers were used with GenIO loaded on all eight, four to drive I/O on the AFF A800 storage controllers. Four servers were used because of server performance limits, and four servers are required for an AFF A800.

FIO is an open-source synthetic IO tool that can be used for both benchmark and hardware verification testing. For our testing, we used FIO to simulate the operations of a Clarity Oracle database workload.

To ensure repeatable results and to maximize testing efficiency, we used Ansible automation to create the storage, switching, and server layout. We used Ansible automation to install packages, copy required files, attach to external shares, configure multipathing, create logical volumes and file systems, and other various tasks. To assist with reproduction of our test results, we have made these Ansible scripts available from the following GitHub repositories:

- [NetApp Ansible automation (server/storage)](#)
- [Brocade Ansible automation (switch)](#)

We have additionally included other test configuration files, such as FIO config files, on the NetApp Ansible automation site.

Performance testing methodology

As part of the solution verification, we created a test methodology that demonstrated the performance of the solution to highlight FC and NVMe/FC performance, single-server and multiple-server performance, and RHEL and Windows performance. Our test methodology covers these different scenarios.

As mentioned in "Workload design", we used the GenIO and FIO tools to conduct our performance measurements.

We conducted the following performance measurements using FIO:

- Clarity on Oracle with NVMe/FC protocol
- Clarity on Oracle with FC protocol

The goal of our FIO testing was to find the maximum number of IOPS for each scenario.

For our testing, the goal was to use FIO to simulate a Clarity on Oracle workload by using our RHEL 8.2 server environment.

For all FIO tests, we had all eight workload servers generating a 75%-read/ 25%-write random workload using 8KB I/O size. Between test runs, we increased the iodepth in increments of 10, starting at 10 iodepth and ending at 40 iodepth, incrementing by 10 between runs. We used number of jobs = 4 in the FIO definition.

We conducted the following performance measurements using GenIO:

- Single server with NVMe/FC protocol
- Multiple server with NVMe/FC protocol
- Multiple server with FC protocol

The goal of the GenIO testing was to find the maximum number of total IOPS that could be reached while not exceeding the 45 second write cycle threshold. The 80 second write cycle threshold was considered to be the absolute maximum.

For all GenIO testing, we ran with the Epic DB deployed on one AFF A800 HA pair and the Epic journal on the other AFF A800 HA pair. We used the following GenIO test configuration settings:

- aioQueueSize = 32

- aioWIJ = 32
- runtime = 15 minutes

Figure 20) Sizing NetApp storage for Epic workloads.
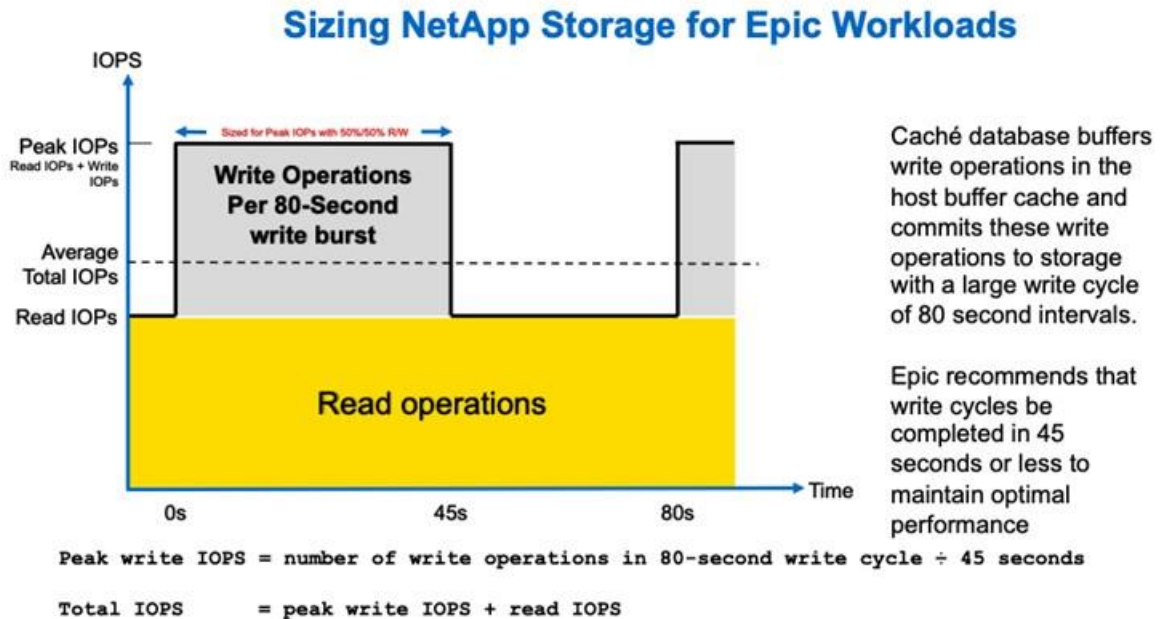
The DB volume group stripe size was 16MB while the JRN stripe size was 1MB. We created logical volumes with eight stripes and used 100% of the volume group space. The logical volumes included two namespaces from each of the SVMs so that the data would be spread equally across the SVMs and LIFs.

Performance measurements

We collected performance measurements on the workloads described in the previous section, analyzed our results, and generated the charts below.

As shown in Figure 21, for the NVMe/FC protocol configuration, we observed roughly 2.4M total IOPS at just below 1ms of write latency. Similarly, we observed just under 1.7M total IOPS at just below 1ms for the FC protocol configuration.

For both protocols, as we increased the iodepth from 10 to 40, the number of total IOPS increased. Both the FC and NVMe/FC protocol configurations demonstrated increasing write latencies as total IOPS increased. During the peak IOPS measurements, latencies began to increase greater than linear scaling. This increase in latency typically occurs when the storage system headroom is approaching zero.

As shown in Figure 21, our FIO testing achieved a much greater number of IOPS using NVMe/FC protocol versus the FC protocol. The NVMe/FC connected solution achieved roughly 2400k IOPS at under 1ms of write latency, whereas the FC connected solution achieved roughly 1700k IOPS at the same latency.

Figure 21) FIO: IOPS versus write latency.
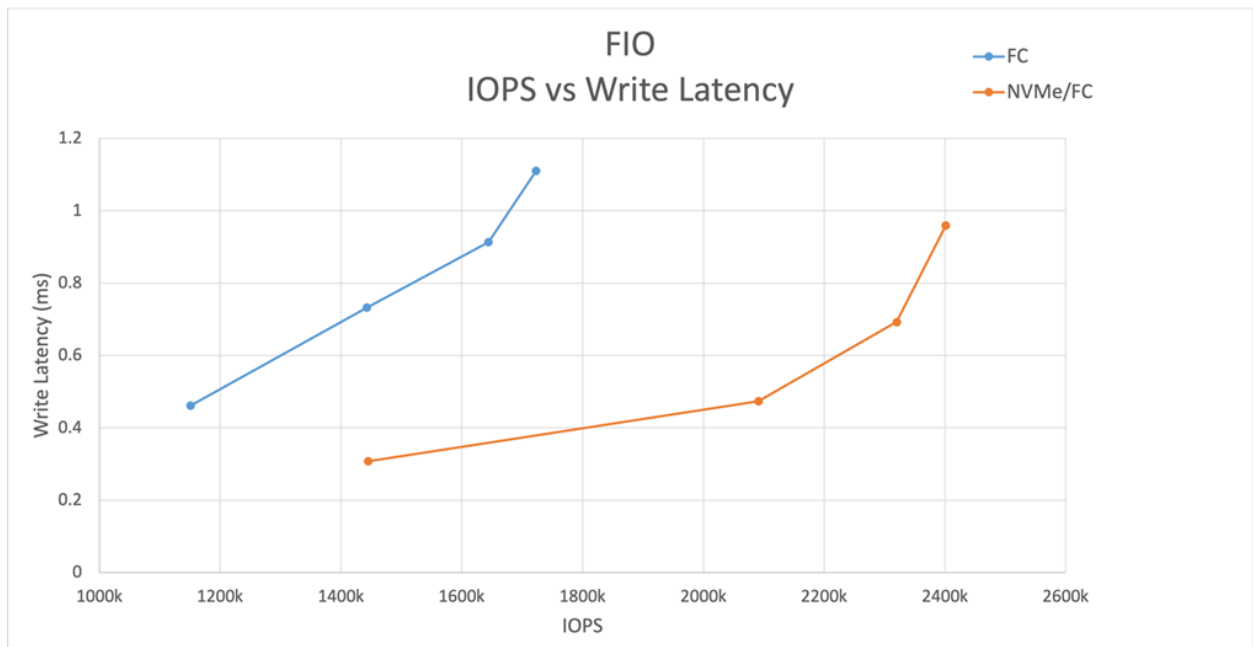
As shown in Figure 22, our GenIO testing similarly achieved a much greater number of IOPS using NVMe/FC protocol versus the FC protocol. The NVMe/FC connected solution achieved over 700k aggregated IOPS before surpassing the 45-second write cycle threshold. This solution was able to pass 800k IOPS before meeting the 80 second write cycle threshold.

Our FC connected solutions achieved roughly 570k IOPS before surpassing the 45-second write cycle threshold.

Figure 22) GenIO: IOPS versus write cycle.
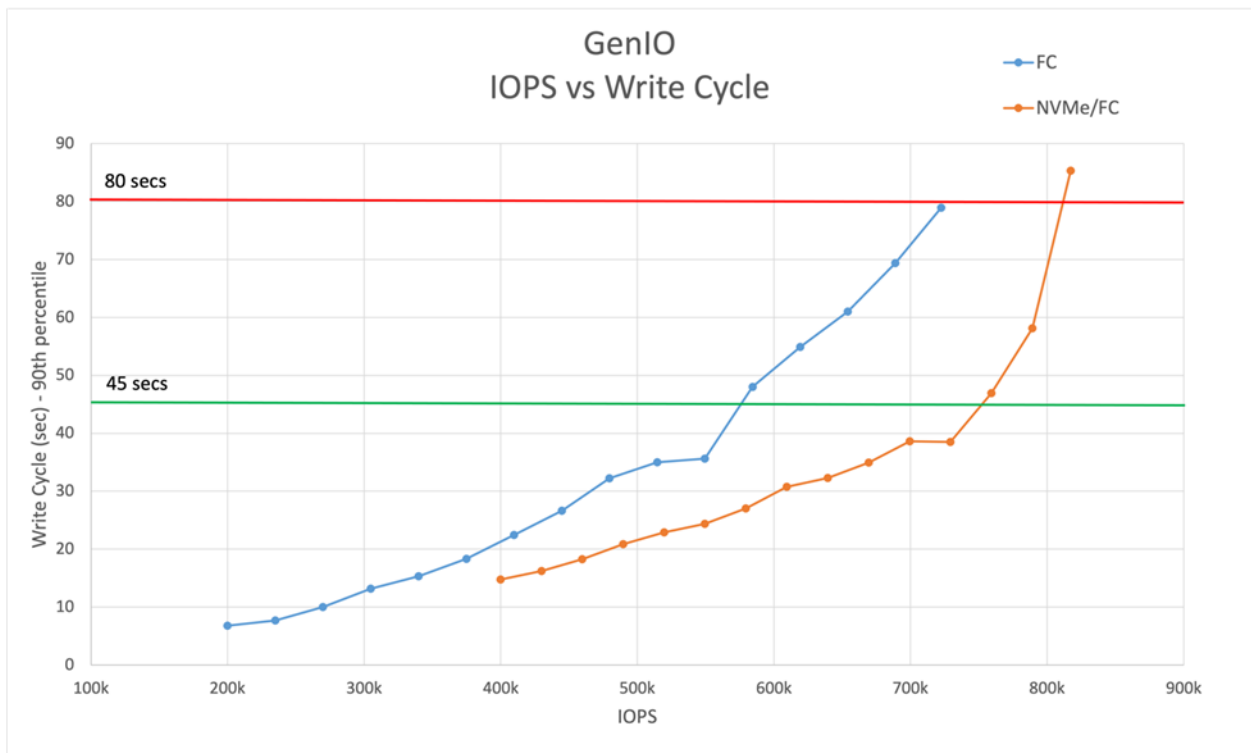
As shown in Figure 23, when limiting the workload generator capacity down from four servers to one, we were still able to achieve roughly 330k IOPS before surpassing the 45-second write cycle threshold.

Figure 23) Single Server GenIO: IOPS versus write cycle.
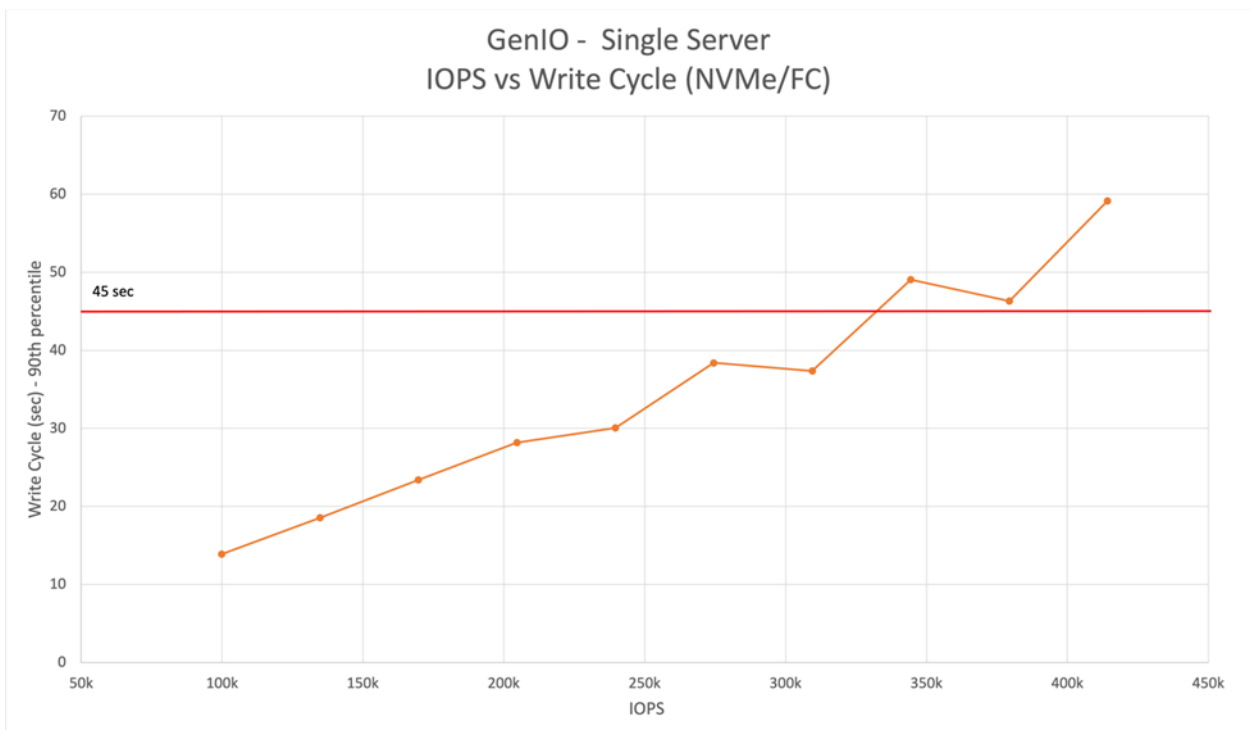
As shown in Figure 24, the VMware on FC configuration achieved close to 800k IOPS while the NVMe/FC configuration reached approximately 900k IOPS under the same workload. These tests were performed with a single AFF A800 controller. For comparison to above graphs, we assumed that a two controller AFF A800 could achieve twice the IOPS as a single controller AFF A800.

Figure 24) FIO on VMware: IOPS versus write latency.
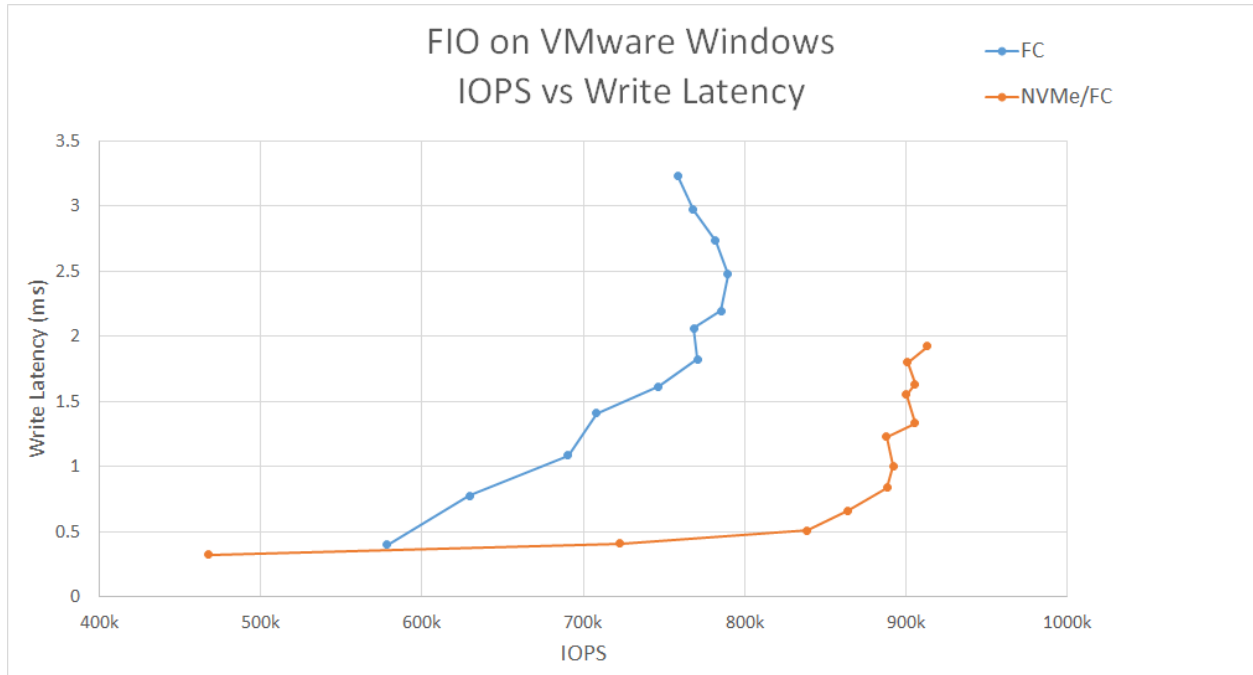
Table 5) Aggregated read/write IOPS and write cycles.

Reads	Writes	Total IOPS	90% write cycle	Maximum write cycle
299604.71	100214.2	399818.9	14.755	15.2425
322061.12	107724.4	429785.5	16.23	17.28
344460.48	115229	459689.4	18.2575	20.025
366955.99	122752	489708	20.8525	22.595
389306.85	130269.3	519576.2	22.8775	24.4575
411724.56	137791.4	549516	24.3675	27.2375
434207.97	145295.3	579503.2	27.0325	29.2725
456627.53	152807.8	609435.3	30.77	36.6
479053.08	160342.4	639395.5	32.285	41.3125
501518.09	167855.4	669373.5	34.9625	41.54
523963.93	175367.2	699331.1	38.62	43.045
546399.81	182889.6	729289.4	38.515	48.0775
568851.55	190382.6	759234.1	46.955	49.3025

Table 5 shows how we were able to achieve ~730K IOPs on a single AFF A800 HA.

Conclusion

Healthcare organizations are facing a wide array of challenges when it comes to modernizing their EHR systems. There are many infrastructure, hardware, and software factors to consider. Having a pathway to transition to a modernized EHR platform, that leverages validated best of breed and proven technologies is the key to successful transformation.

This NetApp Verified Architecture for Epic EHR is a proven and tested reference model, delivering optimal scale and performance for Epic, Oracle, Red Hat, and Clarity, enabling your EHR environment to leverage the very best modern technologies and platforms such as NVMe/FC SAN, Hybrid Cloud technologies, automation frameworks, and a data protection framework that ensures maximum availability, uptime, and recoverability.

Where to find additional information

To learn more about the information that is described in this document, review the following documents and/or websites:

- SB-4089: Modern SAN for the healthcare industry with NetApp and Broadcom
  https://www.netapp.com/pdf.html?item=/media/20028-sb-4089.pdf

  Note: This solution brief is part of the NetApp Modern SAN Verified Architecture Program, which provides test results and validated design and configuration recommendations for Epic EHR deployment.

- TR-3928: NetApp Best Practices for Epic
  https://www.netapp.com/pdf.html?item=/media/17137-tr3928pdf.pdf
- NetApp SAN Solutions Website
  https://www.netapp.com/SAN
- Brocade Fibre Channel Networking Switches
  https://www.broadcom.com/products/fibre-channel-networking/switches/
- Brocade Fibre Channel Networking Directors
  https://www.broadcom.com/products/fibre-channel-networking/directors/
- Brocade/NetApp Partner Documents
  https://www.broadcom.com/company/oem-partners/fibre-channel-networking/netapp
- NetApp SAN Health Program
  https://www.netapp.com/us/forms/campaign/amer-us-fy19q3-sss-san-san-health-check-inquiry-form.aspx?ref_source=smc&cid=27476
- SANnav Management Portal
  https://www.broadcom.com/products/fibre-channel-networking/software/sannav-management-portal
- Brocade Fabric OS Flow Vision User Guide, 9.0.x
  https://docs.broadcom.com/doc/FOS-90x-FlowVision-UG
- Broadcom Emulex Drivers for VMware ESXi
  https://docs.broadcom.com/doc/12398084
- Brocade Fabric Vision Technology
  https://www.broadcom.com/products/fibre-channel-networking/software/storage-fabrics-technology

Version history

Version	Date	Document version history
Version 1.0	April 2021	Initial release.

Version	Date	Document version history
Version 2.0	August 2021	Added the "Brocade IO Insight and VM Insight" section; added "FIO on VMware: IOPS versus Write Latency" performance results; and general rewording.

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