



**Hewlett Packard**  
Enterprise

# **HPE Reference Architecture for highly available Microsoft SQL Server 2017 with VMware vSphere on HPE Synergy 620 Compute Modules**

# Contents

Executive summary.....	3
Introduction.....	3
Solution overview.....	4
Solution components.....	5
HPE Synergy 12000 Frame.....	5
HPE Synergy Composer.....	5
HPE Synergy Image Streamer.....	6
HPE Synergy Image Streamer building blocks.....	7
Hardware.....	8
Storage configuration.....	8
Software.....	10
Application software.....	10
Best practices and configuration guidance for the solution.....	10
ESXi deployment using Image Streamer.....	10
HPE Synergy Compute Module BIOS.....	11
Microsoft SQL Server 2017 configuration best practices.....	12
VMware vSphere.....	12
Capacity and sizing.....	12
Database consolidation.....	12
Data reduction.....	15
High Availability.....	17
Analysis and recommendations.....	18
Summary.....	18
Implementing a proof-of-concept.....	18
Appendix A: Bill of materials.....	18
Resources and additional links.....	20

## Executive summary

As business data continues to expand rapidly, organizations are looking for robust infrastructure which is flexible, cost efficient, scalable and provides a stable platform for mixed workloads without compromising on performance and ability to meet required SLAs to its users. HPE Synergy is architected from the ground up for composable infrastructure, offering an experience that empowers IT to create and deliver new value instantly and continuously. The performance, flexibility, and manageability of the HPE Synergy platform help businesses provision efficiently, and scale on-premises cloud infrastructure resources quickly, thus reducing costs associated with stranded resources.

This HPE Reference Architecture describes an example configuration and provides performance implications associated with deploying highly available Microsoft® SQL Server 2017 with VMware® vSphere on HPE Synergy with HPE 3PAR StoreServ all-flash arrays. This helps organizations plan and provide the appropriate level of performance while meeting business requirements and SLAs.

For organizations building a consolidated SQL Server infrastructure there are several key design criteria including performance, scalability, flexibility, and manageability. These are critical components in ensuring that the business objectives and application SLAs can be achieved. This white paper highlights important elements of each of these design tenets for a Reference Architecture supporting hundreds of SQL databases on a consolidated HPE Synergy and HPE 3PAR solution.

- Performance – Test results show HPE Synergy was able to deliver over 120k batch requests per second with a mix of multiple OLTP databases provisioned using HPE 3PAR StoreServ all-flash array storage.
- Scalability – Composable infrastructure provides a balance of computing, storage, and network components in HPE Synergy that are key to predictable linear scaling and unabated performance under consolidated workloads. Testing shows that three HPE Synergy 12000 Frames with six HPE Synergy 620 Compute Modules was easily able to consolidate the 24 VMs with hundreds of SQL databases.
- Flexibility – Adjust resources to match changing workloads. Compute, storage, and network resources can be rapidly provisioned to accommodate various high availability (HA) topology options for Microsoft SQL Server. HPE Synergy has both direct attach (DAS) and storage area network (SAN) storage options to build SQL Server Failover Clusters and Always On Availability Groups. The HPE Synergy 12000 Frame is optimized to include all elements to run any workload. It includes embedded management and is designed to support a wide range of compute modules and storage options. The back of the frame includes fabric interconnects, enabling flexibility with regard to storage and other interconnectivity needs.
- Manageability – The HPE OneView management simplifies database management with HPE Synergy Composer, powered by HPE OneView, and HPE Synergy Image Streamer. HPE OneView provides an operational interface that allows system administrators to configure, update, and provision both DAS and SAN storage from a single tool greatly streamlining the database provisioning process. Availability of ReST APIs can further automate frequent database deployments.
- Agility – The HPE Synergy Image Streamer works with HPE Synergy Composer to provision compute modules with bootable images created from predefined sets of golden images. With these golden images, you can deploy and update infrastructure with unmatched speed and agility. The entire deployment starting from bare metal until ESXi host is up and ready for SQL installation is less than 16 minutes, which is a significant reduction as compared to traditional deployment times of hours or days.

**Target audience:** CIOs, IT architects, IT managers, database engineers, and administrators. A working knowledge of server architecture, networking architecture, and storage design is recommended.

**Document purpose:** The purpose of this document is to describe a Reference Architecture that organizations can utilize to plan for their deployment of consolidated Microsoft SQL Server 2017 OLTP workloads on the HPE Synergy platform.

## Introduction

In the data-driven world, traditional IT struggles to keep up with data growth rates of databases; and, customers are looking for a platform to improve scalability, perform quick deployments, and provide faster transaction processing. HPE Synergy with HPE 3PAR StoreServ offers an excellent platform for building a SQL Server environment using VMware vSphere 6.5. The solution leverages HPE Synergy technologies, such as software-defined intelligence, and uses workload templates to compose, decompose, and recompose based on the workload. This can help businesses to deploy SQL Server VMs at nearly cloud speed. In this paper, the solution is provisioned using three HPE Synergy 12000 Frames to showcase the flexibility of the composable infrastructure for running mixed transactional workloads.

## Solution overview

HPE Synergy enables IT organizations to accelerate application and service delivery through a single interface that composes physical and virtual compute, storage, and fabric pools into any configuration for any application. Composable resources are provisioned together with their state (determined by variables such as BIOS settings, firmware, drivers, and protocols) and their OS and application image using repeatable templates. This is ideal for applications such as SQL Server because it eliminates time-consuming provisioning processes. The key components of this solution are the HPE Synergy Composer and HPE Synergy Image Streamer. The combination of these tools allows automating the customization of an ESXi OS image, resulting in faster deployment of desired environment.

This Reference Architecture focuses on deploying a Microsoft SQL Server 2017 database environment designed to run a transactional workload.

High availability is additionally provided by Microsoft SQL Server failover clustering, installed on two VMs, which are part of a VMware vSphere cluster with two nodes. This example was selected to provide a real-world, complex solution demonstrating the consolidation of databases using VMware vSphere on the HPE Synergy Composable Infrastructure. The workload was built on the HPE Synergy 620 Gen9 Compute Module. An OLTP-style workload was then applied to the system by a varied volume of transactions on different sized databases. The simulated transaction rates, were progressively increased until performance thresholds for the configuration were reached. HPE 3PAR data reduction capabilities have been showcased by deploying databases on virtual volumes with thin, thin dedupe, thin compression, and thin compression with dedupe.

Figure 1 shows the components that were used for this solution.

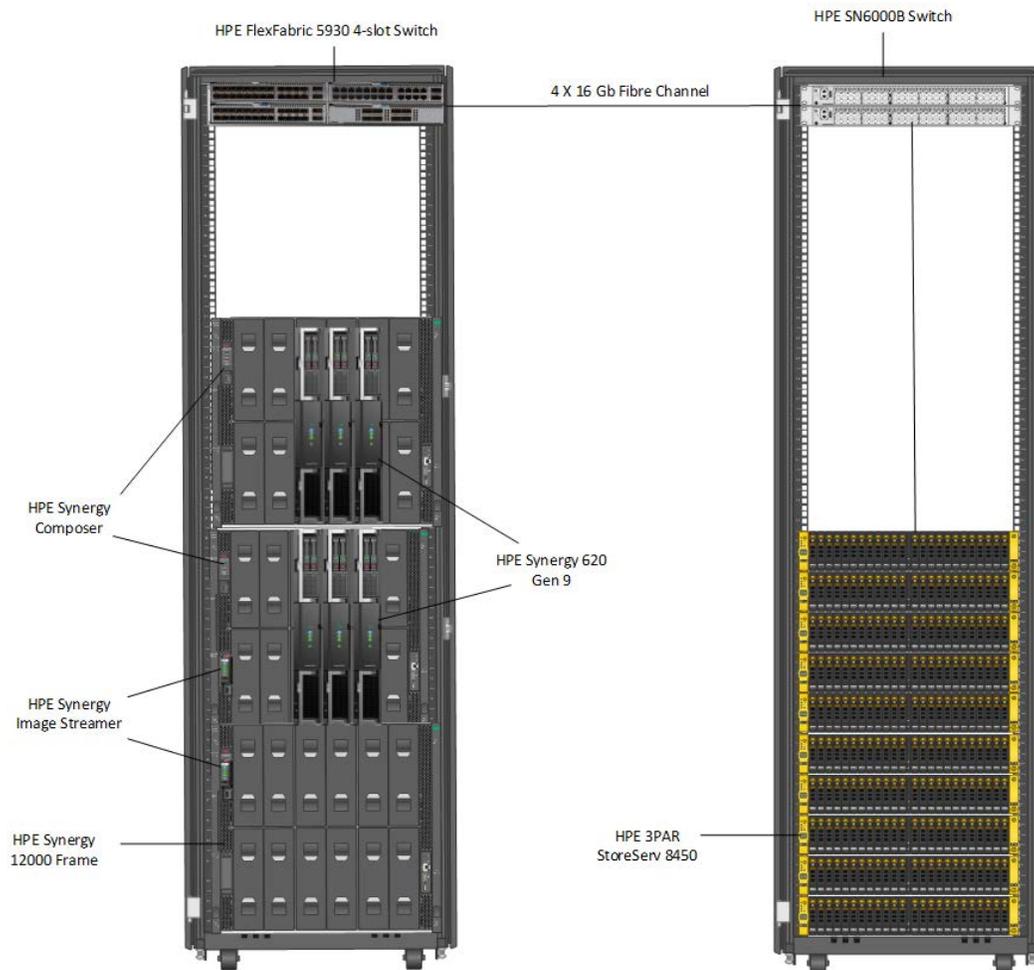


Figure 1. HPE Synergy solution diagram

## Solution components

The HPE Synergy components used in this solution included the following:

- Three HPE Synergy 12000 Frames
  - Two HPE Synergy Composers
  - Two HPE Synergy Image Streamers
  - Six HPE Synergy 620 Gen9 Compute Modules
- Network Interconnects
  - Two Virtual Connect SE 40 Gb F8 Modules
  - Four HPE Synergy 20Gb Interconnect Link Modules
  - Four Virtual Connect SE 16Gb FC Modules for Synergy provided FC connectivity
- External HPE 3PAR SAN storage

For this solution, HPE 3PAR StoreServ 8450 all-flash storage was used for the SQL database data and log files. Shared storage is required for SQL Server cluster implementations, and the all-flash performance, as well as mission-critical resiliency of the HPE 3PAR StoreServ 8450, make it ideal for both SQL standalone and clustered instances.

### HPE Synergy 12000 Frame

The HPE Synergy 12000 Frame is the base infrastructure that ties together compute, storage, network fabric, and power into a scalable solution that easily addresses and scales with various customer workloads and infrastructure. The Synergy 12000 reduces complexity in the IT infrastructure by unifying all these resources into a common bus, and with the myriad of available network and storage interconnects, allows the frame to interoperate with any other IT environment. At a high level the Synergy frame supports the following:

- 12 half-height or 6 full-height compute modules per frame. The HPE Synergy design allows for the inclusion of double-wide modules as well as support for internal storage with the HPE Synergy D3940 Storage Module
- Two Frame Link Modules for in-band and out-of-band management
- Up to six 2650 watt power supplies and ten fans
- Up to six interconnect modules for full redundancy of three fabrics

The Synergy 12000 features a fully automated and managed composer module. HPE OneView handles all the setup, provisioning, and management both at the physical and logical level.

### HPE Synergy Composer

HPE Synergy Composer is a hardware management appliance that is powered by HPE OneView. The HPE Synergy Composer provides a single interface for assembling and reassembling flexible compute, storage, and fabric resources to support business-critical applications and a variety of workloads, whether they are bare metal, virtualized, or containerized.

The HPE Synergy Composer provides lifecycle management to deploy, monitor, and update your infrastructure using a single interface or the Unified API. IT departments can rapidly deploy infrastructure for traditional, virtualized, and cloud environments in just a few minutes — sometimes in a single step. Resources can be updated, expanded, flexed, and redeployed without service interruptions. Key features of the composer are:

- Simplify deployment and configuration of resources in your environment
- Accelerate updates using templates
- Automate applications and workloads using the Unified API
- Designed for high availability using redundant physical appliances

## HPE Synergy Image Streamer

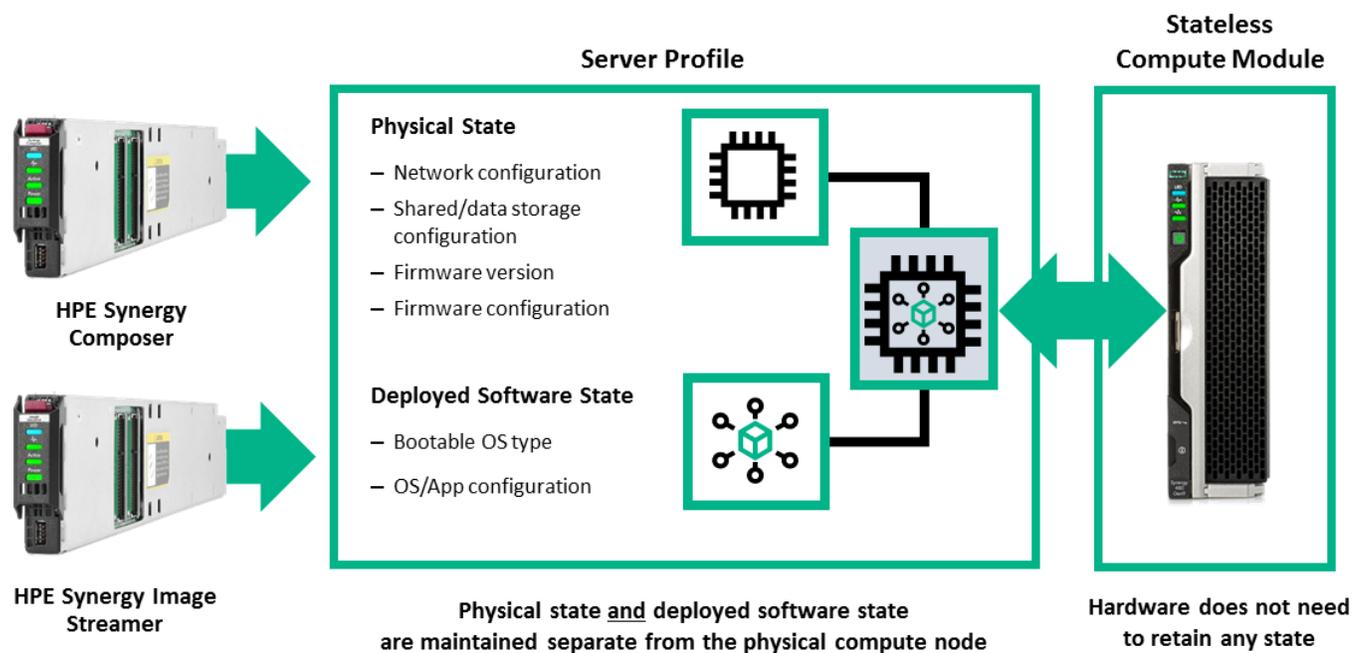
HPE Synergy Image Streamer is a management appliance option for the HPE Synergy solution that is used to deploy stateless compute modules within the HPE Synergy environment. The HPE Synergy Image Streamer solution offers a stateless deployment experience for bare-metal compute modules by managing and maintaining the software state (operating system and settings) separate from the physical state (firmware, BIOS settings, etc.). Boot volumes for the compute modules are hosted and maintained on the HPE Synergy Image Streamer appliance as iSCSI boot volumes. Image Streamer uses scripts and build plans to generalize and personalize the OS boot volumes during capture and deployment.

HPE Synergy Image Streamer adds a powerful dimension to “infrastructure as code”—the ability to manage physical servers like virtual machines. In traditional environments, deploying an OS and applications or hypervisor is time-consuming because it requires building or copying the software image onto individual servers, possibly requiring multiple reboot cycles. In HPE Synergy, the tight integration of HPE Synergy Image Streamer with HPE Synergy Composer enhances server profiles with images and personalities for true stateless operation.

HPE Synergy Composer, powered by HPE OneView, captures the physical state of the server in the server profile. HPE Synergy Image Streamer enhances this server profile (and its desired configuration) by capturing your golden image as the “deployed software state” in the form of bootable image volumes. These enhanced server profiles and bootable OS images, plus application images are software structures (infrastructure as code)—no compute module hardware is required for these operations. The bootable images are stored on redundant HPE Synergy Image Streamer appliances, and they are available for fast implementation onto multiple compute modules at any time. This enables bare-metal compute modules to boot directly into a running OS with applications, and multiple compute modules to be quickly updated. HPE Image Streamer:

- Manages physical servers like virtual machines
- Enables true stateless operation by capturing software (OS and settings) state separate from the hardware (firmware, BIOS) state
- Deploys, updates, and rolls back compute images rapidly for multiple compute modules
- Enables automation via Unified API

Figure 2 shows how HPE Synergy Composer and HPE Synergy Image Streamer manage a compute module via a server profile.



**Figure 2.** HPE Synergy Composer and HPE Synergy Image Streamer managing compute module with a server profile

## HPE Synergy Image Streamer building blocks

HPE Synergy Image Streamer uses the following components for capture and deployment of images:

- **Plan script:** A guestfish script used by OS build plans to personalize OS volumes based on the values of custom attributes. There are three types of plan scripts. Capture type plan scripts are only for use in the capture build plans. Deploy type plan scripts are only for use in the deploy build scripts. General type plan scripts are for use in both.
- **OS build plan:** Build plans provide the order of execution for customization of the OS volumes. That is they provide the order in which plan scripts are executed within a deployment plan. A build plan may contain many plan scripts or none at all.
- **Golden image:** A generic format of an application and operating system image that can be customized for multiple deployments.
- **Deployment plan:** A combination of an OS build plan and golden image that is used by a server profile for the deployment of a server.
- **Artifact bundles:** Artifacts included during bundle creation are compressed to a zip file and stored on the appliance. The zipped artifact bundle can then be downloaded for offline storage or uploaded to other Image Streamer appliances in the environment.

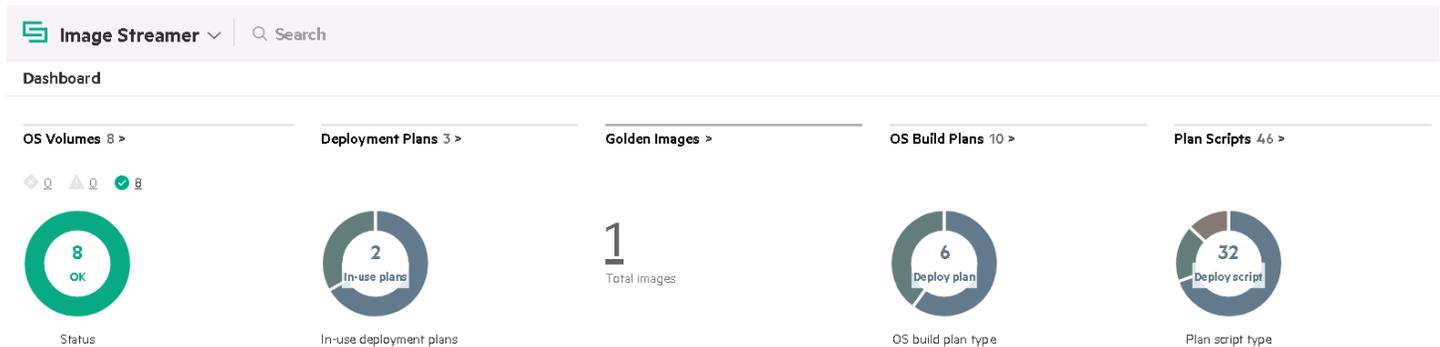
---

### Note

Hewlett Packard Enterprise provides artifact bundles for certain supported operating systems. These artifact bundles and other HPE Synergy Image Streamer content can be downloaded from <https://github.com/HewlettPackard>.

---

Figure 3 shows the HPE Synergy Image Streamer Dashboard, which displays the resources available to create and modify OS images.



**Figure 3.** HPE Synergy Image Streamer Dashboard

HPE Synergy Image Streamer supports a variety of operations for flexibility in how you handle your images. For example, you can capture golden images for your use, import golden images from another location, or modify some of your “known good” images for re-use. This flexibility allows you to easily establish your desired images for use. A variety of images can be used on HPE Synergy Image Streamer. Reference implementations provide artifacts for recent versions of VMware ESXi (5.0, 6.0, 6.5), and application images based on Red Hat® Enterprise Linux® (RHEL 7.2, 7.3) and SUSE Linux Enterprise Server (SLES 12 SP1) using ext3 and ext4 file systems. You can also enable your own specific images and image types using the tools provided with HPE Synergy Image Streamer. In this solution, we have used HPE Synergy Image Streamer to deploy ESXi 6.5 U1 on six HPE Synergy 620 Compute Modules.

## Hardware

In this solution, the following configuration was used for testing, but the solution can be built with other larger and smaller configurations.

Three HPE Synergy 12000 Frames had the following components.

### First frame

- One HPE Synergy Composer
- One HPE Virtual Connect SE 40 Gb F8 Module for Synergy
- One HPE Synergy 20Gb Interconnect Link Module
- 2 x HPE Virtual Connect SE 16Gb FC Module for Synergy
- 2 x HPE Synergy Frame Link Module (active and standby)
- 3 x HPE Synergy 620 Gen9 Compute Module. This is a two-socket compute module and was populated with 20-core processors for a total of 40 cores

### Second frame

- One HPE Synergy Composer
- One HPE Synergy Image Streamer
- One HPE Virtual Connect SE 40 Gb F8 Module for Synergy
- One HPE Synergy 20Gb Interconnect Link Module
- 2 x HPE Virtual Connect SE 16Gb FC Module for Synergy
- 2 x HPE Synergy Frame Link Module (active and standby)
- 3 x HPE Synergy 620 Gen9 Compute Module. This is a two-socket compute module and was populated with 20-core processors for a total of 40 cores

### Third frame

- One HPE Synergy Image Streamer
- 2 x HPE Synergy 20Gb Interconnect Link Module
- 2 x HPE Synergy Frame Link Module (active and standby)

## Storage configuration

The HPE 3PAR StoreServ 8450 was configured as follows:

- 1 x HPE 3PAR StoreServ 8450 all-flash array
  - Four controller nodes
  - 384GiB of cache
  - 8 x drive enclosures
  - 64 x 480GB MLC SSD
  - 20 x 16Gb Fibre Channel ports

For the SQL database, the HPE 3PAR StoreServ 8450 provided the backend storage. When provisioning storage from the HPE 3PAR array, two different storage concepts are presented:

- **Common Provisioning Group (CPG):** A CPG is a pool of drives from which virtual or logical storage volumes can be allocated. CPGs also dictate which RAID will be used when virtual storage volumes are created from this pool. Fully provisioned virtual volumes (FPVVs), thinly provisioned virtual volumes (TPVVs), thinly deduped virtual volumes (TDVVs), and compressed VVs can be created that draw space from a CPG’s logical disks. Full provisioned virtual volumes allocate volume space at the time of creation, where as thin provisioned virtual volumes allocate volume space on demand. It is important to note that if no volumes of any type have been created in a CPG, it consumes no space.
- **Virtual Volume (VV):** Virtual volumes are the storage LUNs that are presented to the host. When creating virtual volumes, a CPG must be specified. All data residing on the virtual volume will be spread across the drives residing in the CPG.

Figure 4 below provides an overview of the HPE 3PAR storage model.

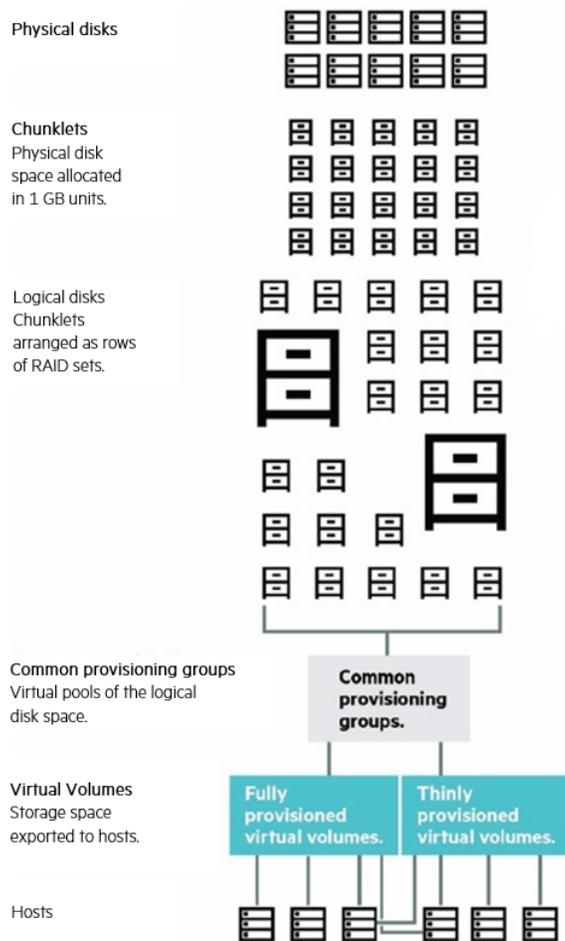


Figure 4. HPE 3PAR storage hierarchy

Best practices were implemented for RAID usage, SAN zoning, and connection redundancy from the HPE 3PAR StoreServ storage best practices guide at <http://h20195.www2.hp.com/V2/GetDocument.aspx?docname=4AA4-4524ENW>.

Thin provisioning was used for all virtual volumes. Table 1 provides details about the CPG configuration for the HPE 3PAR array. A RAID 5 CPG was created for data volumes and RAID 1 for log volumes.

**Table 1.** 3PAR CPG layout

	RAID Type	Media	Content
SSD_RAID5	5	SSD	Data and OS Virtual Volumes
SSD_RAID1	1	SSD	Log Virtual Volumes

## Software

The following Operating system was used for the solution.

- VMware ESXi 6.5 U1
- Microsoft Windows Server® 2016 Enterprise Edition (x64)

## Application software

The following management and application software was used for the solution.

- Microsoft SQL Server 2017 RTM
- HPE OneView 3.10.00
- VMware vSphere Web Client 6.5.0 Build 5178943
- HPE 3PAR StoreServ Management Console 3.1.0.22913

## Best practices and configuration guidance for the solution

### ESXi deployment using Image Streamer

The first step in an Image Streamer deployment is building the golden image from a reference host operating system. The Image Streamer deployment is initiated through the HPE OneView interface by creating a server profile that is assigned an Image Streamer deployment plan. The expanded golden image – the golden volume – is smart cloned to create the OS volume. The OS volume is then mounted and customized via deploy plan scripts on the Image Streamer appliance. Once the OS volume customization is complete the volume is placed in server volume storage and configured as an iSCSI boot target. High-level steps for deploying ESXi using Image Streamer are:

1. Create a deployment plan for creating an empty OS volume: In order to capture an initial golden image for a given operating system, an empty volume deployment must be done and an operating system installed to this volume manually.
  - a. Create plan scripts.
  - b. Create OS build plan using plan script created in previous step.
  - c. Create deployment plan using OS build plan created previously with no selection of golden image.
2. Create the server profile utilizing the empty volume deployment plan:
  - a. Select a target HPE Synergy 620 Compute Module for the server profile from the Server Hardware drop down box.
  - b. Select the deployment plan created in the previous step from the list box.
  - c. Specify the volume size 20 GB.
  - d. Create the profile.
3. Once the Server profile is created, the new OS volume can be seen by selecting OS Volumes in the HPE Synergy Image Streamer UI.
  - a. Install the operating system: The ESXi 6.5 U1 is installed using iLO virtual media to boot to an OS distribution ISO file.
  - b. Capture the golden image:

- c. Shut down the OS.
- d. Find the OS volume number in the HPE OneView server profile created in the step above. It is listed under the OS Deployment section of the profile.
- e. On the Image Streamer Golden Image screen, select “Create Golden Image” and specify a name (“ESXi Image”), description, OS volume, and Capture OS build plan.

## Create Golden Image

Name	ESXi Image
Description	
OS volume	OSVolume-12 <span style="float: right;">✕ 🔍</span>
Capture OS build plan	HPE - ESXi - generalize full state - 2017-08-02 <span style="float: right;">✕ 🔍</span>

**Figure 5.** Golden Image creation

Once the golden image is created it must be attached to a deployment plan. We have used the golden image which was created with the above steps to deploy ESXi on the other five HPE Synergy 620 Compute Modules.

1. Create a deployment plan:
  - a. Choose a build plan for customization. We have used the “HPE - ESXi - deploy with multiple management NIC HA config- 2017-07-14” build plan, which was available from the HPE-ESXi Artifact bundle.
  - b. Choose the golden image, created in previous step.
2. Create the Synergy server profile: Created the server profile using deployment plan created in the previous step and other deployment settings.

The total time to complete the deployment on one node was less than 3 minutes.

### **HPE Synergy Compute Module BIOS**

Following BIOS settings were enabled on all six HPE Synergy 620 compute modules.

- Hyper-Threading—Enabled
- Intel® Turbo Boost—Enabled
- HPE Power Profile—Maximum Performance

## Microsoft SQL Server 2017 configuration best practices

All SQL server instances were configured with below configurations.

- MAXDOP for instances and for OLTP databases is set to 1
- Enable “Lock pages in Memory” for the user account running SQL Server 2017 instance
- Trace flag -T834: Enable large-page allocation for the buffer pool
- Trace flag -T652: Disable page pre-fetching scans.
- Multiple tempdb data files created after installation.
- Max server memory set to allow the OS to have operational memory. For our configuration, max server memory was set to 166GB for each of 16 instances and 76GB for each of 8 instances which have less numbers of databases. This provided about 30GB of memory for the operating system for each virtual machine.

## VMware vSphere

The following settings were used for virtual machines.

- Enable jumbo frames on the vSwitch for all nodes.
- SCSI adapters were created for VM disks with paravirtual (PVSCSI) drivers. Each disk (OS, data, log, tempdb) was assigned a separate SCSI adapter.
- Configure VM disk with thick eager-zeroed.
- The virtual disks path selection policy under multipathing policy was set to Round Robin.
- As a best practice, data and transaction log files were placed on separate volumes.
- We set the adapter queue depths greater than the Paravirtual SCSI (PVSCSI) default values, including:
  - Adjust the queue depth for the HBAs on the ESXi host on which the Windows® virtual machine runs.
  - Increase the PVSCSI queue depth inside the Windows virtual machine.

For more information, refer to VMware Knowledge Base article 2053145, <https://kb.vmware.com/s/article/2053145>

## Capacity and sizing

An OLTP-style workload was used to evaluate database consolidation and 3PAR compression. Four database sizes, 25GB (very small), 50GB (small), 100GB (medium), and 150GB (large) were used. Databases were created with enough disk capacity to accommodate their growing in size when running the tests. Eight load generator servers were used to generate the load on the SQL Server databases.

In this Reference Architecture, SQL Server is set up to illustrate one of many possible ways to deploy multiple databases at a reasonable scale on the HPE Synergy platform. In addition to demonstrating the scalability of the platform, the document also highlights how SQL works with the Dedupe, Compression, and Dedupe with Compression features of the platform and SQL Server high availability with vSphere high availability.

## Database consolidation

For this guide, the design model chosen was multiple databases per instance and a single instance per virtual machine. Any other valid topology could be used; this one was chosen simply for ease of implementation and testing purposes. In this solution, the HPE Synergy environment includes six compute modules with each compute module hosting four virtual machines configured using VMware vSphere. Each host contained four VMs, with a total of 24 VMs deployed across the HPE Synergy environment. The SQL Server databases were deployed as followed:

- 16 virtual machines were deployed with 4 x 25GB, 3 x 50GB, 2 x 100GB, and 1 x 150GB databases, for a total of 10 databases per VM.
- 8 virtual machines were deployed with 3 x 25GB, 2 x 50GB, and 1 x 100GB, for a total of 6 databases per VM.

Overall there were 208 databases created across 24 virtual machines.

For optimum performance, the following VM sizing criteria was used:

- No overprovisioning of memory or vCPUs was performed.
- 4:1 database size to VM memory size ratio was used.

The databases were provisioned on HPE 3PAR storage. We created thin virtual volumes for SQL data of 650GB, and 50GB volumes for the SQL logs for the virtual machines that had ten databases provisioned. Similarly, thin virtual volumes of size 300GB for SQL data, and 50GB volumes for SQL logs for the virtual machines provisioned with six databases. To speed the deployment of databases across 24 VMs, snapshots of initial virtual volumes were created. 16 snapshots of 650GB SQL data and 50GB SQL log virtual volumes were created. Another 8 snapshots of 300GB SQL data and 50GB SQL log volumes were created. SQL Server data and log virtual volumes were attached as RDM disks to the virtual machines.

**Table 2.** VM drives for VMs with 10 databases for consolidation test case

Drive	Used for	Virtual Volume Name	Provisioning	Size
C	Operating System	SynergyOs	Thin	25 GB
D	Data files	SynergyVM01_data	Thin	650 GB
E	Transaction log	SynergyVM01_log	Thin	50 GB
T	Temp DB	TempDB_SY620_bay3_94_esx	Thin	12 GB

**Table 3.** VM drives for VMs with 6 databases for consolidation test case

Drive	Used for	Virtual Volume Name	Provisioning	Size
C	Operating System	SynergyOs	Thin	25 GB
D	Data files	SynergyVM09_data	Thin	300 GB
E	Transaction log	SynergyVM09_log	Thin	50 GB
T	Temp DB	TempDB_SY620_bay5_r8_esx	Thin	12 GB

The virtual machines were imaged with Windows Server 2016 and SQL Server 2017 RTM. Each VM provisioned with 10 databases was defined with 18 vCPUs and 196GB of RAM; and each VM provisioned with 6 databases was defined with 18 vCPUs and 106GB RAM. The storage for each VM was provisioned with a boot drive, Temp DB drive, and two raw drives for Data (RAID 5) and Logs (RAID 1).

For a streamlined deployment process, the VM deployment was performed using a Windows image created using Windows Sysprep with an embedded SQL Server pre-installation. SQL instance completion was performed after VM cloning. Figures 6 and 7 show the final VM configuration for each VM after provisioning and adding volumes.

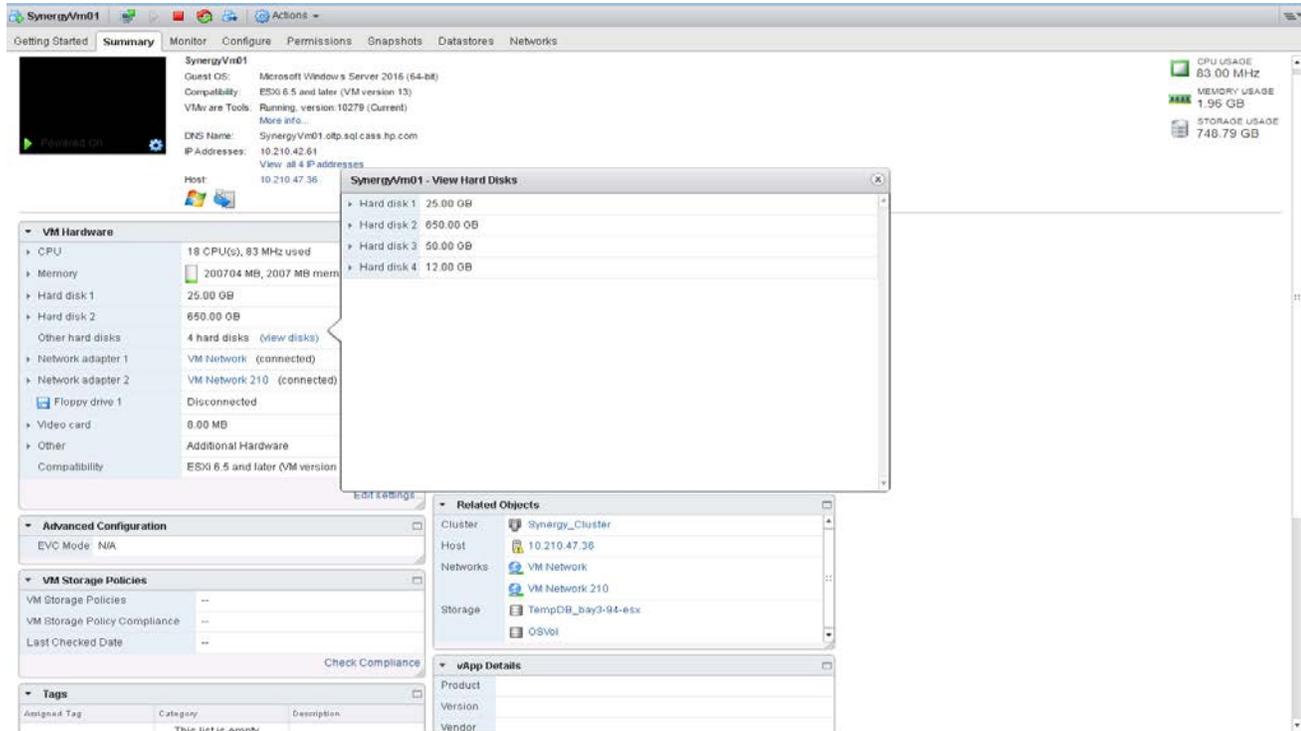


Figure 6. vSphere virtual machine detail for SynergyVm01 (VM with 10 databases)

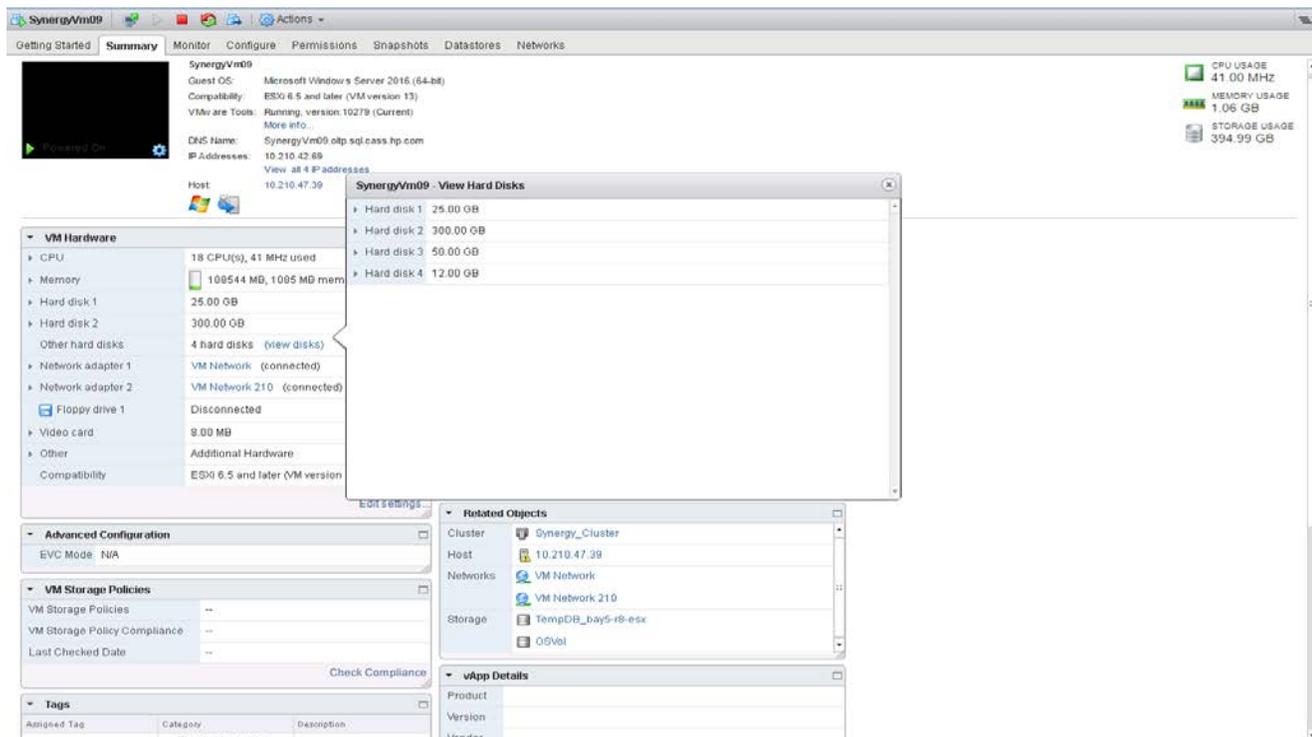


Figure 7. vSphere virtual machine detail for SynergyVm09 (VM with 6 databases)

Varied user workloads were used across VMs, tuning them for maximum performance. For this testing, a total workload of 1824 users was driving transactions across all VMs, which resulted in a maximum batch request per second with disk latencies under the expected limit of 10ms. Table 4 lists the number of VMs and their configuration that were run on the system with acceptable latencies.

**Table 4.** VM performance for consolidation test

Number of VMs	VM Core/memory	SQL Max Server Memory	Database size	Batch requests/sec	IOPS
16	18 vCPU/ 196 GB	166	600 GB	95,044	132,582
8	18 vCPU/ 106 GB	76	275 GB	25,527	32,430

With 24 VMs, the consolidation test reached 120K batch requests/second, 165K IOPS, and disk latency was less than 10ms average. While comparing the IOPS to the configured storage array capacity we were able to achieve 65% of the IOPS with 6 HPE Synergy 620 Compute Modules, which is good. We can scale the system and add more resources to achieve higher numbers.

## Data reduction

We need to use storage efficiently. One way to save on storage usage is through data reduction techniques. HPE 3PAR provides Adaptive Data Reduction (ADR), which has major functional features for improving storage efficiency:

- Thin provisioning
- Deduplication
- Compression

HPE 3PAR deduplication and compression both look to reduce the amount of physical space consumed on disk compared to the logical amount of data written or seen by the host. HPE 3PAR compression complements the existing deduplication technology to provide a further layer of data reduction. This test shows how HPE 3PAR provisioning (Thin, Thin with Dedupe, Thin with Compression, and Thin with combination of dedupe and compress) saves physical space on virtual volumes.

We deployed databases across 4 virtual machines, each with 10 databases (4 x 25GB, 3 x 50GB, 2 x 100GB, and 1 x 150GB) on the HPE 3PAR provisioned virtual volumes. The database files are 2525.12GB in total size and include pre-allocated internal space. The actual database data utilization inside the files consists of data from tables and indexes, shown below in Table 5. A total workload of 368 users was driving transactions across all VMs.

**Table 5.** Utilization of disk space within the database after running the workload

Provisioning	Database Size(GB)	Data File(GB)	Unallocated space(GB)	Reserved(GB)	Data(GB)	Index size(GB)	Unused(GB)
Thin	2571.02	2525.12	943.67	1581.44	1258.64	322.16	0.65
Thin Dedupe	2571.02	2525.12	943.45	1581.67	1258.81	322.22	0.64
Thin Compress	2571.02	2525.12	943.50	1581.62	1258.77	322.21	0.65
Thin Dedupe with Compression	2571.02	2525.12	943.48	1581.64	1258.79	322.21	0.64

Table 6 shows that the combination of thin provision virtual volume with dedupe and compression generates an overall compaction ratio that reflects maximum physical disk space savings on HPE 3PAR. This level of space saving greatly reduces system costs due to the reduction in the number of SSD drives needed to meet the same capacity requirements.

**Table 6.** HPE 3PAR virtual volume utilization for each provisioning type

Provisioning	Virtual Size(GB)	User volume Used(GB)	% of User volume Used	Reserved(GB)	Compaction	Compression
Thin	2650	2440.25	92	2449	1.1:1	-
Thin Dedupe	2650	197.52	7.4	209	13.4:1	-
Thin Compress	2650	1490.20	56.2	1505	1.8:1	1.64
Thin Dedupe with Compression	2650	133.75	5	144.38	19.8:1	1.61

A performance comparison was also performed between databases with different provisioning types. Table 7 shows the results.

**Table 7.** Performance of HPE 3PAR virtual volume with different provisioning types

Provisioning	BRPS	IOPS
Thin	21,092	25,408
Thin Dedupe	21,043	24,964
Thin Compress	20,880	24,988
Thin Dedupe with Compression	20,759	18,452

From the results, we can see that for thin deduped, thin compress, and thin dedupe with compression volumes, the average transactional BRPS counter rate is slightly lower than thin provisioned volumes.

This means the thin deduplication, compression, and compression with deduplication are valuable features for Microsoft SQL Server that result in capacity savings with minimal performance impact when enabled.

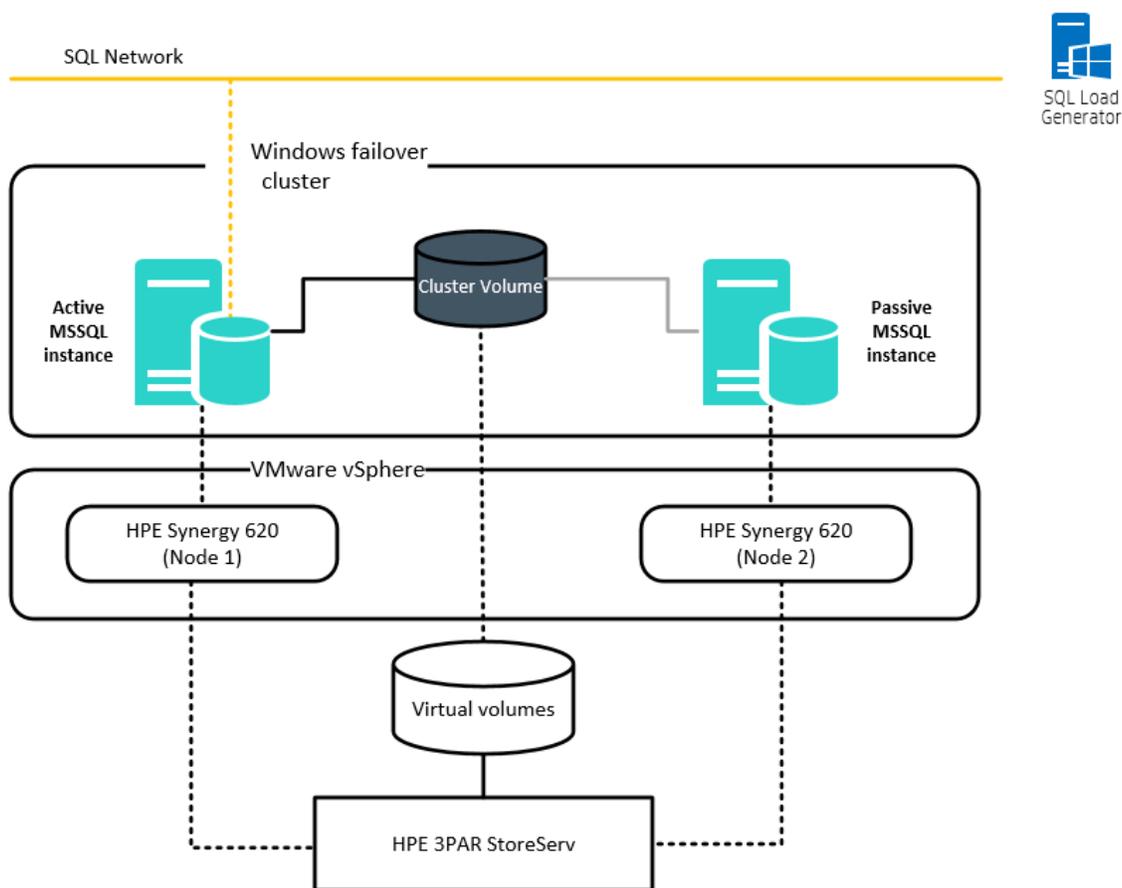
## High Availability

Along with performance and scalability, ensuring that SQL Server is highly available is a core requirement of mission critical environments. This test case focused on building a highly available SQL Server using VMware vSphere HA on an HPE Synergy platform with HPE 3PAR as storage.

For this use case, we have created a SQL Server cluster on VMware vSphere HA using cluster across boxes (cluster of virtual machines across physical hosts).

The Figure 8 shows a cluster across boxes setup.

- Two virtual machines on two different physical machines (ESXi hosts) run clustering software.
- The virtual machines share a private network connection for the private heartbeat and a public network connection.
- Each virtual machine is connected to shared storage, which is allocated on the HPE 3PAR StoreServ 8450.



**Figure 8.** Logical solution diagram for SQL Server cluster on Cluster across Box and vSphere HA.

Two virtual machines were deployed on different physical hosts connected to each other with public and private networks. Shared volume has been provisioned on HPE 3PAR 8450 and attached to the VM as RDM disk. Windows Server Failover Clustering (WSFC) was installed on both virtual machines. SQL Server cluster was installed on both virtual machines in active-passive mode.

vSphere HA was enabled with DRS turned on. A VM-VM anti affinity rule was created to keep virtual machines apart on different physical hosts. With this configuration SQL Server is highly available with vSphere HA and DRS enabled, on cluster across boxes.

To test high availability during host failure, we powered off the node which currently owned the cluster resources and SQL Server instance. The SQL Server instance and other cluster resources successfully failed over to the other node. All databases were in a healthy state after the failover. The VM which was hosted on the failed node did not move to another available node, due to the VM-VM anti affinity rule, which was expected behavior. This implementation protects against software failures and hardware failures on the physical machine.

### **Analysis and recommendations**

HPE Synergy provides a platform to support need-based deployment, which helps organizations deploy required workloads quickly and easily. The fluid resource pools and software-defined intelligence of HPE Synergy allow administrators to rapidly compose any configuration required, reducing deployment time from hours or days down to minutes.

This Reference Architecture demonstrates deploy highly available SQL Server 2017 workloads on VMware VMs with Image Streamer and demonstrates the ability to deploy “Infrastructure-as-code” using composer. By leveraging the HPE Synergy Image Streamer and HPE Synergy Composer, users can rapidly deploy hosts and install SQL server. Testing shows that the entire deployment starting from bare metal until ESXi host is up and ready for SQL installation is less than 16 minutes, which is a significant reduction as compared to traditional deployment times of hours. VM with Windows image created using Windows Sysprep with an embedded SQL Server pre-installation and cloned to deploy other VMs.

The testing performed as part of this Reference Architecture has demonstrated that running Microsoft SQL Server 2017 workloads on HPE Synergy with HPE 3PAR StoreServ can easily scale and support high availability, and consolidate OLTP databases of different sizes, while delivering sustained and scalable performance.

Additionally, the solution demonstrates leveraging the HPE 3PAR StoreServ data reduction features such as compression and dedupe to help reduce storage media costs.

For organizations looking to support enterprise SQL Server workloads, with highly available, flexible, and scalable Hybrid IT solutions, the HPE Synergy platform with HPE 3PAR is an ideal choice to achieve business goals and SLAs. Performance testing showed that we were able to achieve 65% of the IOPS of the configured storage array capacity and 125K batch requests per second with 6 HPE Synergy 620 Compute Modules. The system can be further scaled by adding more resources to achieve higher performance. The HPE Synergy solution is ideal for enterprise customers of various sizes with different workload requirements.

### **Summary**

The deployment of Microsoft SQL Server databases on HPE Synergy Composable Infrastructure and HPE 3PAR StoreServ all-flash arrays provides options to consolidate database workloads and respond to changing business workloads more quickly. This Reference Architecture demonstrated that the solution allows deployment of a modular design and the ability to deploy the environment quickly and flex the environment rapidly and seamlessly as business needs change. The use of integrated networking interconnect modules allows the deployment of a simple networking model with a reduced number of components.

This Reference Architecture describes solution testing performed in December 2017.

### **Implementing a proof-of-concept**

As a matter of best practice for all deployments, HPE recommends implementing a proof-of-concept using a test environment that matches as closely as possible the planned production environment. In this way, appropriate performance and scalability characterizations can be obtained. For help with a proof-of-concept, contact an HPE Services representative ([hpe.com/us/en/services/consulting.html](http://hpe.com/us/en/services/consulting.html)) or your HPE partner.

### **Appendix A: Bill of materials**

The following table show the bill of materials (BOM) for this solution.

---

#### **Note**

Part numbers are at time of testing and subject to change. The bill of materials does not include complete support options or other rack and power requirements. If you have questions regarding ordering, please consult with your HPE Reseller or HPE Sales Representative for more details. [hpe.com/us/en/services/consulting.html](http://hpe.com/us/en/services/consulting.html)

---

Table 8. Bill of materials

Qty	Part number	Description
<b>Frame components</b>		
3	797739-B21	HPE Synergy 12000 Frame
2	804353-B21	HPE Synergy Composer
2	804937-B21	HPE Synergy Image Streamer
6	804942-B21	HPE Synergy Frame Link Module
2	794502-B23	HPE Virtual Connect SE 40Gb F8 Module for HPE Synergy
18	798095-B21	HPE 2650 Watts Titanium Hot Plug AC Power Supply
4	779218-B21	HPE Synergy 20Gb Interconnect Link Module
4	779227-B21	HPE Virtual Connect SE 16Gb FC Module for HPE Synergy
<b>HPE Synergy Compute Module components</b>		
6	834485-B21	HPE SY 620 Gen9 2S-EX CTO Compute Module
6	777430-B21	HPE Synergy 3820C 10/20Gb Converged Network Adapter
6	777452-B21	HPE Synergy 3830C 16G Fibre Channel Host Bus Adapter
6	834501-B21	HPE Synergy 620/680 Gen9 Intel® Xeon® E7-8870 v4 (2.1GHz/20-core/50MB/140W)
6	834501-L21	HPE Synergy 620/680 Gen9 Intel Xeon E7-8870 v4 (2.1GHz/20-core/50MB/140W) FIO Processor Kit
48	805351-B21	HPE 32GB (1x32GB) Dual Rank x4 DDR4-2400 CAS-17-17-17 Registered Memory Kit
<b>HPE 3PAR Storage</b>		
1	BW904A	HPE 42U 600x1075mm Enterprise Shock Rack
1	H6Z25A	HPE 3PAR StoreServ 8450 4N Stor Cent Base
4	H6Z00A	HPE 3PAR 8000 4-pt 16Gb FC Adapter
64	K2Q95A	HPE 3PAR 8000 480GB SFF SSD
1	L7C17A	HPE 3PAR 8450 OS Suite Base LTU
64	L7C18A	HPE 3PAR 8450 OS Suite Drive LTU
8	H6Z26A	HPE 3PAR 8000 SFF(2.5in) SAS Drive Encl
1	K2R28A	HPE 3PAR StoreServ SPS Service Processor
1	TK808A	HPE Rack Front Door Cover Kit
80	QK735A	HPE Premier Flex LC/LC OM4 2f 15m Cbl
16	QK734A	HPE Premier Flex LC/LC OM4 2f 5m Cbl
4	H5M58A	HPE Basic 4.9kVA/L6-30P/C13/NA/J PDU
1	BW906A	HPE 42U 1075mm Side Panel Kit
1	BD362A	HPE 3PAR StoreServ Mgmt/Core SW Media
1	BD363A	HPE 3PAR OS Suite Latest Media
1	BD365A	HPE 3PAR SP SW Latest Media
1	TC472A	HPE Intelligent Inft Analyzer SW v2 LTU
<b>Switches</b>		
1	JH179A	HPE FlexFabric 5930 4-slot Switch
2	QR480B	HPE SN6000B 16Gb 48/48 FC Switch
96	QK724A	HPE B-series 16Gb SFP+SW XCVR

## Resources and additional links

HPE Reference Architectures, [hpe.com/info/ra](http://hpe.com/info/ra)

HPE Synergy, [hpe.com/synergy](http://hpe.com/synergy)

HPE 3PAR StoreServ Storage, [hpe.com/storage/3par](http://hpe.com/storage/3par)

HPE 3PAR StoreServ Storage reference and best practices guide, <http://h20195.www2.hpe.com/V2/GetDocument.aspx?docname=4AA4-4524ENW>

HPE OneView, [hpe.com/info/hpeov](http://hpe.com/info/hpeov)

HPE Storage, [hpe.com/storage](http://hpe.com/storage)

HPE Networking, [hpe.com/networking](http://hpe.com/networking)

Architecting Microsoft SQL Server on VMware vSphere, [vmware.com/content/dam/digitalmarketing/vmware/en/pdf/solutions/sql-server-on-vmware-best-practices-guide.pdf](http://vmware.com/content/dam/digitalmarketing/vmware/en/pdf/solutions/sql-server-on-vmware-best-practices-guide.pdf)

Setup for Failover Clustering and Microsoft Cluster Service, <https://docs.vmware.com/en/VMware-vSphere/6.5/vsphere-esxi-vcenter-server-6.5-setup-mscs.pdf>

SQL Server Failover Cluster Installation, <https://docs.microsoft.com/en-us/sql/sql-server/failover-clusters/install/sql-server-failover-cluster-installation>

To help us improve our documents, please provide feedback at [hpe.com/contact/feedback](http://hpe.com/contact/feedback).



**Sign up for updates**



---

© Copyright 2018 Hewlett Packard Enterprise Development LP. The information contained herein is subject to change without notice. The only warranties for Hewlett Packard Enterprise products and services are set forth in the express warranty statements accompanying such products and services. Nothing herein should be construed as constituting an additional warranty. Hewlett Packard Enterprise shall not be liable for technical or editorial errors or omissions contained herein.

Microsoft, Windows Server, and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries. VMware is a registered trademark or trademark of VMware, Inc. in the United States and/or other jurisdictions. Intel and Xeon are trademarks of Intel Corporation in the U.S. and other countries. Red Hat is a registered trademark of Red Hat, Inc. in the United States and other countries. Linux is the registered trademark of Linus Torvalds in the U.S. and other countries.

a00040635enw, January 2018