Best Practices

NetApp Solutions SAP

NetApp
December 03, 2023

Table of Contents

Best Practices . . . 1
SAP HANA on NetApp AFF Systems with FCP Configuration Guide . . . 1
SAP HANA on NetApp AFF Systems with NFS Configuration Guide . . . 48
SAP HANA on NetApp FAS Systems with NFS Configuration Guide . . . 92
SAP HANA on FAS Systems with FCP Configuration Guide . . . 137
TR-4821: SAP HANA on IBM Power Systems and NetApp AFF Systems with NFS . . . 191
TR-4250: SAP with Oracle on UNIX and NFS with NetApp ONTAP and SnapManager for SAP 3.4 . . . 191
TR-4467: SAP with Microsoft SQL Server on Windows - Best Practices Using NetApp ONTAP and SnapCenter . . . 192

Best Practices

SAP HANA on NetApp AFF Systems with FCP Configuration Guide

TR-4436: SAP HANA on NetApp AFF Systems with Fibre Channel Protocol

Nils Bauer and Marco Schoen, NetApp

Introduction

The NetApp AFF A-Series and AFF C-Series product families have been certified for use with SAP HANA in tailored data center integration (TDI) projects.

This certification is valid for the following models:

- AFF A150, AFF A250, AFF A400, AFF A800, AFF A900
- AFF C250, AFF C400, AFF C800
- ASA A250, ASA A400, ASA A800, ASA A900
- ASA C250, ASA C400, ASA C800

NetApp AFF and ASA C-Series requires NetApp ONTAP 9.13.1 or later

For a complete list of NetApp certified storage solutions for SAP HANA, see the Certified and supported SAP HANA hardware directory.

This document describes AFF configurations that use the Fibre Channel Protocol (FCP).

The configuration described in this paper is necessary to achieve the required SAP HANA KPIs and the best performance for SAP HANA. Changing any settings or using features not listed herein might cause performance degradation or unexpected behavior and should only be done if advised by NetApp support.

The configuration guides for AFF systems using NFS and NetApp FAS systems can be found using the following links:

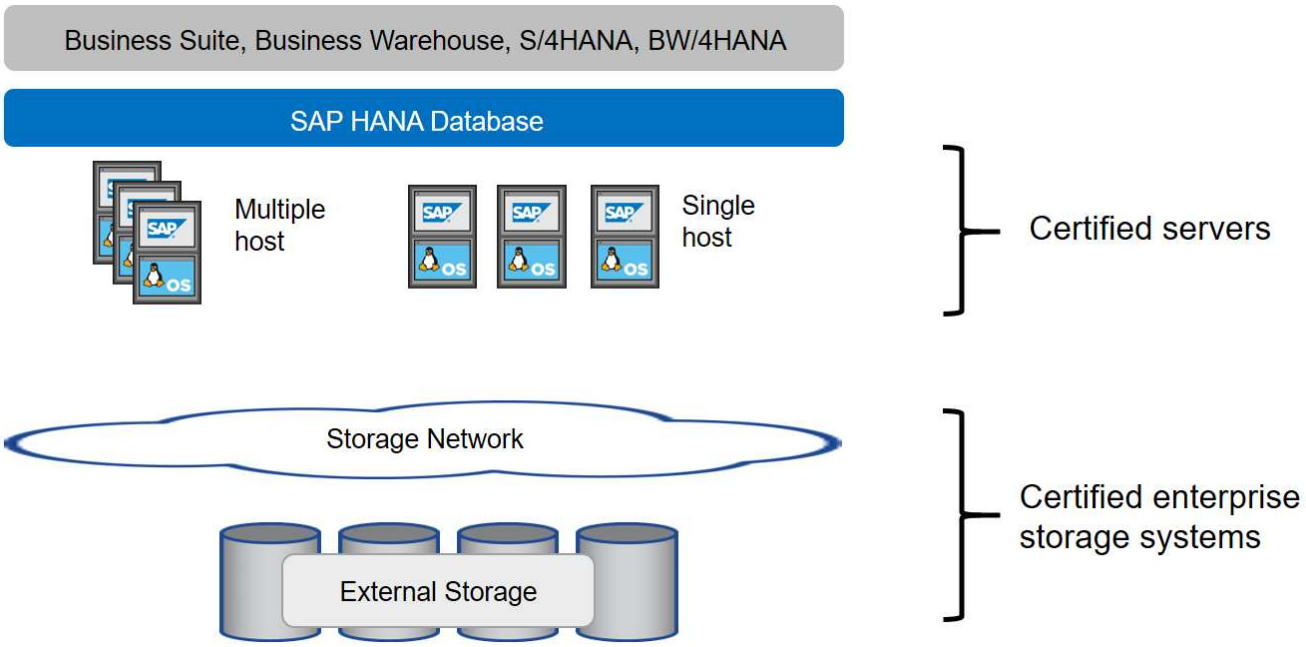
- SAP HANA on NetApp FAS Systems with FCP
- SAP HANA on NetApp FAS Systems with NFS
- SAP HANA on NetApp AFF Systems with NFS

In an SAP HANA multiple-host environment, the standard SAP HANA storage connector is used to provide fencing in the event of an SAP HANA host failover. Always refer to the relevant SAP notes for operating system configuration guidelines and HANA specific Linux kernel dependencies. For more information, see SAP Note 2235581 – SAP HANA Supported Operating Systems.

SAP HANA tailored data center integration

NetApp AFF storage systems are certified in the SAP HANA TDI program using both NFS (NAS) and FC (SAN) protocols. They can be deployed in any of the current SAP HANA scenarios, such as SAP Business

Suite on HANA, S/4HANA, BW/4HANA, or SAP Business Warehouse on HANA in either single-host or multiple-host configurations. Any server that is certified for use with SAP HANA can be combined with NetApp certified storage solutions. The following figure shows an architecture overview.



For more information regarding the prerequisites and recommendations for productive SAP HANA systems, see the following resource:

- SAP HANA Tailored Data Center Integration Frequently Asked Questions

SAP HANA using VMware vSphere

There are several options to connect storage to virtual machines (VMs). The preferred one is to connect the storage volumes with NFS directly out of the guest operating system. This option is described in SAP HANA on NetApp AFF Systems with NFS.

Raw device mappings (RDM), FCP datastores, or VVOL datastores with FCP are supported as well. For both datastore options, only one SAP HANA data or log volume must be stored within the datastore for productive use cases. In addition, Snapshot-based backup and recovery orchestrated by SnapCenter and solutions based on this, such as SAP System cloning, cannot be implemented.

For more information about using vSphere with SAP HANA, see the following links:

- SAP HANA on VMware vSphere - Virtualization - Community Wiki
- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere
- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere
- 2161991 - VMware vSphere configuration guidelines - SAP ONE Support Launchpad (Login required)

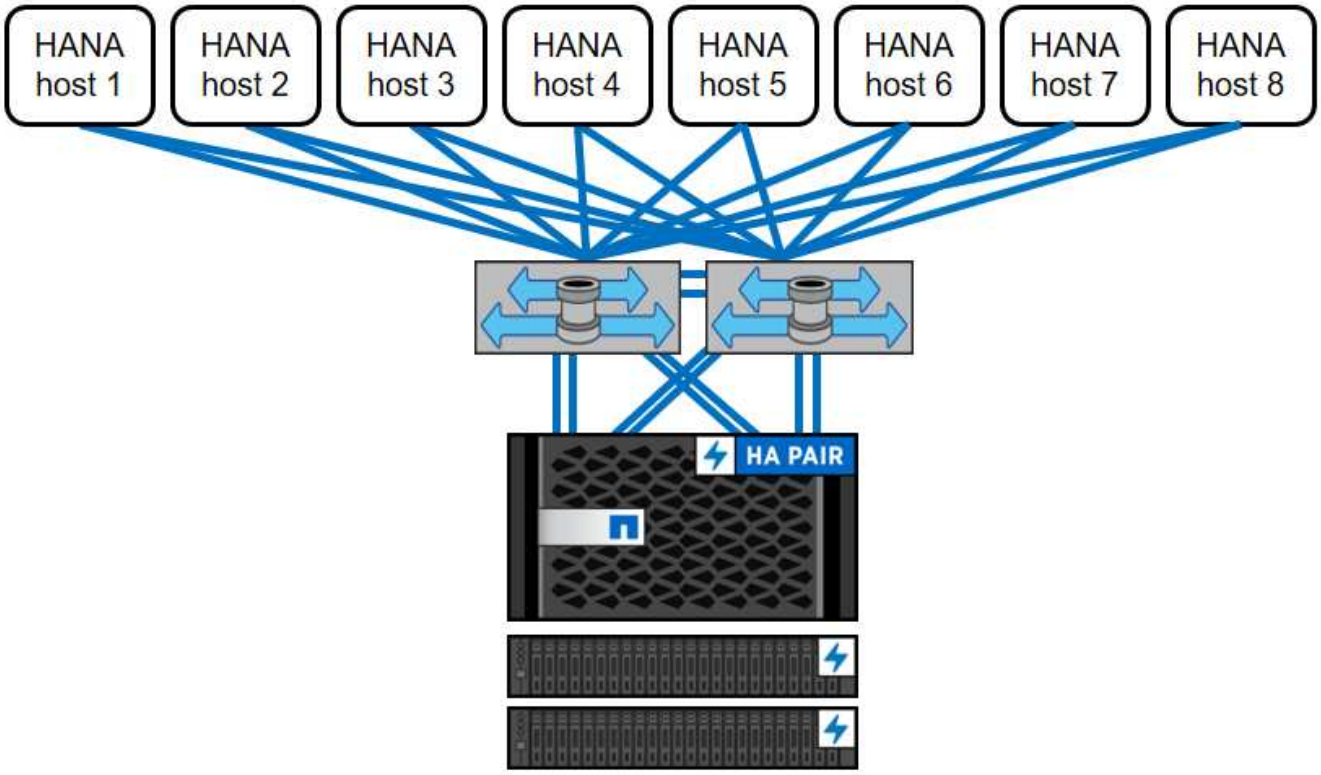
Architecture

SAP HANA hosts are connected to storage controllers using a redundant FCP infrastructure and multipath software. A redundant FCP switch infrastructure is required to provide fault-tolerant SAP HANA host-to-storage connectivity in case of switch or host

bus adapter (HBA) failure. Appropriate zoning must be configured at the switch to allow all HANA hosts to reach the required LUNs on the storage controllers.

Different models of the AFF system product family can be mixed and matched at the storage layer to allow for growth and differing performance and capacity needs. The maximum number of SAP HANA hosts that can be attached to the storage system is defined by the SAP HANA performance requirements and the model of NetApp controller used. The number of required disk shelves is only determined by the capacity and performance requirements of the SAP HANA systems.

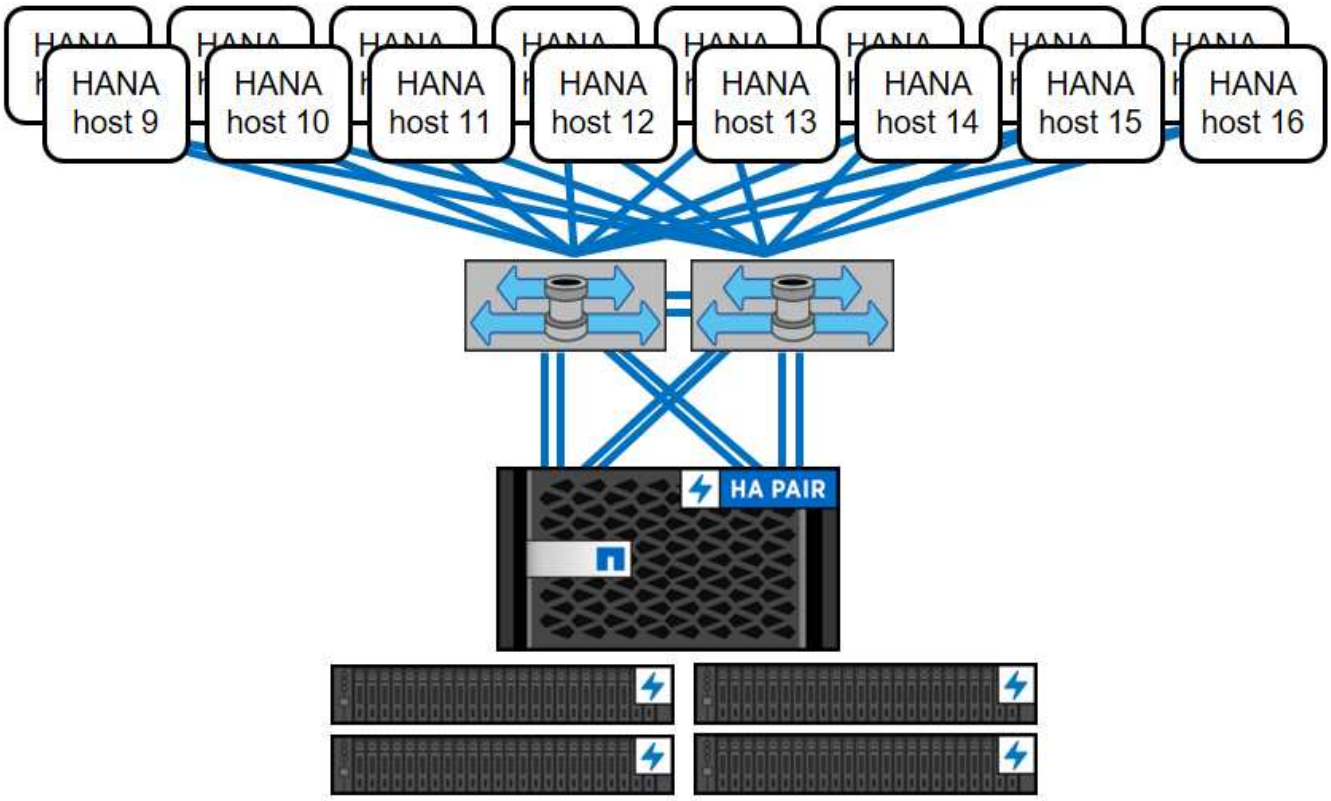
The following figure shows an example configuration with eight SAP HANA hosts attached to a storage HA pair.



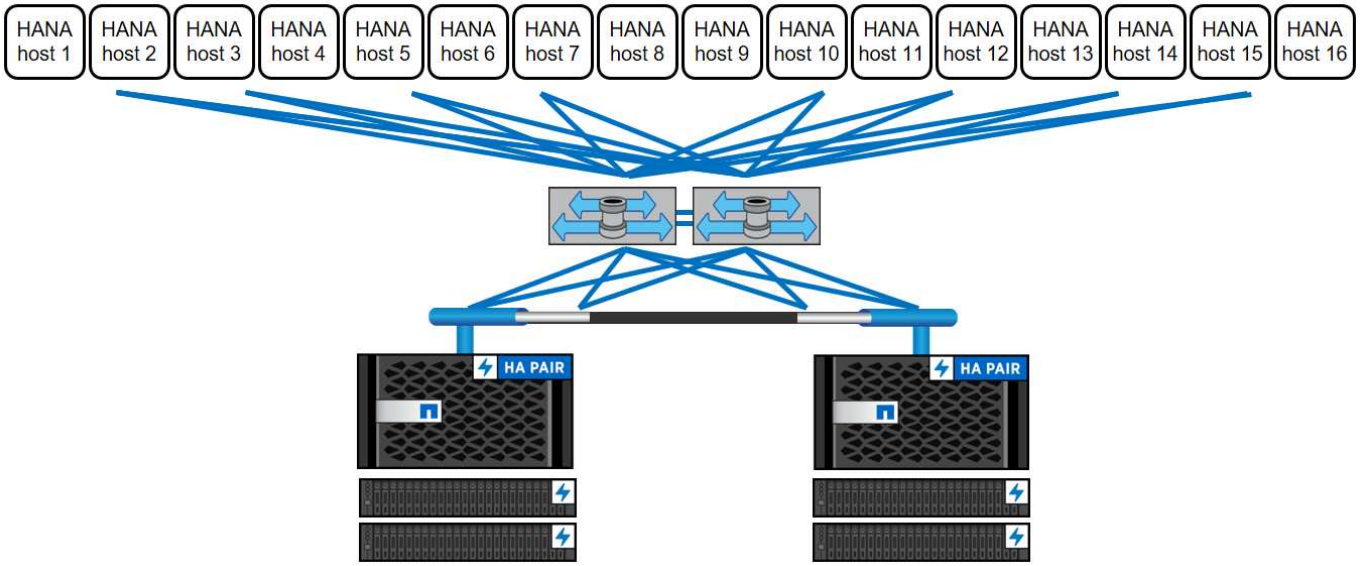
This architecture can be scaled in two dimensions:

- By attaching additional SAP HANA hosts and storage capacity to the existing storage, if the storage controllers provide enough performance to meet the current SAP HANA KPIs
- By adding more storage systems with additional storage capacity for the additional SAP HANA hosts

The following figure shows a configuration example in which more SAP HANA hosts are attached to the storage controllers. In this example, more disk shelves are necessary to meet the capacity and performance requirements of the 16 SAP HANA hosts. Depending on the total throughput requirements, you must add additional FC connections to the storage controllers.



Independent of the deployed AFF system, the SAP HANA landscape can also be scaled by adding any certified storage controllers to meet the desired node density, as shown in the following figure.



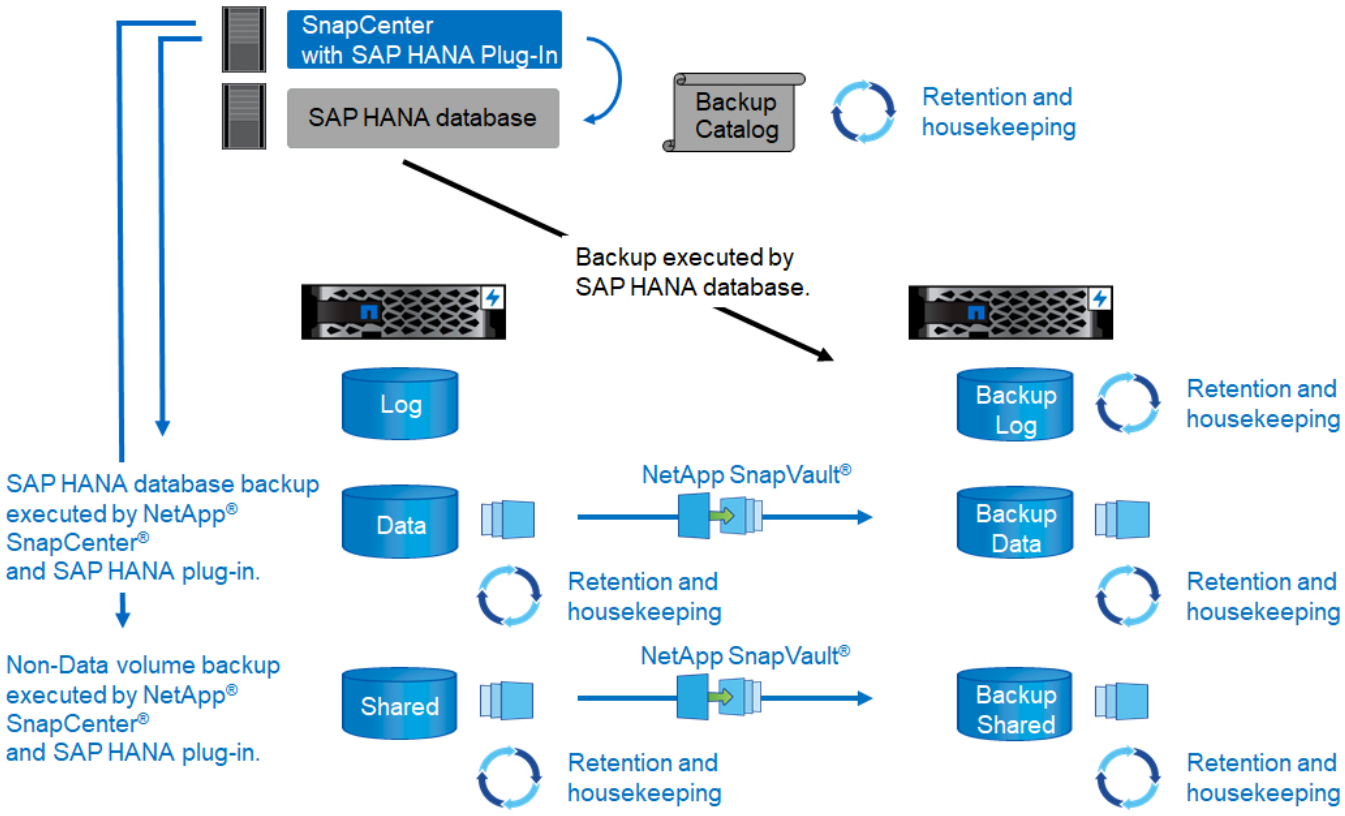
SAP HANA backup

The ONTAP software present on all NetApp storage controllers provides a built-in mechanism to back up SAP HANA databases while in operation with no effect on performance. Storage-based NetApp Snapshot backups are a fully supported and integrated backup solution available for SAP HANA single containers and for SAP HANA MDC systems with a single tenant or multiple tenants.

Storage-based Snapshot backups are implemented by using the NetApp SnapCenter plug-in for SAP HANA. This allows users to create consistent storage-based Snapshot backups by using the interfaces provided natively by SAP HANA databases. SnapCenter registers each of the Snapshot backups into the SAP HANA backup catalog. Therefore, backups taken by SnapCenter are visible within SAP HANA Studio or Cockpit where they can be selected directly for restore and recovery operations.

NetApp SnapMirror technology allows for Snapshot copies that were created on one storage system to be replicated to a secondary backup storage system that is controlled by SnapCenter. Different backup retention policies can then be defined for each of the backup sets on the primary storage and also for the backup sets on the secondary storage systems. The SnapCenter Plug-in for SAP HANA automatically manages the retention of Snapshot copy-based data backups and log backups, including the housekeeping of the backup catalog. The SnapCenter Plug-in for SAP HANA also allows for the execution of a block integrity check of the SAP HANA database by executing a file-based backup.

The database logs can be backed up directly to the secondary storage by using an NFS mount, as shown in the following figure.



Storage-based Snapshot backups provide significant advantages compared to conventional file-based backups. These advantages include, but are not limited to the following:

- Faster backup (a few minutes)
- Reduced RTO due to a much faster restore time on the storage layer (a few minutes) as well as more frequent backups
- No performance degradation of the SAP HANA database host, network, or storage during backup and recovery operations
- Space-efficient and bandwidth-efficient replication to secondary storage based on block changes

For detailed information about the SAP HANA backup and recovery solution, see TR-4614: SAP HANA Backup and Recovery with SnapCenter.

SAP HANA disaster recovery

SAP HANA disaster recovery can be done either on the database layer by using SAP HANA system replication or on the storage layer by using storage replication technologies. The following section provides an overview of disaster recovery solutions based on storage replication.

For detailed information about the SAP HANA disaster recovery solutions, see TR-4646: SAP HANA Disaster Recovery with Storage Replication.

Storage replication based on SnapMirror

The following figure shows a three-site disaster recovery solution using synchronous SnapMirror replication to the local DR datacenter and asynchronous SnapMirror to replicate the data to the remote DR datacenter.

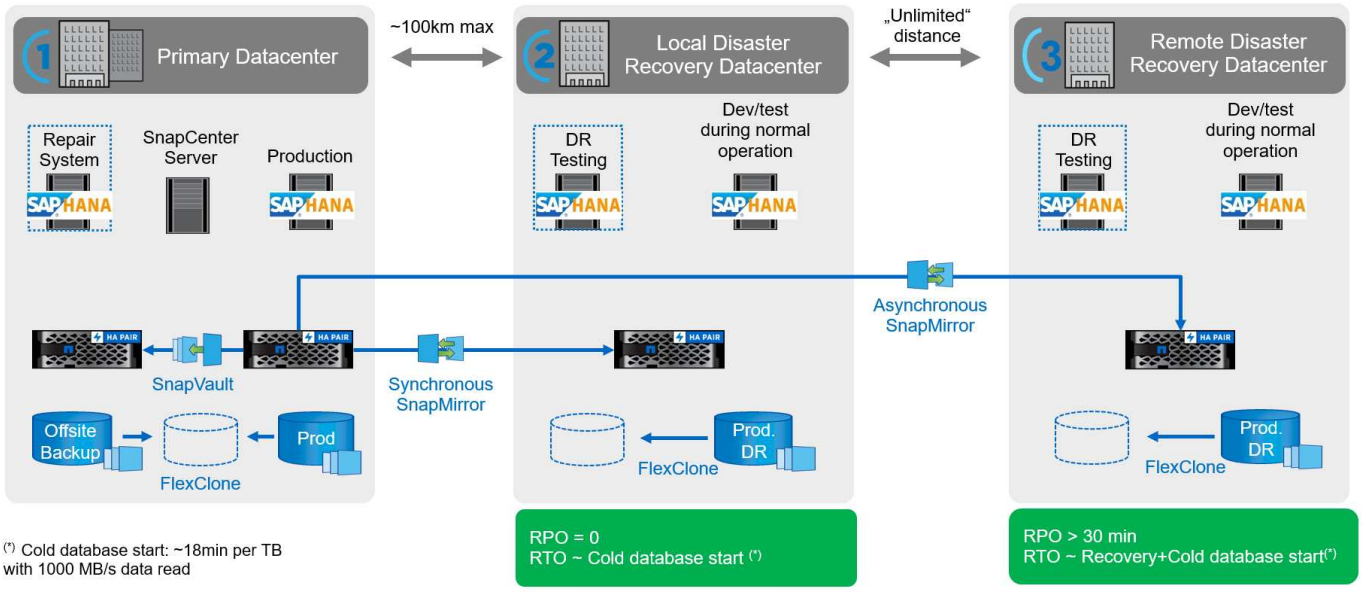
Data replication using synchronous SnapMirror provides an RPO of zero. The distance between the primary and the local DR datacenter is limited to around 100km.

Protection against failures of both the primary and the local DR site is performed by replicating the data to a third remote DR datacenter using asynchronous SnapMirror. The RPO depends on the frequency of replication updates and how fast they can be transferred. In theory, the distance is unlimited, but the limit depends on the amount of data that must be transferred and the connection that is available between the data centers. Typical RPO values are in the range of 30 minutes to multiple hours.

The RTO for both replication methods primarily depends on the time needed to start the HANA database at the DR site and load the data into memory. With the assumption that the data is read with a throughput of 1000MBps, loading 1TB of data would take approximately 18 minutes.

The servers at the DR sites can be used as dev/test systems during normal operation. In the case of a disaster, the dev/test systems would need to be shut down and started as DR production servers.

Both replication methods allow to you execute DR workflow testing without influencing the RPO and RTO. FlexClone volumes are created on the storage and are attached to the DR testing servers.

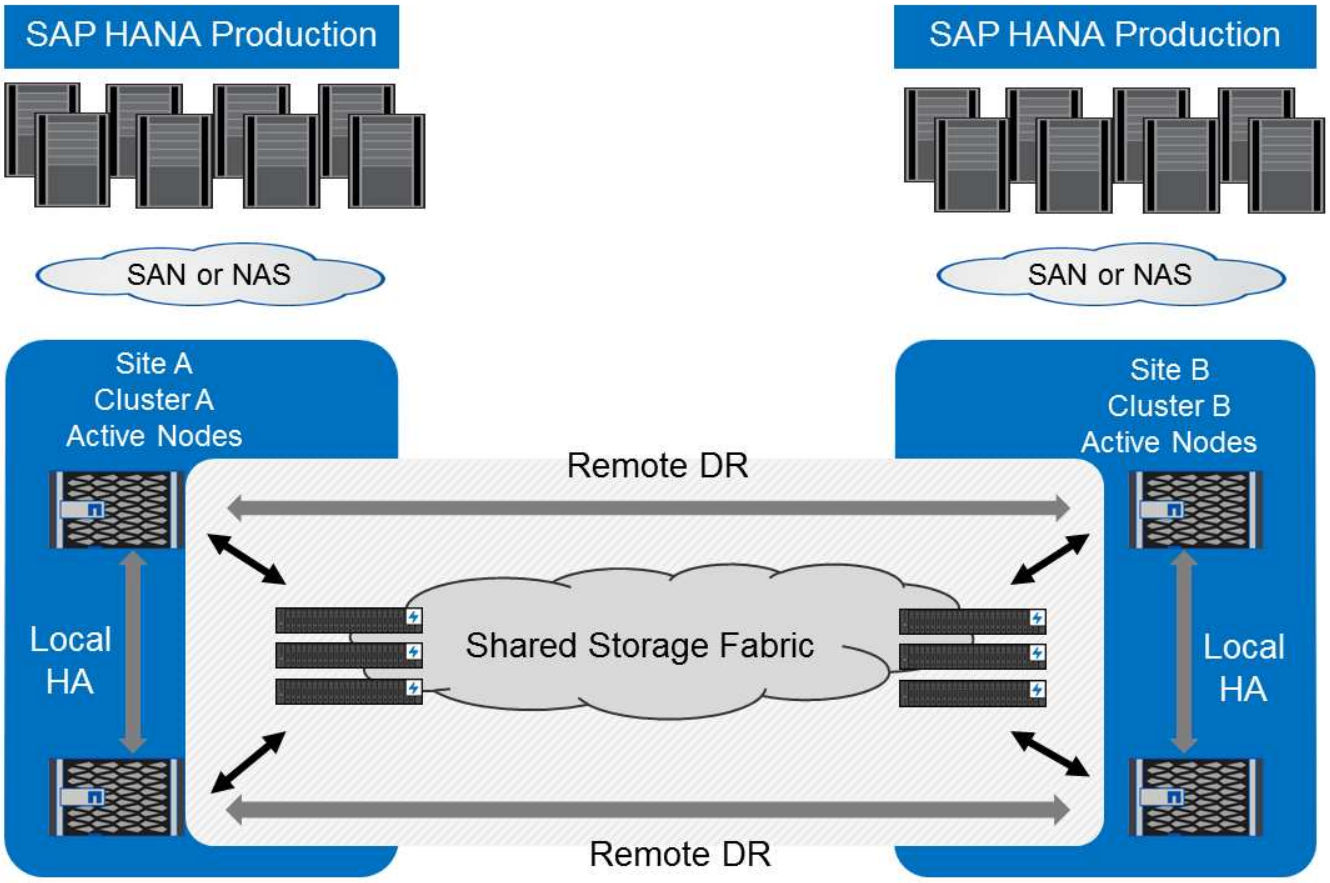


Synchronous replication offers StrictSync mode. If the write to secondary storage is not completed for any reason, the application I/O fails, thereby ensuring that the primary and secondary storage systems are identical. Application I/O to the primary resumes only after the SnapMirror relationship returns to the InSync status. If the primary storage fails, application I/O can be resumed on the secondary storage after failover with

no loss of data. In StrictSync mode, the RPO is always zero.

Storage replication based on NetApp MetroCluster

The following figure shows a high-level overview of the solution. The storage cluster at each site provides local high availability and is used for the production workload. The data of each site is synchronously replicated to the other location and is available in case of disaster failover.



Storage sizing

The following section provides an overview of performance and capacity considerations required for sizing a storage system for SAP HANA.

Contact your NetApp or NetApp partner sales representative to support the storage sizing process and to assist you with creating a properly sized storage environment.

Performance considerations

SAP has defined a static set of storage key performance indicators (KPIs). These KPIs are valid for all production SAP HANA environments independent of the memory size of the database hosts and the applications that use the SAP HANA database. These KPIs are valid for single-host, multiple-host, Business Suite on HANA, Business Warehouse on HANA, S/4HANA, and BW/4HANA environments. Therefore, the current performance sizing approach depends on only the number of active SAP HANA hosts that are attached to the storage system.

Storage performance KPIs are only mandated for production SAP HANA systems, but you can implement them in for all HANA system.

SAP delivers a performance test tool which must be used to validate the storage systems performance for active SAP HANA hosts attached to the storage.

NetApp tested and predefined the maximum number of SAP HANA hosts that can be attached to a specific storage model, while still fulfilling the required storage KPIs from SAP for production-based SAP HANA systems.

The maximum number of SAP HANA hosts that can be run on a disk shelf and the minimum number of SSDs required per SAP HANA host were determined by running the SAP performance test tool. This test does not consider the actual storage capacity requirements of the hosts. You must also calculate the capacity requirements to determine the actual storage configuration needed.

SAS disk shelf

With the 12Gb SAS disk shelf (DS224C), the performance sizing is performed by using fixed disk- shelf configurations:

- Half-loaded disk shelves with 12 SSDs
- Fully loaded disk shelves with 24 SSDs

Both configurations use advanced drive partitioning (ADPv2). A half-loaded disk shelf supports up to 9 SAP HANA hosts; a fully loaded shelf supports up to 14 hosts in a single disk shelf. The SAP HANA hosts must be equally distributed between both storage controllers.

The DS224C disk shelf must be connected by using 12Gb SAS to support the number of SAP HANA hosts.

The 6Gb SAS disk shelf (DS2246) supports a maximum of 4 SAP HANA hosts. The SSDs and the SAP HANA hosts must be equally distributed between both storage controllers. The following figure summarizes the supported number of SAP HANA hosts per disk shelf.

	6Gb SAS shelves (DS2246)Fully loaded with 24 SSDs	**12Gb SAS shelves (DS224C)Half-loaded with 12 SSDs and ADPv2**	**12Gb SAS shelves (DS224C)Fully loaded with 24 SSDs and ADPv2**
Maximum number of SAP HANA hosts per disk shelf	4	9	14

This calculation is independent of the storage controller used. Adding more disk shelves does not increase the maximum number of SAP HANA hosts that a storage controller can support.

NS224 NVMe shelf

The minimum number of 12 NVMe SSDs for the first shelf supports up to 18 SAP HANA hosts. A fully populated shelf supports up to 48 SAP HANA hosts.

Adding more disk shelves does not increase the maximum number of SAP HANA hosts that a storage controller can support.

Mixed workloads

SAP HANA and other application workloads running on the same storage controller or in the same storage aggregate are supported. However, it is a NetApp best practice to separate SAP HANA workloads from all other application workloads.

You might decide to deploy SAP HANA workloads and other application workloads on either the same storage controller or the same aggregate. If so, you must make sure that adequate performance is available for SAP HANA within the mixed workload environment. NetApp also recommends that you use quality of service (QoS) parameters to regulate the effect these other applications could have on SAP HANA applications and to guarantee throughput for SAP HANA applications.

The SAP HCMT test tool must be used to check if additional SAP HANA hosts can be run on an existing storage controller that is already in use for other workloads. SAP application servers can be safely placed on the same storage controller and/or aggregate as the SAP HANA databases.

Capacity considerations

A detailed description of the capacity requirements for SAP HANA is in the SAP Note 1900823 white paper.

The capacity sizing of the overall SAP landscape with multiple SAP HANA systems must be determined by using SAP HANA storage sizing tools from NetApp. Contact NetApp or your NetApp partner sales representative to validate the storage sizing process for a properly sized storage environment.

Configuration of performance test tool

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage system used. These parameters must also be set for the performance test tool from SAP when the storage performance is being tested with the SAP test tool.

NetApp conducted performance tests to define the optimal values. The following table lists the parameters that must be set within the configuration file of the SAP test tool.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For more information about the configuration of SAP test tool, see SAP note 1943937 for HWCCT (SAP HANA 1.0) and SAP note 2493172 for HCMT/HCOT (SAP HANA 2.0).

The following example shows how variables can be set for the HCMT/HCOT execution plan.

```
…
{
         "Comment": "Log Volume: Controls whether read requests are
submitted asynchronously, default is 'on'",
         "Name": "LogAsyncReadSubmit",
```

```
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls whether read requests are
submitted asynchronously, default is 'on'",
         "Name": "DataAsyncReadSubmit",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "LogAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "DataAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "LogAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "DataAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "LogExtMaxParallelIoRequests",
         "Value": "128",
         "Request": "false"
```

```
      },
      {
         "Comment": "Data Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "DataExtMaxParallelIoRequests",
         "Value": "128",
         "Request": "false"
      }, …
```

These variables must be used for the test configuration. This is usually the case with the predefined execution plans SAP delivers with the HCMT/HCOT tool. The following example for a 4k log write test is from an execution plan.

```
…
      {
         "ID": "D664D001-933D-41DE-A904F304AEB67906",
         "Note": "File System Write Test",
         "ExecutionVariants": [
            {
               "ScaleOut": {
                  "Port": "${RemotePort}",
                  "Hosts": "${Hosts}",
                  "ConcurrentExecution": "${FSConcurrentExecution}"
               },
               "RepeatCount": "${TestRepeatCount}",
               "Description": "4K Block, Log Volume 5GB, Overwrite",
               "Hint": "Log",
               "InputVector": {
                  "BlockSize": 4096,
                  "DirectoryName": "${LogVolume}",
                  "FileOverwrite": true,
                  "FileSize": 5368709120,
                  "RandomAccess": false,
                  "RandomData": true,
                  "AsyncReadSubmit": "${LogAsyncReadSubmit}",
                  "AsyncWriteSubmitActive":
"${LogAsyncWriteSubmitActive}",
                  "AsyncWriteSubmitBlocks":
"${LogAsyncWriteSubmitBlocks}",
                  "ExtMaxParallelIoRequests":
"${LogExtMaxParallelIoRequests}",
                  "ExtMaxSubmitBatchSize": "${LogExtMaxSubmitBatchSize}",
                  "ExtMinSubmitBatchSize": "${LogExtMinSubmitBatchSize}",
                  "ExtNumCompletionQueues":
"${LogExtNumCompletionQueues}",
                  "ExtNumSubmitQueues": "${LogExtNumSubmitQueues}",
                  "ExtSizeKernelIoQueue": "${ExtSizeKernelIoQueue}"
               }
            },
…
```

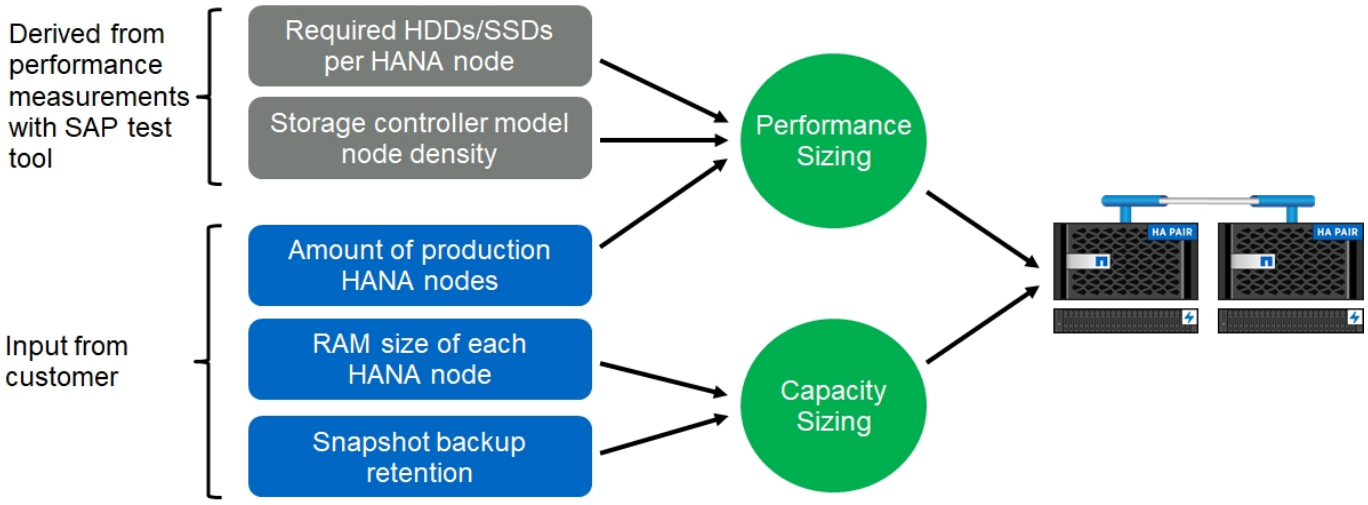
Storage sizing process overview

The number of disks per HANA host and the SAP HANA host density for each storage model were determined using the SAP HANA test tool.

The sizing process requires details such as the number of production and nonproduction SAP HANA hosts, the RAM size of each host, and the backup retention of the storage-based Snapshot copies. The number of SAP HANA hosts determines the storage controller and the number of disks required.

The size of the RAM, net data size on the disk of each SAP HANA host, and the Snapshot copy backup retention period are used as inputs during capacity sizing.

The following figure summarizes the sizing process.



Infrastructure setup and configuration

Infrastructure setup and configuration

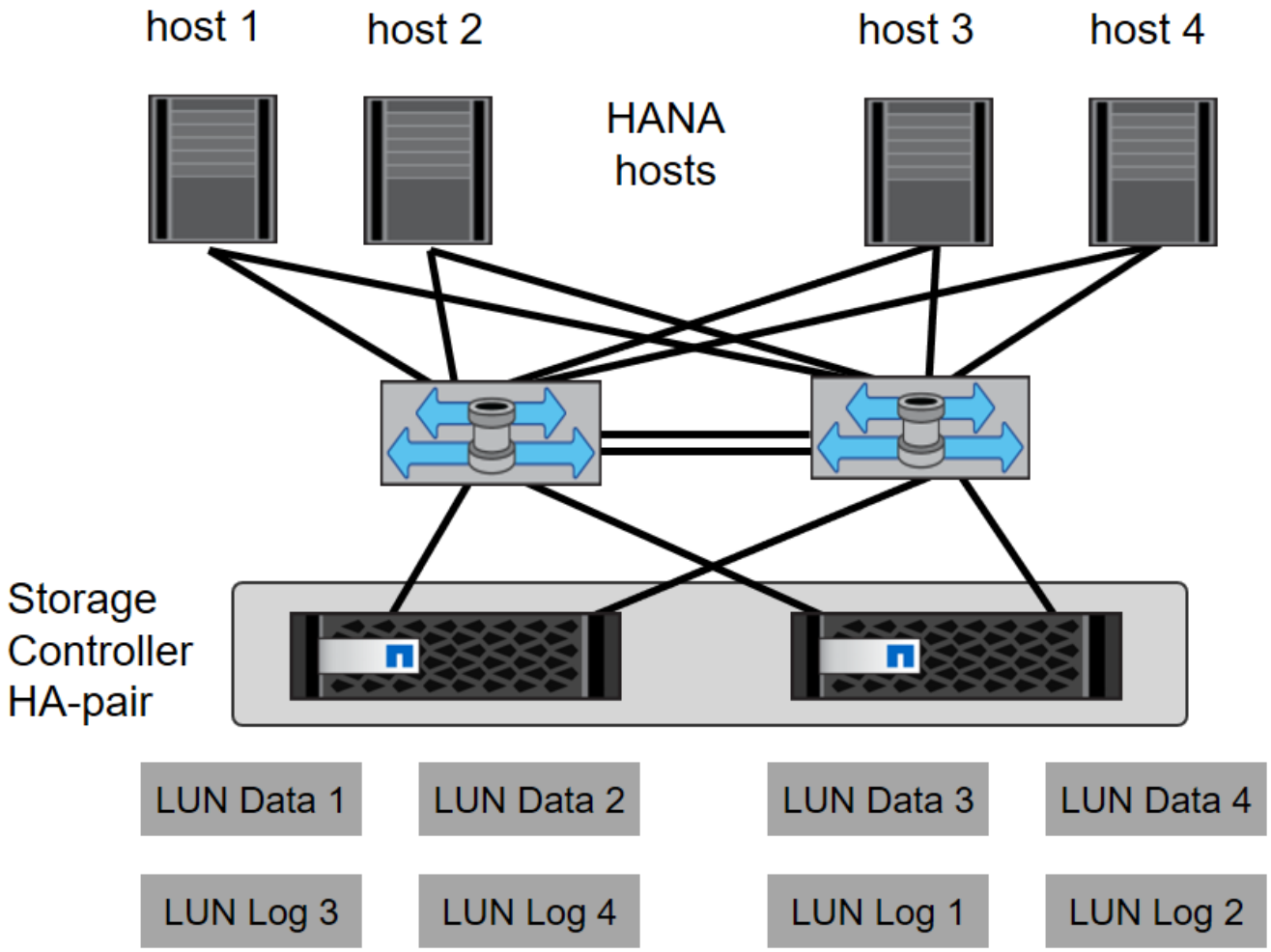
The following sections provide SAP HANA infrastructure setup and configuration guidelines and describes all the steps needed to set up an SAP HANA system. Within these sections, the following example configurations are used:

- HANA system with SID=SS3 and ONTAP 9.7 or earlier
  - SAP HANA single and multiple host
  - SAP HANA single host using SAP HANA multiple partitions
- HANA system with SID=FC5 and ONTAP 9.8 using Linux logical volume manager (LVM)
  - SAP HANA single and multiple host

SAN fabric setup

Each SAP HANA server must have a redundant FCP SAN connection with a minimum of 8Gbps bandwidth. For each SAP HANA host attached to a storage controller, at least 8Gbps bandwidth must be configured at the storage controller.

The following figure shows an example with four SAP HANA hosts attached to two storage controllers. Each SAP HANA host has two FCP ports connected to the redundant fabric. At the storage layer, four FCP ports are configured to provide the required throughput for each SAP HANA host.



In addition to the zoning on the switch layer, you must map each LUN on the storage system to the hosts that connect to this LUN. Keep the zoning on the switch simple; that is, define one zone set in which all host HBAs can see all controller HBAs.

Time synchronization

You must synchronize the time between the storage controllers and the SAP HANA database hosts. To do so, set the same time server for all storage controllers and all SAP HANA hosts.

Storage controller setup

This section describes the configuration of the NetApp storage system. You must complete the primary installation and setup according to the corresponding Data ONTAP setup and configuration guides.

Storage efficiency

Inline deduplication, cross-volume inline deduplication, inline compression, and inline compaction are supported with SAP HANA in an SSD configuration.

NetApp Volume and Aggregate Encryption

The use of NetApp Volume Encryption (NVE) and NetApp Aggregate Encryption (NAE) are supported with SAP HANA.

Quality of service

QoS can be used to limit the storage throughput for specific SAP HANA systems or no- SAP applications on a shared-use controller. One use case would be to limit the throughput of development and test systems so that they cannot influence production systems in a mixed setup.

During the sizing process, you should determine the performance requirements of a nonproduction system. Development and test systems can be sized with lower performance values, typically in the range of 20% to 50% of a production-system KPI as defined by SAP.

Starting with ONTAP 9, QoS is configured on the storage volume level and uses maximum values for throughput (MBps) and the amount of I/O (IOPS).

Large write I/O has the biggest performance effect on the storage system. Therefore, the QoS throughput limit should be set to a percentage of the corresponding write SAP HANA storage performance KPI values in the data and log volumes.

NetApp FabricPool

NetApp FabricPool technology must not be used for active primary file systems in SAP HANA systems. This includes the file systems for the data and log area as well as the `/hana/shared` file system. Doing so results in unpredictable performance, especially during the startup of an SAP HANA system.

You can use the Snapshot-Only tiering policy along with FabricPool at a backup target such as SnapVault or SnapMirror destination.

> ⓘ Using FabricPool for tiering Snapshot copies at primary storage or using FabricPool at a backup target changes the required time for the restore and recovery of a database or other tasks such as creating system clones or repair systems. Take this into consideration for planning your overall lifecycle-management strategy, and check to make sure that your SLAs are still being met while using this function.

FabricPool is a good option for moving log backups to another storage tier. Moving backups affects the time needed to recover an SAP HANA database. Therefore, the option `tiering-minimum-cooling-days` should be set to a value that places log backups, which are routinely needed for recovery, on the local fast storage tier.

Configure storage

The following overview summarizes the required storage configuration steps. Each step is covered in more detail in the subsequent sections. In this section, we assume that the storage hardware is set up and that the ONTAP software is already installed. Also, the connection of the storage FCP ports to the SAN fabric must already be in place.

1. Check the correct disk shelf configuration, as described in "Disk shelf connection."
2. Create and configure the required aggregates, as described in "Aggregate configuration."
3. Create a storage virtual machine (SVM), as described in "Storage virtual machine configuration."
4. Create logical interfaces (LIFs), as described in "Logical interface configuration."

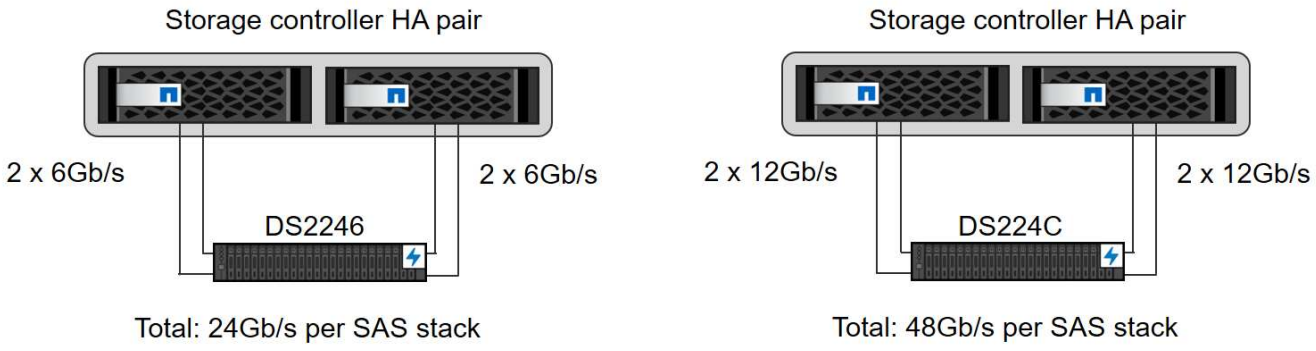
5. Create a port set, as described in "FCP port sets."
6. Create initiator groups, volumes, and LUNs within the aggregates, as described in creating "[LUNs and volumes and mapping LUNs to initiator groups]."

Disk shelf connection

SAS-based disk shelves

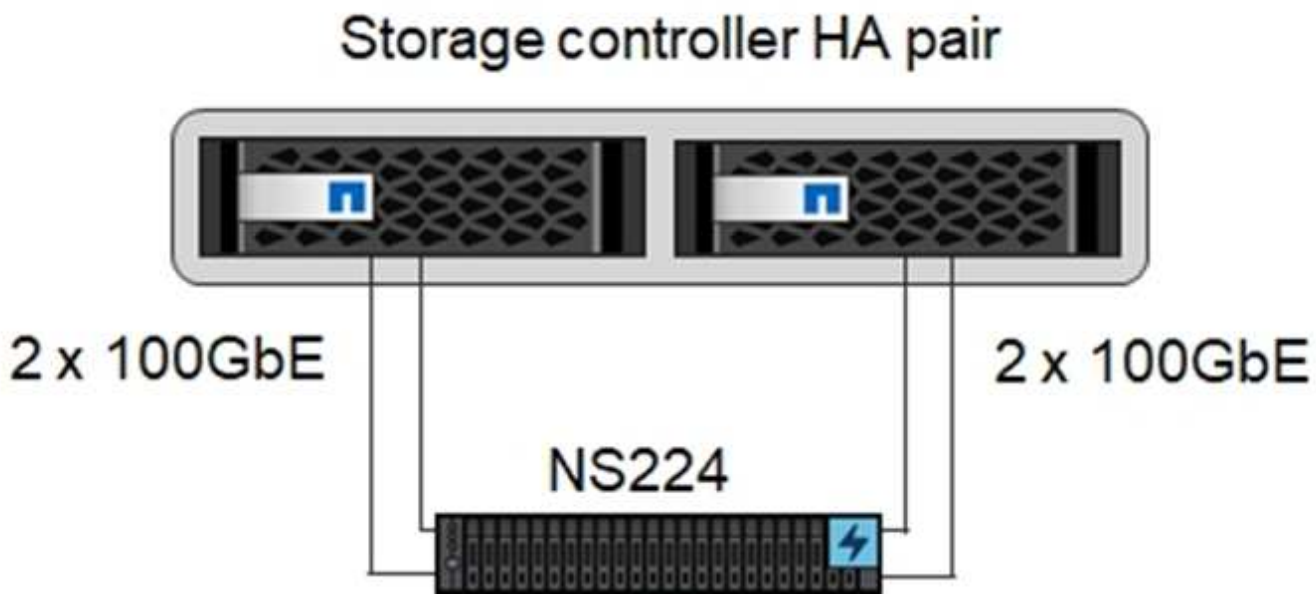
A maximum of one disk shelf can be connected to one SAS stack to provide the required performance for the SAP HANA hosts, as shown in the following figure. The disks within each shelf must be distributed equally between both controllers of the HA pair. ADPv2 is used with ONTAP 9 and the new DS224C disk shelves.

With the DS224C disk shelf, quad-path SAS cabling can also be used but is not required.



NVMe(100GbE)-based disk shelves

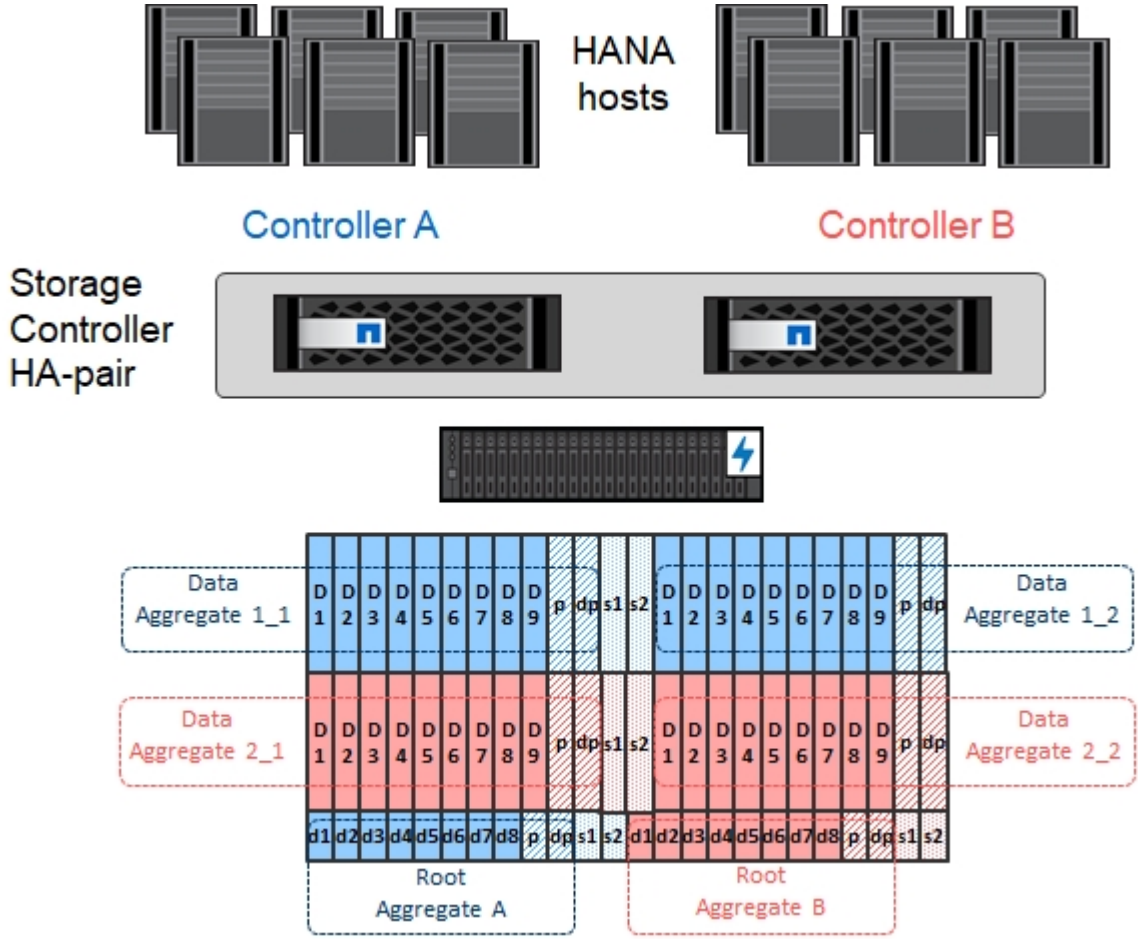
Each NS224 NVMe desk shelf is connected with two 100GbE ports per controller, as shown in the following figure. The disks within each shelf must be distributed equally to both controllers of the HA pair. ADPv2 is also used for the NS224 disk shelf.



Aggregate configuration

In general, you must configure two aggregates per controller, independent of which disk shelf or disk technology (SSD or HDD) is used. This step is necessary so that you can use all available controller resources. For AFF A200 series systems, one data aggregate is sufficient.

The following figure shows a configuration of 12 SAP HANA hosts running on a 12Gb SAS shelf configured with ADPv2. Six SAP HANA hosts are attached to each storage controller. Four separate aggregates, two at each storage controller, are configured. Each aggregate is configured with 11 disks with nine data and two parity disk partitions. For each controller, two spare partitions are available.



Storage virtual machine configuration

Multiple SAP landscapes with SAP HANA databases can use a single SVM. An SVM can also be assigned to each SAP landscape, if necessary, in case they are managed by different teams within a company.

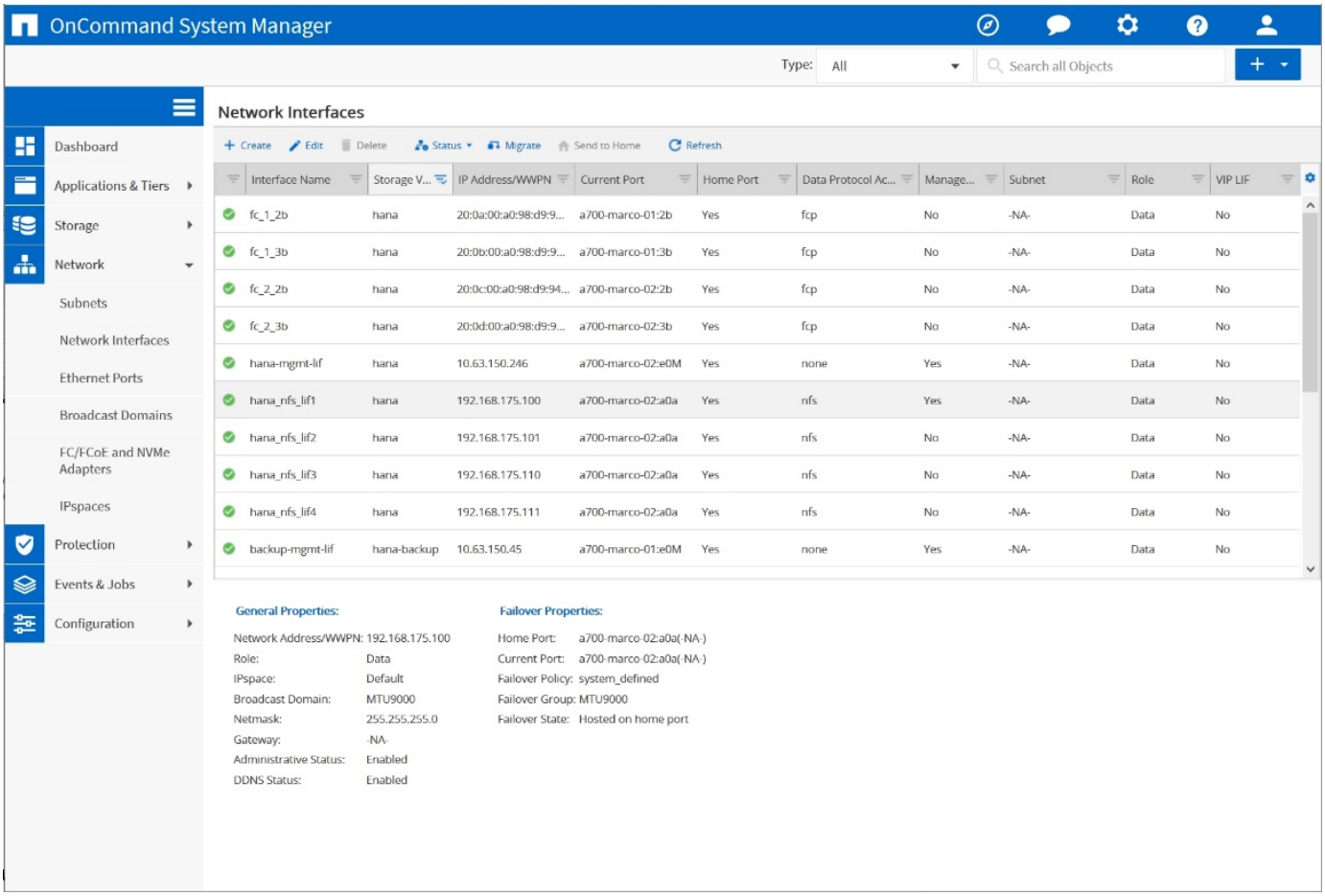
If there is a QoS profile automatically created and assigned while creating a new SVM, remove this automatically created profile from the SVM to ensure the required performance for SAP HANA:

```
vserver modify -vserver <svm-name> -qos-policy-group none
```

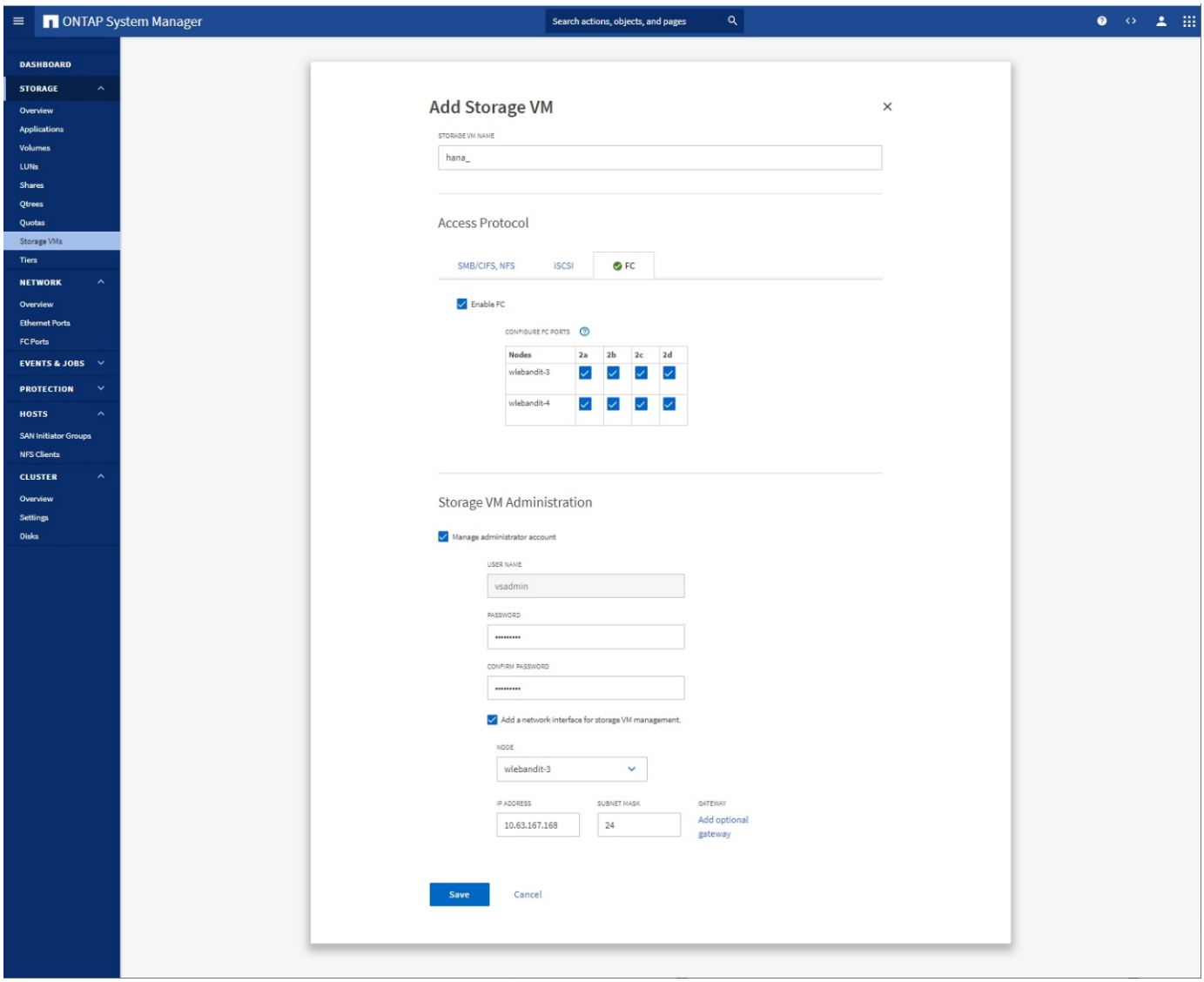
Logical interface configuration

Within the storage cluster configuration, one network interface (LIF) must be created and assigned to a dedicated FCP port. If, for example, four FCP ports are required for performance reasons, four LIFs must be

created. The following figure shows a screenshot of the eight LIFs (named `fc_*_*`) that were configured on the `hana` SVM.

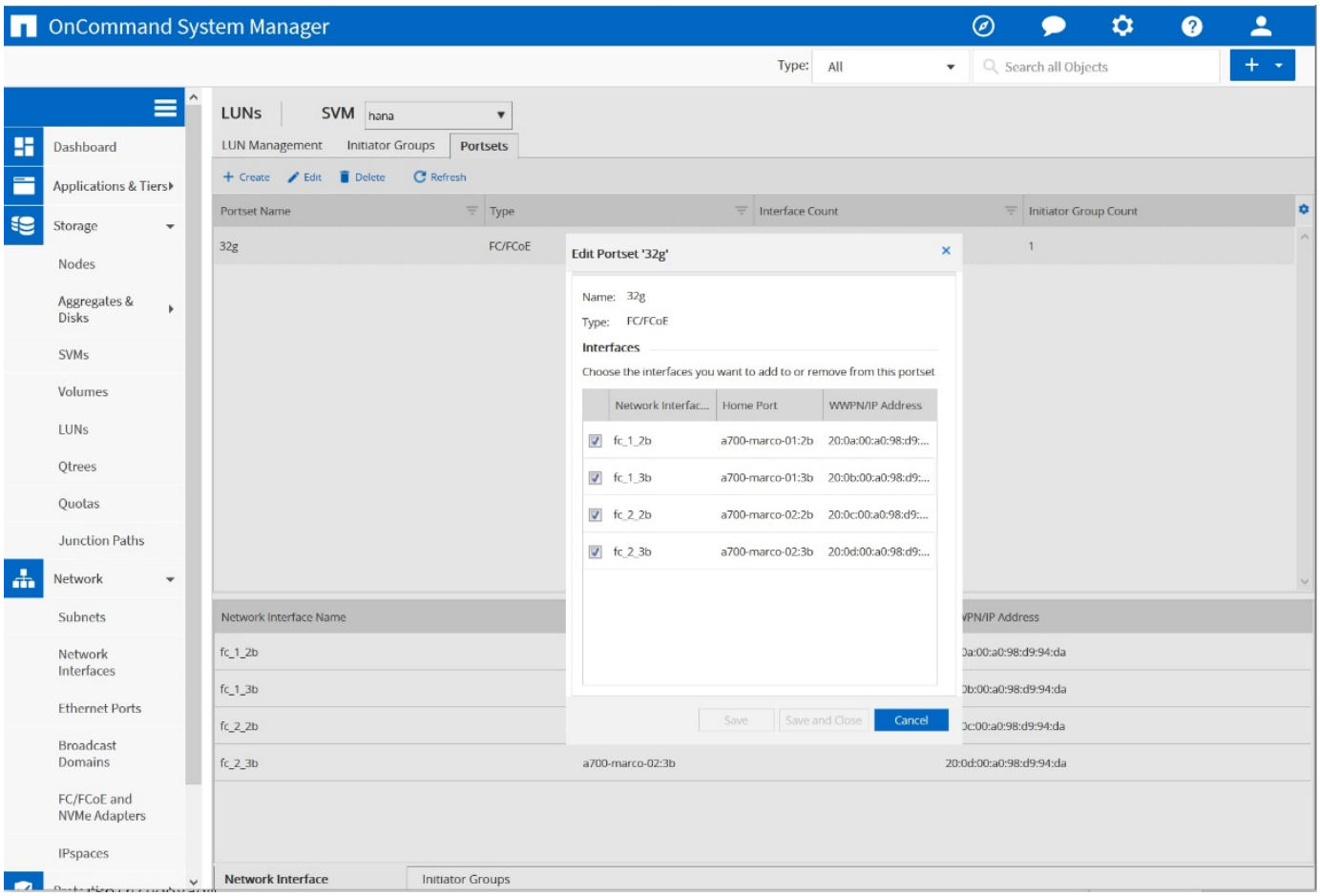


During the SVM creation with ONTAP 9.8 System Manager, you can select all of the required physical FCP ports, and one LIF per physical port is created automatically.



FCP port sets

An FCP port set is used to define which LIFs are to be used by a specific initiator group. Typically, all LIFs created for the HANA systems are placed in the same port set. The following figure shows the configuration of a port set named 32g that includes the four LIFs that were already created.

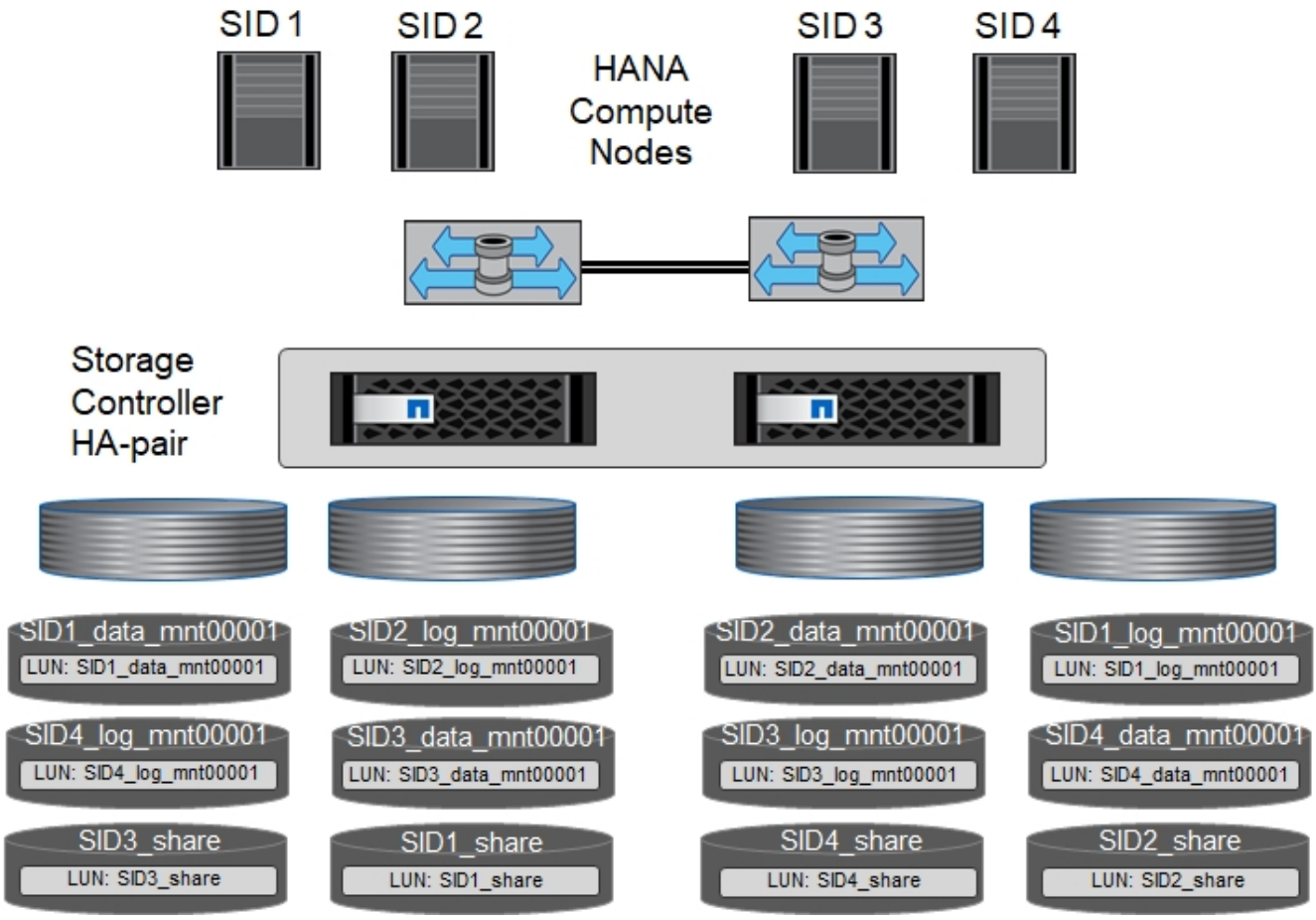


With ONTAP 9.8, a port set is not required, but it can be created and used through the command line.

Volume and LUN configuration for SAP HANA single-host systems

The following figure shows the volume configuration of four single-host SAP HANA systems. The data and log volumes of each SAP HANA system are distributed to different storage controllers. For example, volume `SID1_data_mnt00001` is configured on controller A, and volume `SID1_log_mnt00001` is configured on controller B. Within each volume, a single LUN is configured.

If only one storage controller of a HA pair is used for the SAP HANA systems, data volumes and log volumes can also be stored on the same storage controller.



For each SAP HANA host, a data volume, a log volume, and a volume for `/hana/shared` are configured. The following table shows an example configuration with four SAP HANA single-host systems.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data, log, and shared volumes for system SID1	Data volume: SID1_data_mnt00001	Shared volume: SID1_shared	–	Log volume: SID1_log_mnt00001
Data, log, and shared volumes for system SID2	–	Log volume: SID2_log_mnt00001	Data volume: SID2_data_mnt00001	Shared volume: SID2_shared
Data, log, and shared volumes for system SID3	Shared volume: SID3_shared	Data volume: SID3_data_mnt00001	Log volume: SID3_log_mnt00001	–
Data, log, and shared volumes for system SID4	Log volume: SID4_log_mnt00001	–	Shared volume: SID4_shared	Data volume: SID4_data_mnt00001

The following table shows an example of the mount point configuration for a single-host system.

LUN	Mount point at SAP HANA host	Note
SID1_data_mnt00001	/hana/data/SID1/mnt00001	Mounted using /etc/fstab entry

LUN	Mount point at SAP HANA host	Note
SID1_log_mnt00001	/hana/log/SID1/mnt00001	Mounted using /etc/fstab entry
SID1_shared	/hana/shared/SID1	Mounted using /etc/fstab entry

With the described configuration, the `/usr/sap/SID1` directory in which the default home directory of user SID1adm is stored, is on the local disk. In a disaster recovery setup with disk-based replication, NetApp recommends creating an additional LUN within the `SID1_shared` volume for the `/usr/sap/SID1` directory so that all file systems are on the central storage.

Volume and LUN configuration for SAP HANA single-host systems using Linux LVM

The Linux LVM can be used to increase performance and to address LUN size limitations. The different LUNs of an LVM volume group should be stored within a different aggregate and at a different controller. The following table shows an example for two LUNs per volume group.

It is not necessary to use LVM with multiple LUNs to fulfill the SAP HANA KPIs. A single LUN setup fulfills the required KPIs.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data, log, and shared volumes for LVM based system	Data volume: SID1_data_mnt00001	Shared volume: SID1_shared Log2 volume: SID1_log2_mnt00001	Data2 volume: SID1_data2_mnt00001	Log volume: SID1_log_mnt00001

At the SAP HANA host, volume groups and logical volumes need to be created and mounted, as indicated in the following table.

Logical volume/LUN	Mount point at SAP HANA host	Note
LV: SID1_data_mnt0000-vol	/hana/data/SID1/mnt00001	Mounted using /etc/fstab entry
LV: SID1_log_mnt00001-vol	/hana/log/SID1/mnt00001	Mounted using /etc/fstab entry
LUN: SID1_shared	/hana/shared/SID1	Mounted using /etc/fstab entry

With the described configuration, the `/usr/sap/SID1` directory in which the default home directory of user SID1adm is stored, is on the local disk. In a disaster recovery setup with disk-based replication, NetApp recommends creating an additional LUN within the `SID1_shared` volume for the `/usr/sap/SID1` directory so that all file systems are on the central storage.

Volume and LUN configuration for SAP HANA multiple-host systems

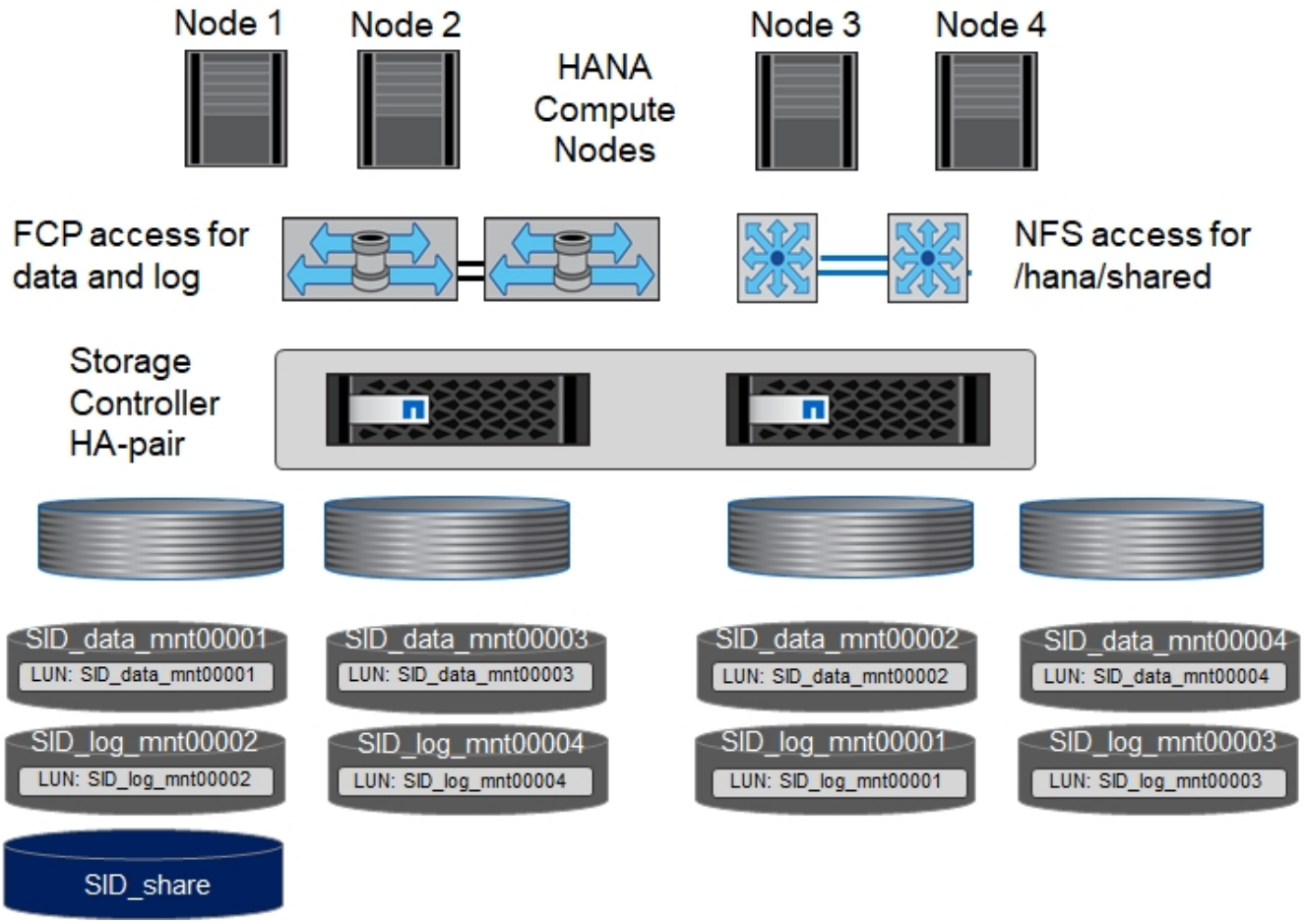
The following figure shows the volume configuration of a 4+1 multiple-host SAP HANA system. The data volumes and log volumes of each SAP HANA host are distributed to different storage controllers. For example, the volume `SID_data_mnt00001` is configured on controller A and the volume `SID_log_mnt00001` is configured on controller B. One LUN is configured within each volume.

The `/hana/shared` volume must be accessible by all HANA hosts and is therefore exported by using NFS.

Even though there are no specific performance KPIs for the `/hana/shared` file system, NetApp recommends using a 10Gb Ethernet connection.

If only one storage controller of an HA pair is used for the SAP HANA system, data and log volumes can also be stored on the same storage controller.

NetApp ASA AFF systems do not support NFS as a protocol. NetApp recommends using an additional AFF or FAS system for the `/hana/shared` file system.



For each SAP HANA host, a data volume and a log volume are created. The `/hana/shared` volume is used by all hosts of the SAP HANA system. The following table shows an example configuration for a 4+1 multiple-host SAP HANA system.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	–	Log volume: SID_log_mnt00001	–
Data and log volumes for node 2	Log volume: SID_log_mnt00002	–	Data volume: SID_data_mnt00002	–
Data and log volumes for node 3	–	Data volume: SID_data_mnt00003	–	Log volume: SID_log_mnt00003

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 4	–	Log volume: SID_log_mnt00004	–	Data volume: SID_data_mnt00004
Shared volume for all hosts	Shared volume: SID_shared	–	–	–

The following table shows the configuration and the mount points of a multiple-host system with four active SAP HANA hosts.

LUN or volume	Mount point at SAP HANA host	Note
LUN: SID_data_mnt00001	/hana/data/SID/mnt00001	Mounted using storage connector
LUN: SID_log_mnt00001	/hana/log/SID/mnt00001	Mounted using storage connector
LUN: SID_data_mnt00002	/hana/data/SID/mnt00002	Mounted using storage connector
LUN: SID_log_mnt00002	/hana/log/SID/mnt00002	Mounted using storage connector
LUN: SID_data_mnt00003	/hana/data/SID/mnt00003	Mounted using storage connector
LUN: SID_log_mnt00003	/hana/log/SID/mnt00003	Mounted using storage connector
LUN: SID_data_mnt00004	/hana/data/SID/mnt00004	Mounted using storage connector
LUN: SID_log_mnt00004	/hana/log/SID/mnt00004	Mounted using storage connector
Volume: SID_shared	/hana/shared	Mounted at all hosts using NFS and /etc/fstab entry

With the described configuration, the `/usr/sap/SID` directory in which the default home directory of user SIDadm is stored, is on the local disk for each HANA host. In a disaster recovery setup with disk-based replication, NetApp recommends creating four additional subdirectories in the `SID_shared` volume for the `/usr/sap/SID` file system so that each database host has all its file systems on the central storage.

Volume and LUN configuration for SAP HANA multiple-host systems using Linux LVM

The Linux LVM can be used to increase performance and to address LUN size limitations. The different LUNs of an LVM volume group should be stored within a different aggregate and at a different controller.

It is not necessary to use LVM to combine several LUN to fulfill the SAP HANA KPIs. A single LUN setup fulfills the required KPIs.

The following table shows an example for two LUNs per volume group for a 2+1 SAP HANA multiple host system.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	Log2 volume: SID_log2_mnt00001	Log volume: SID_log_mnt00001	Data2 volume: SID_data2_mnt00001

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 2	Log2 volume: SID_log2_mnt00002	Data volume: SID_data_mnt00002	Data2 volume: SID_data2_mnt00002	Log volume: SID_log_mnt00002
Shared volume for all hosts	Shared volume: SID_shared	–	–	–

At the SAP HANA host, volume groups and logical volumes need to be created and mounted, as indicated in the following table.

Logical volume (LV) or volume	Mount point at SAP HANA host	Note
LV: SID_data_mnt00001-vol	/hana/data/SID/mnt00001	Mounted using storage connector
LV: SID_log_mnt00001-vol	/hana/log/SID/mnt00001	Mounted using storage connector
LV: SID_data_mnt00002-vol	/hana/data/SID/mnt00002	Mounted using storage connector
LV: SID_log_mnt00002-vol	/hana/log/SID/mnt00002	Mounted using storage connector
Volume: SID_shared	/hana/shared	Mounted at all hosts using NFS and /etc/fstab entry

With the described configuration, the `/usr/sap/SID` directory in which the default home directory of user SIDadm is stored, is on the local disk for each HANA host. In a disaster recovery setup with disk-based replication, NetApp recommends creating four additional subdirectories in the `SID_shared` volume for the `/usr/sap/SID` file system so that each database host has all its file systems on the central storage.

Volume options

The volume options listed in the following table must be verified and set on all SVMs.

Action	
Disable automatic Snapshot copies	vol modify –vserver <vserver-name> -volume <volname> -snapshot-policy none
Disable visibility of Snapshot directory	vol modify -vserver <vserver-name> -volume <volname> -snapdir-access false

Creating LUNs, volumes, and mapping LUNs to initiator groups

You can use NetApp ONTAP System Manager to create storage volumes and LUNs and map them to the servers.

NetApp offers an automated application wizard for SAP HANA within ONTAP System Manager 9.7 and earlier, which simplifies the volume and LUN provisioning process significantly. It creates and configures the volumes and LUNs automatically according to NetApp best practices for SAP HANA.

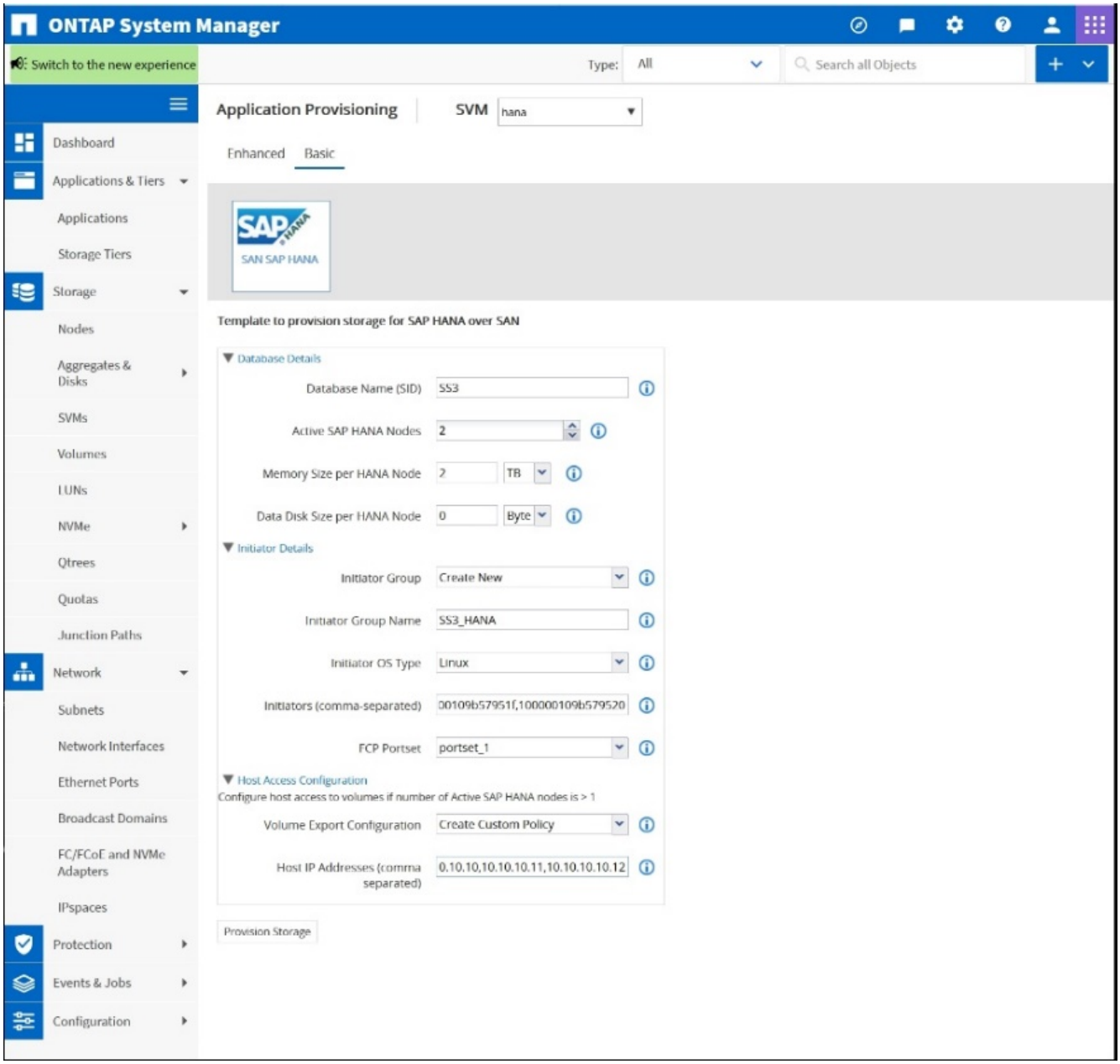
Using the `sanlun` tool, run the following command to obtain the worldwide port names (WWPNs) of each SAP HANA host:

```
stlrx300s8-6:~ # sanlun fcp show adapter
/sbin/udevadm
/sbin/udevadm
host0 ..... WWPN:2100000e1e163700
host1 ..... WWPN:2100000e1e163701
```

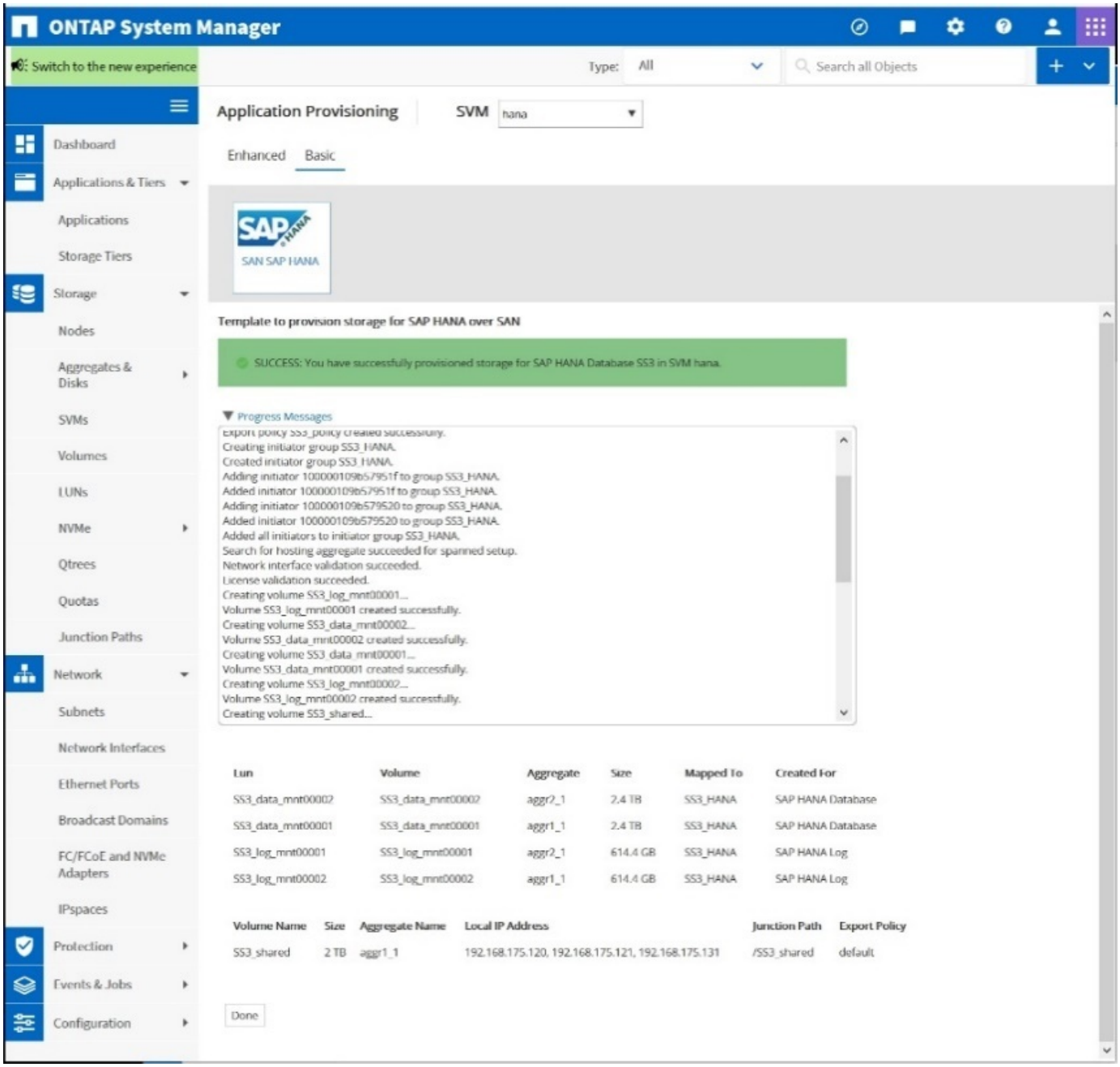
The `sanlun` tool is part of the NetApp Host Utilities and must be installed on each SAP HANA host. For more information, see the section "host_setup."

The following steps show the configuration of a 2+1 multiple-host HANA system with the SID SS3:

1. Start the Application Provisioning wizard for SAP HANA in System Manager and provide the required information. All initiators (WWPNs) from all hosts must be added.



2. Confirm that storage is successfully provisioned.



Creating LUNs, volumes, and mapping LUNs to initiator groups using the CLI

This section shows an example configuration using the command line with ONTAP 9.8 for a 2+1 SAP HANA multiple host system with SID FC5 using LVM and two LUNs per LVM volume group:

1. Create all necessary volumes.

```
vol create -volume FC5_data_mnt00001 -aggregate aggr1_1 -size 1200g
-snapshot-policy none -foreground true -encrypt false  -space-guarantee
none
vol create -volume FC5_log_mnt00002  -aggregate aggr2_1 -size 280g
-snapshot-policy none -foreground true -encrypt false  -space-guarantee
none
vol create -volume FC5_log_mnt00001  -aggregate aggr1_2 -size 280g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_data_mnt00002  -aggregate aggr2_2 -size 1200g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_data2_mnt00001 -aggregate aggr1_2 -size 1200g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_log2_mnt00002  -aggregate aggr2_2 -size 280g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_log2_mnt00001  -aggregate aggr1_1 -size 280g
-snapshot-policy none -foreground true -encrypt false  -space-guarantee
none
vol create -volume FC5_data2_mnt00002  -aggregate aggr2_1 -size 1200g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
nonevol create -volume FC5_shared -aggregate aggr1_1 -size 512g -state
online -policy default -snapshot-policy none -junction-path /FC5_shared
-encrypt false  -space-guarantee none
```

2. Create all LUNs.

```
lun create -path  /vol/FC5_data_mnt00001/FC5_data_mnt00001   -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_data2_mnt00001/FC5_data2_mnt00001 -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_data_mnt00002/FC5_data_mnt00002 -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_data2_mnt00002/FC5_data2_mnt00002 -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log_mnt00001/FC5_log_mnt00001 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log2_mnt00001/FC5_log2_mnt00001 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log_mnt00002/FC5_log_mnt00002 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log2_mnt00002/FC5_log2_mnt00002 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
```

3. Create the initiator group for all servers belonging to system FC5.

```
lun igroup create -igroup HANA-FC5 -protocol fcp -ostype linux
-initiator 10000090fadcc5fa,10000090fadcc5fb,
10000090fadcc5c1,10000090fadcc5c2,10000090fadcc5c3,10000090fadcc5c4
-vserver hana
```

4. Map all LUNs to created initiator group.

```
lun map -path /vol/FC5_data_mnt00001/FC5_data_mnt00001    -igroup HANA-
FC5
lun map -path /vol/FC5_data2_mnt00001/FC5_data2_mnt00001  -igroup HANA-
FC5
lun map -path /vol/FC5_data_mnt00002/FC5_data_mnt00002  -igroup HANA-FC5
lun map -path /vol/FC5_data2_mnt00002/FC5_data2_mnt00002  -igroup HANA-
FC5
lun map -path /vol/FC5_log_mnt00001/FC5_log_mnt00001  -igroup HANA-FC5
lun map -path /vol/FC5_log2_mnt00001/FC5_log2_mnt00001  -igroup HANA-FC5
lun map -path /vol/FC5_log_mnt00002/FC5_log_mnt00002  -igroup HANA-FC5
lun map -path /vol/FC5_log2_mnt00002/FC5_log2_mnt00002  -igroup HANA-FC5
```

SAP HANA storage connector API

A storage connector is required only in multiple-host environments that have failover capabilities. In multiple-host setups, SAP HANA provides high-availability functionality so that an SAP HANA database host can fail over to a standby host.

In this case, the LUNs of the failed host are accessed and used by the standby host. The storage connector is used to make sure that a storage partition can be actively accessed by only one database host at a time.

In SAP HANA multiple-host configurations with NetApp storage, the standard storage connector delivered by SAP is used. The “SAP HANA Fibre Channel Storage Connector Admin Guide” can be found as an attachment to SAP note 1900823.

Host setup

Before setting up the host, NetApp SAN host utilities must be downloaded from the NetApp Support site and installed on the HANA servers. The host utility documentation includes information about additional software that must be installed depending on the FCP HBA used.

The documentation also contains information on multipath configurations that are specific to the Linux version used. This document covers the required configuration steps for SLES 12 SP1 or higher and RHEL 7. 2 or later, as described in the Linux Host Utilities 7.1 Installation and Setup Guide.

Configure multipathing

Steps 1 through 6 must be executed on all worker and standby hosts in an SAP HANA multiple-host configuration.

To configure multipathing, complete the following steps:

1. Run the Linux `rescan-scsi-bus.sh -a` command on each server to discover new LUNs.
2. Run the `sanlun lun show` command and verify that all required LUNs are visible. The following example shows the `sanlun lun show` command output for a 2+1 multiple-host HANA system with two data LUNs and two log LUNs. The output shows the LUNs and the corresponding device files, such as LUN `SS3_data_mnt00001` and the device file `/dev/sdag` Each LUN has eight FC paths from the host to the

storage controllers.

```
stlrx300s8-6:~ # sanlun lun show
controller(7mode/E-Series)/
device        host                  lun
vserver(cDOT/FlashRay)        lun-pathname
filename        adapter    protocol   size    product
------------------------------------------------------------------------
-----------------------------------------------
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdah       host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdag       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdaf       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdae       host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdad       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdac       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdab       host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdaa       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdz        host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdy        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdx        host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdw        host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdv        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdu        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdt        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sds        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdr        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdq        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
```

```
/dev/sdp        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdo        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdn        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdm        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdl        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdk        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdj        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdi        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdh        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdg        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdf        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sde        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdd        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdc        host10     FCP        512.0g  cDOT
```

3. Run the `multipath -r` command to get the worldwide identifiers (WWIDs) for the device file names.

   In this example, there are four LUNs.

```
stlrx300s8-6:~ # multipath -r
create: 3600a098038304436375d4d442d753878 undef NETAPP,LUN C-Mode
size=512G features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:1:0 sdd  8:48   undef ready running
| |- 10:0:3:0 sdf  8:80   undef ready running
| |- 11:0:0:0 sds  65:32  undef ready running
| `- 11:0:2:0 sdu  65:64  undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:0:0 sdc  8:32   undef ready running
  |- 10:0:2:0 sde  8:64   undef ready running
  |- 11:0:1:0 sdt  65:48  undef ready running
```

```
  `- 11:0:3:0 sdv  65:80  undef ready running
create: 3600a098038304436375d4d442d753879 undef NETAPP,LUN C-Mode
size=1.2T features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:1:1 sdj  8:144  undef ready running
| |- 10:0:3:1 sdp  8:240  undef ready running
| |- 11:0:0:1 sdw  65:96  undef ready running
| `- 11:0:2:1 sdac 65:192 undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:0:1 sdg  8:96   undef ready running
  |- 10:0:2:1 sdm  8:192  undef ready running
  |- 11:0:1:1 sdz  65:144 undef ready running
  `- 11:0:3:1 sdaf 65:240 undef ready running
create: 3600a098038304436392b4d442d6f534f undef NETAPP,LUN C-Mode
size=1.2T features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:0:2 sdh  8:112  undef ready running
| |- 10:0:2:2 sdn  8:208  undef ready running
| |- 11:0:1:2 sdaa 65:160 undef ready running
| `- 11:0:3:2 sdag 66:0   undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:1:2 sdk  8:160  undef ready running
  |- 10:0:3:2 sdq  65:0   undef ready running
  |- 11:0:0:2 sdx  65:112 undef ready running
  `- 11:0:2:2 sdad 65:208 undef ready running
create: 3600a098038304436392b4d442d6f5350 undef NETAPP,LUN C-Mode
size=512G features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:0:3 sdi  8:128  undef ready running
| |- 10:0:2:3 sdo  8:224  undef ready running
| |- 11:0:1:3 sdab 65:176 undef ready running
| `- 11:0:3:3 sdah 66:16  undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:1:3 sdl  8:176  undef ready running
  |- 10:0:3:3 sdr  65:16  undef ready running
  |- 11:0:0:3 sdy  65:128 undef ready running
  `- 11:0:2:3 sdae 65:224 undef ready running
```

4. Edit the `/etc/multipath.conf` file and add the WWIDs and alias names.

The example output shows the content of the `/etc/multipath.conf` file, which includes alias names for the four LUNs of a 2+1 multiple-host system. If there is no multipath.conf file available, you can create one by running the following command: `multipath -T > /etc/multipath.conf`.

```
stlrx300s8-6:/ # cat /etc/multipath.conf
multipaths {
        multipath {
                wwid    3600a098038304436392b4d442d6f534f
                alias   hana-SS3_data_mnt00001
        }
        multipath {
                wwid    3600a098038304436375d4d442d753879
                alias   hana-SS3_data_mnt00002
        }
        multipath {
                wwid    3600a098038304436375d4d442d753878
                alias   hana-SS3_log_mnt00001
        }
        multipath {
                wwid    3600a098038304436392b4d442d6f5350
                alias   hana-SS3_log_mnt00002
        }

}
```

5. Run the `multipath -r` command to reload the device map.
6. Verify the configuration by running the `multipath -ll` command to list all the LUNs, alias names, and active and standby paths.

The following example output shows the output of a 2+1 multiple-host HANA system with two data and two log LUNs.

```
stlrx300s8-6:~ # multipath -ll
hana-SS3_data_mnt00002 (3600a098038304436375d4d442d753879) dm-1
NETAPP,LUN C-Mode
size=1.2T features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:1:1 sdj  8:144  active ready running
| |- 10:0:3:1 sdp  8:240  active ready running
| |- 11:0:0:1 sdw  65:96  active ready running
| `- 11:0:2:1 sdac 65:192 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
```

```
  |- 10:0:0:1 sdg  8:96   active ready running
  |- 10:0:2:1 sdm  8:192  active ready running
  |- 11:0:1:1 sdz  65:144 active ready running
  `- 11:0:3:1 sdaf 65:240 active ready running
hana-SS3_data_mnt00001 (3600a098038304436392b4d442d6f534f) dm-2
NETAPP,LUN C-Mode
size=1.2T features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:0:2 sdh  8:112  active ready running
| |- 10:0:2:2 sdn  8:208  active ready running
| |- 11:0:1:2 sdaa 65:160 active ready running
| `- 11:0:3:2 sdag 66:0   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:2 sdk  8:160  active ready running
  |- 10:0:3:2 sdq  65:0   active ready running
  |- 11:0:0:2 sdx  65:112 active ready running
  `- 11:0:2:2 sdad 65:208 active ready running
hana-SS3_log_mnt00002 (3600a098038304436392b4d442d6f5350) dm-3
NETAPP,LUN C-Mode
size=512G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:0:3 sdi  8:128  active ready running
| |- 10:0:2:3 sdo  8:224  active ready running
| |- 11:0:1:3 sdab 65:176 active ready running
| `- 11:0:3:3 sdah 66:16  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:3 sdl  8:176  active ready running
  |- 10:0:3:3 sdr  65:16  active ready running
  |- 11:0:0:3 sdy  65:128 active ready running
  `- 11:0:2:3 sdae 65:224 active ready running
hana-SS3_log_mnt00001 (3600a098038304436375d4d442d753878) dm-0
NETAPP,LUN C-Mode
size=512G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:1:0 sdd  8:48   active ready running
| |- 10:0:3:0 sdf  8:80   active ready running
| |- 11:0:0:0 sds  65:32  active ready running
| `- 11:0:2:0 sdu  65:64  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:0:0 sdc  8:32   active ready running
  |- 10:0:2:0 sde  8:64   active ready running
  |- 11:0:1:0 sdt  65:48  active ready running
  `- 11:0:3:0 sdv  65:80  active ready running
```

Create LVM volume groups and logical volumes

This step is only required if LVM is used. The following example is for 2+1 host setup using SID FC5.

> For an LVM-based setup, the multipath configuration described in the previous section must be completed as well. In this example, eight LUNs must be configured for multipathing.

1. Initialize all LUNs as a physical volume.

```
pvcreate /dev/mapper/hana-FC5_data_mnt00001
pvcreate /dev/mapper/hana-FC5_data2_mnt00001
pvcreate /dev/mapper/hana-FC5_data_mnt00002
pvcreate /dev/mapper/hana-FC5_data2_mnt00002
pvcreate /dev/mapper/hana-FC5_log_mnt00001
pvcreate /dev/mapper/hana-FC5_log2_mnt00001
pvcreate /dev/mapper/hana-FC5_log_mnt00002
pvcreate /dev/mapper/hana-FC5_log2_mnt00002
```

2. Create the volume groups for each data and log partition.

```
vgcreate FC5_data_mnt00001 /dev/mapper/hana-FC5_data_mnt00001
/dev/mapper/hana-FC5_data2_mnt00001
vgcreate FC5_data_mnt00002 /dev/mapper/hana-FC5_data_mnt00002
/dev/mapper/hana-FC5_data2_mnt00002
vgcreate FC5_log_mnt00001 /dev/mapper/hana-FC5_log_mnt00001
/dev/mapper/hana-FC5_log2_mnt00001
vgcreate FC5_log_mnt00002 /dev/mapper/hana-FC5_log_mnt00002
/dev/mapper/hana-FC5_log2_mnt00002
```

3. Create a logical volume for each data and log partition. Use a stripe size that is equal to the number of LUNs used per volume group (in this example, it is two) and a stripe size of 256k for data and 64k for log. SAP only supports one logical volume per volume group.

```
lvcreate --extents 100%FREE -i 2 -I 256k --name vol FC5_data_mnt00001
lvcreate --extents 100%FREE -i 2 -I 256k --name vol FC5_data_mnt00002
lvcreate --extents 100%FREE -i 2 -I 64k --name vol FC5_log_mnt00002
lvcreate --extents 100%FREE -i 2 -I 64k --name vol FC5_log_mnt00001
```

4. Scan the physical volumes, volume groups, and vol groups at all other hosts.

```
modprobe dm_mod
pvscan
vgscan
lvscan
```

If these commands do not find the volumes, a restart is required.

To mount the logical volumes, the logical volumes must be activated. To activate the volumes, run the following command:

```
vgchange -a y
```

Create file systems

To create the XFS file system on each LUN belonging to the HANA system, take one of the following actions:

- For a single-host system, create the XFS file system on the data, log, and `/hana/shared` LUNs.

```
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_data_mnt00001
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_log_mnt00001
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_shared
```

- For a multiple-host system, create the XFS file system on all data and log LUNs.

```
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_log_mnt00001
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_log_mnt00002
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_data_mnt00001
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_data_mnt00002
```

- If LVM is used, create the XFS file system on all data and log logical volumes.

```
mkfs.xfs FC5_data_mnt00001-vol
mkfs.xfs FC5_data_mnt00002-vol
mkfs.xfs FC5_log_mnt00001-vol
mkfs.xfs FC5_log_mnt00002-vol
```

The multiple host example commands show a 2+1 multiple-host HANA system.

Create mount points

To create the required mount point directories, take one of the following actions:

- For a single-host system, set permissions and create mount points on the database host.

```
stlrx300s8-6:/ # mkdir -p /hana/data/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/log/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/shared
stlrx300s8-6:/ # chmod -R 777 /hana/log/SS3
stlrx300s8-6:/ # chmod -R 777 /hana/data/SS3
stlrx300s8-6:/ # chmod 777 /hana/shared
```

- For a multiple-host system, set permissions and create mount points on all worker and standby hosts.

The example commands show a 2+1 multiple-host HANA system.

```
stlrx300s8-6:/ # mkdir -p /hana/data/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/log/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/data/SS3/mnt00002
stlrx300s8-6:/ # mkdir -p /hana/log/SS3/mnt00002
stlrx300s8-6:/ # mkdir -p /hana/shared
stlrx300s8-6:/ # chmod -R 777 /hana/log/SS3
stlrx300s8-6:/ # chmod -R 777 /hana/data/SS3
stlrx300s8-6:/ # chmod 777 /hana/shared
```

The same steps must be executed for a system configuration with Linux LVM.

Mount file systems

To mount file systems during system boot using the `/etc/fstab` configuration file, complete the following steps:

- For a single-host system, add the required file systems to the `/etc/fstab` configuration file.

The XFS file systems for the data and log LUNs must be mounted with the `relatime` and `inode64` mount options.

```
stlrx300s8-6:/ # cat /etc/fstab
/dev/mapper/hana-SS3_shared /hana/shared xfs defaults 0 0
/dev/mapper/hana-SS3_log_mnt00001 /hana/log/SS3/mnt00001 xfs
relatime,inode64 0 0
/dev/mapper/hana-SS3_data_mnt00001 /hana/data/SS3/mnt00001 xfs
relatime,inode64 0 0
```

If LVM is used, use the logical volume names for data and log.

```
# cat /etc/fstab
/dev/mapper/hana-FC5_shared /hana/shared xfs defaults 0 0
/dev/mapper/FC5_log_mnt00001-vol /hana/log/FC5/mnt00001 xfs
relatime,inode64 0 0
/dev/mapper/FC5_data_mnt00001-vol /hana/data/FC5/mnt00001 xfs
relatime,inode64 0 0
```

- For a multiple-host system, add the `/hana/shared` file system to the `/etc/fstab` configuration file of each host.

  All the data and log file systems are mounted through the SAP HANA storage connector.

```
stlrx300s8-6:/ # cat /etc/fstab
<storage-ip>:/hana_shared /hana/shared nfs rw,vers=3,hard,timeo=600,
intr,noatime,nolock 0 0
```

To mount the file systems, run the `mount -a` command at each host.

I/O Stack configuration for SAP HANA

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage system used.

NetApp conducted performance tests to define the ideal values. The following table lists the optimal values as inferred from the performance tests.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For SAP HANA 1.0 up to SPS12, these parameters can be set during the installation of the SAP HANA database, as described in SAP Note 2267798 – Configuration of the SAP HANA Database during Installation Using hdbparam.

Alternatively, the parameters can be set after the SAP HANA database installation by using the `hdbparam` framework.

```
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.max_parallel_io_requests=128
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.async_write_submit_active=on
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.async_read_submit=on
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.async_write_submit_blocks=all
```

Starting with SAP HANA 2.0, `hdbparam` is deprecated, and the parameters are moved to the `global.ini` file. The parameters can be set by using SQL commands or SAP HANA Studio. For more details, refer to SAP note 2399079: Elimination of hdbparam in HANA 2. The parameters can be also set within the `global.ini` file.

```
SS3adm@stlrx300s8-6: /usr/sap/SS3/SYS/global/hdb/custom/config> cat
global.ini
…
[fileio]
async_read_submit = on
async_write_submit_active = on
max_parallel_io_requests = 128
async_write_submit_blocks = all
…
```

For SAP HANA 2.0 SPS5 and later, use the `setParameter.py` script to set the correct parameters.

```
fc5adm@sapcc-hana-tst-03:/usr/sap/FC5/HDB00/exe/python_support>
python setParameter.py
-set=SYSTEM/global.ini/fileio/max_parallel_io_requests=128
python setParameter.py -set=SYSTEM/global.ini/fileio/async_read_submit=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_active=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_blocks=all
```

SAP HANA software installation

This section describes the preparation necessary to install SAP HANA on single-host and multiple-host systems.

Installation on single-host system

SAP HANA software installation does not require any additional preparation for a single-host system.

Installation on multiple-host system

Before beginning the installation, create a `global.ini` file to enable use of the SAP storage connector during the installation process. The SAP storage connector mounts the required file systems at the worker hosts during the installation process. The `global.ini` file must be available in a file system that is accessible from all hosts, such as the `/hana/shared` file system.

Before installing SAP HANA software on a multiple-host system, the following steps must be completed:

1. Add the following mount options for the data LUNs and the log LUNs to the `global.ini` file:
   - `relatime` and `inode64` for the data and log file system
2. Add the WWIDs of the data and log partitions. The WWIDs must match the alias names configured in the `/etc/multipath.conf` file.

   The following output shows an example of a 2+1 multiple-host setup in which the system identifier (SID) is SS3.

```
stlrx300s8-6:~ # cat /hana/shared/global.ini
[communication]
listeninterface = .global
[persistence]
basepath_datavolumes = /hana/data/SS3
basepath_logvolumes = /hana/log/SS3
[storage]
ha_provider = hdb_ha.fcClient
partition_*_*__prtype = 5
partition_*_data__mountoptions = -o relatime,inode64
partition_*_log__mountoptions = -o relatime,inode64,nobarrier
partition_1_data__wwid = hana-SS3_data_mnt00001
partition_1_log__wwid = hana-SS3_log_mnt00001
partition_2_data__wwid = hana-SS3_data_mnt00002
partition_2_log__wwid = hana-SS3_log_mnt00002
[system_information]
usage = custom
[trace]
ha_fcclient = info
stlrx300s8-6:~ #
```

   If the Linux LVM is used, the required configuration is different. The following example shows a 2+1 multiple-host setup with SID=FC5.

```
sapcc-hana-tst-03:/hana/shared # cat global.ini
[communication]
listeninterface = .global
[persistence]
basepath_datavolumes = /hana/data/FC5
basepath_logvolumes = /hana/log/FC5
[storage]
ha_provider = hdb_ha.fcClientLVM
partition_*_*__prtype = 5
partition_*_data__mountOptions = -o relatime,inode64
partition_*_log__mountOptions = -o relatime,inode64
partition_1_data__lvmname = FC5_data_mnt00001-vol
partition_1_log__lvmname = FC5_log_mnt00001-vol
partition_2_data__lvmname = FC5_data_mnt00002-vol
partition_2_log__lvmname = FC5_log_mnt00002-vol
sapcc-hana-tst-03:/hana/shared #
Using the SAP hdblcm installation tool, start the installation by
running the following command at one of the worker hosts. Use the
`addhosts` option to add the second worker (sapcc-hana-tst-04) and the
standby host (sapcc-hana-tst-05).
```

The directory where the prepared `global.ini` file is stored is included with the `storage_cfg` CLI option (`-- storage_cfg=/hana/shared`).

Depending on the OS version being used, it might be necessary to install Python 2.7 before installing the SAP HANA database.

```
sapcc-hana-tst-03:/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_LCM_LINUX_X86_64 # ./hdblcm --action=install
--addhosts=sapcc-hana-tst-04:role=worker:storage_partion=2,sapcc-hana
-tst-05:role:=standby --storage_cfg=/hana(shared/shared


SAP HANA Lifecycle Management - SAP HANA Database 2.00.052.00.1599235305
************************************************************************


Scanning software locations...
Detected components:
    SAP HANA AFL (incl.PAL,BFL,OFL) (2.00.052.0000.1599259237) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_AFL_LINUX_X86_64/packages
    SAP HANA Database (2.00.052.00.1599235305) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_SERVER_LINUX_X86_64/server
```

```
    SAP HANA Database Client (2.5.109.1598303414) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_CLIENT_LINUX_X86_64/client
    SAP HANA Smart Data Access (2.00.5.000.0) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/SAP_HANA_SDA_20_LINUX_X86_64/packages
    SAP HANA Studio (2.3.54.000000) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_STUDIO_LINUX_X86_64/studio
    SAP HANA Local Secure Store (2.4.24.0) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HANA_LSS_24_LINUX_X86_64/packages
    SAP HANA XS Advanced Runtime (1.0.130.519) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_RT_10_LINUX_X86_64/packages
    SAP HANA EML AFL (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_EML_AFL_10_LINUX_X86_64/packages
    SAP HANA EPM-MDS (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/SAP_HANA_EPM-MDS_10/packages
    GUI for HALM for XSA (including product installer) Version 1
(1.014.1) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACALMPIUI14_1.zip
    XSAC FILEPROCESSOR 1.0 (1.000.85) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACFILEPROC00_85.zip
    SAP HANA tools for accessing catalog content, data preview, SQL
console, etc. (2.012.20341) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_HRTT_20/XSACHRTT12_20341.zip
    XS Messaging Service 1 (1.004.10) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACMESSSRV04_10.zip
    Develop and run portal services for customer apps on XSA (1.005.1)
in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACPORTALSERV05_1.zip
    SAP Web IDE Web Client (4.005.1) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_SAP_WEB_IDE_20/XSACSAPWEBIDE05_1.zip
    XS JOB SCHEDULER 1.0 (1.007.12) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACSERVICES07_12.zip
    SAPUI5 FESV6 XSA 1 - SAPUI5 1.71 (1.071.25) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5FESV671_25.zip
    SAPUI5 SERVICE BROKER XSA 1 - SAPUI5 Service Broker 1.0 (1.000.3) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5SB00_3.zip
    XSA Cockpit 1 (1.001.17) in /mnt/sapcc-share/software/SAP/HANA2SP5-
```

```
52/DATA_UNITS/XSA_CONTENT_10/XSACXSACOCKPIT01_17.zip


SAP HANA Database version '2.00.052.00.1599235305' will be installed.

Select additional components for installation:
  Index | Components | Description

-------------------------------------------------------------------------
---------------------
  1     | all        | All components
  2     | server     | No additional components
  3     | client     | Install SAP HANA Database Client version
2.5.109.1598303414
  4     | lss        | Install SAP HANA Local Secure Store version
2.4.24.0
  5     | studio     | Install SAP HANA Studio version 2.3.54.000000
  6     | smartda    | Install SAP HANA Smart Data Access version
2.00.5.000.0
  7     | xs         | Install SAP HANA XS Advanced Runtime version
1.0.130.519
  8     | afl        | Install SAP HANA AFL (incl.PAL,BFL,OFL) version
2.00.052.0000.1599259237
  9     | eml        | Install SAP HANA EML AFL version
2.00.052.0000.1599259237
  10    | epmmds     | Install SAP HANA EPM-MDS version
2.00.052.0000.1599259237

Enter comma-separated list of the selected indices [3]: 2,3
Enter Installation Path [/hana/shared]:
Enter Local Host Name [sapcc-hana-tst-03]:
```

3. Verify that the installation tool installed all selected components at all worker and standby hosts.

Adding additional data volume partitions for SAP HANA single-host systems

Starting with SAP HANA 2.0 SPS4, additional data volume partitions can be configured. This feature allows you to configure two or more LUNs for the data volume of an SAP HANA tenant database and to scale beyond the size and performance limits of a single LUN.

> It is not necessary to use multiple partitions to fulfill the SAP HANA KPIs. A single LUN with a single partition fulfills the required KPIs.

Using two or more individual LUNs for the data volume is only available for SAP HANA single-host systems. The SAP storage connector required for SAP HANA multiple-host systems does only support one device for the data volume.

Adding additional data volume partitions can be done at any time but might require a restart of the SAP HANA database.

Enabling additional data volume partitions

To enable additional data volume partitions, complete the following steps:

1. Add the following entry within the `global.ini` file.

```
[customizable_functionalities]
persistence_datavolume_partition_multipath = true
```

2. Restart the database to enable the feature. Adding the parameter through the SAP HANA Studio to the `global.ini` file by using the Systemdb configuration prevents the restart of the database.

Volume and LUN configuration

The layout of volumes and LUNs is like the layout of a single host with one data volume partition, but with an additional data volume and LUN stored on a different aggregate as the log volume and the other data volume. The following table shows an example configuration of an SAP HANA single-host systems with two data volume partitions.

Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data volume: SID_data_mnt00001	Shared volume: SID_shared	Data volume: SID_data2_mnt00001	Log volume: SID_log_mnt00001

The following table shows an example of the mount point configuration for a single-host system with two data volume partitions.

LUN	Mount point at HANA host	Note
SID_data_mnt00001	/hana/data/SID/mnt00001	Mounted using /etc/fstab entry
SID_data2_mnt00001	/hana/data2/SID/mnt00001	Mounted using /etc/fstab entry
SID_log_mnt00001	/hana/log/SID/mnt00001	Mounted using /etc/fstab entry
SID_shared	/hana/shared/SID	Mounted using /etc/fstab entry

Create the new data LUNs using either ONTAP System Manager or the ONTAP CLI.

Host configuration

To configure a host, complete the following steps:

1. Configure multipathing for the additional LUNs, as described in chapter 0.
2. Create the XFS file system on each additional LUN belonging to the HANA system:

```
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_data2_mnt00001
```

3. Add the additional file system/s to the `/etc/fstab` configuration file.

> The XFS file systems for the data and log LUN must be mounted with the `relatime` and `inode64` mount options.

```
stlrx300s8-6:/ # cat /etc/fstab
/dev/mapper/hana-SS3_shared /hana/shared xfs defaults 0 0
/dev/mapper/hana-SS3_log_mnt00001 /hana/log/SS3/mnt00001 xfs
relatime,inode64 0 0
/dev/mapper/hana-SS3_data_mnt00001 /hana/data/SS3/mnt00001 xfs
relatime,inode64 0 0
/dev/mapper/hana-SS3_data2_mnt00001 /hana/data2/SS3/mnt00001 xfs
relatime,inode64 0 0
```

4. Create mount points and set permissions on the database host.

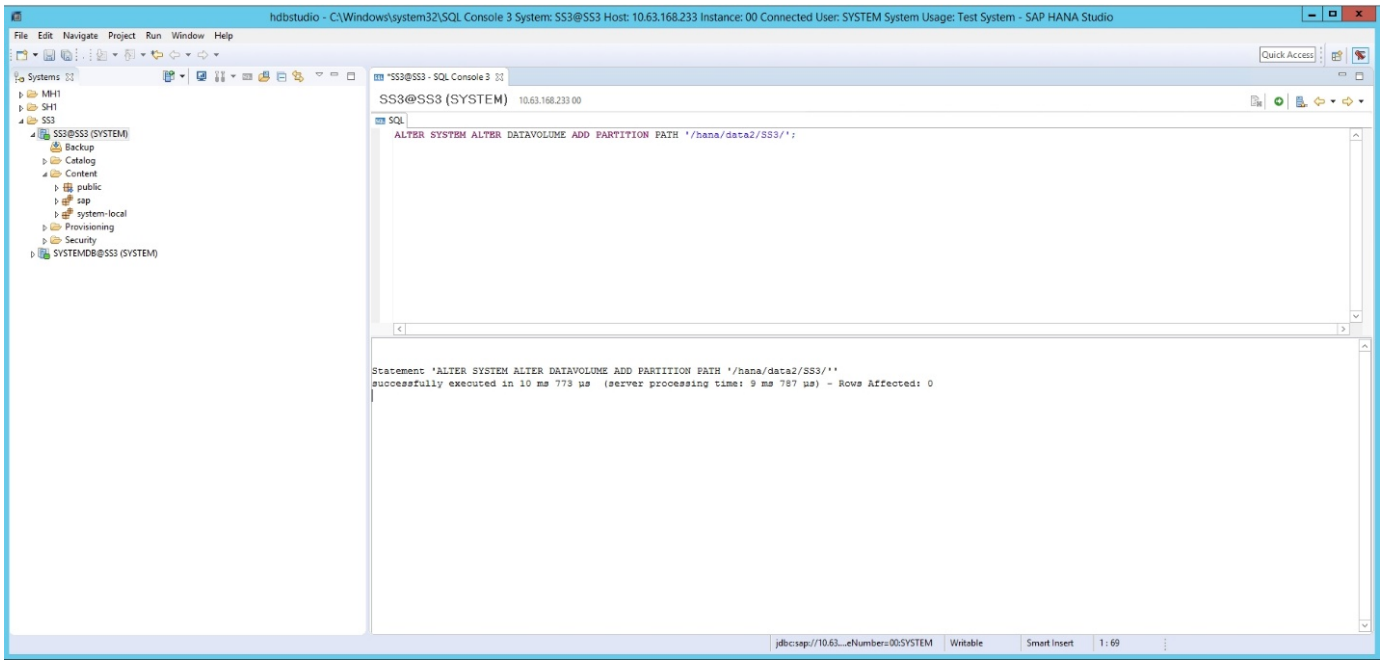
```
stlrx300s8-6:/ # mkdir -p /hana/data2/SS3/mnt00001
stlrx300s8-6:/ # chmod –R 777 /hana/data2/SS3
```

5. Mount the file systems, run the `mount –a` command.

Adding an additional datavolume partition

To add an additional datavolume partition to your tenant database, execute the following SQL statement against the tenant database. Each additional LUN can have a different path:

```
ALTER SYSTEM ALTER DATAVOLUME ADD PARTITION PATH '/hana/data2/SID/';
```



Where to find additional information

To learn more about the information described in this document, refer to the following documents and/or websites:

- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere

  www.vmware.com/files/pdf/SAP_HANA_on_vmware_vSphere_best_practices_guide.pdf

- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere

  http://www.vmware.com/files/pdf/sap-hana-scale-out-deployments-on-vsphere.pdf

- SAP Certified Enterprise Storage Hardware for SAP HANA

  https://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/enterprise-storage.html

- SAP HANA Storage Requirements

  http://go.sap.com/documents/2015/03/74cdb554-5a7c-0010-82c7-eda71af511fa.html

- SAP HANA Tailored Data Center Integration Frequently Asked Questions

  https://www.sap.com/documents/2016/05/e8705aae-717c-0010-82c7-eda71af511fa.html

- TR-4646: SAP HANA Disaster Recovery with Storage Replication Using SnapCenter 4.0 SAP HANA Plug-In

  https://www.netapp.com/us/media/tr-4646.pdf

- TR-4614: SAP HANA Backup and Recovery with SnapCenter

  https://www.netapp.com/us/media/tr-4614.pdf

- TR-4338: SAP HANA on VMware vSphere with NetApp FAS and AFF Systems

  www.netapp.com/us/media/tr-4338.pdf

- TR-4667: Automating SAP System Copies Using the SnapCenter 4.0 SAP HANA Plugin

  https://docs.netapp.com/us-en/netapp-solutions-sap/lifecycle/sc-copy-clone-introduction.html

- NetApp Documentation Centers

  https://www.netapp.com/us/documentation/index.aspx

- NetApp AFF Storage System Resources

  https://mysupport.netapp.com/info/web/ECMLP2676498.html

- SAP HANA Software Solutions

  www.netapp.com/us/solutions/applications/sap/index.aspx#sap-hana

SAP HANA on NetApp AFF Systems with NFS Configuration Guide

TR-4435: SAP HANA on NetApp AFF Systems with NFS - Configuration Guide

Nils Bauer and Marco Schön, NetApp

The NetApp AFF A-Series and AFF C-Series product families have been certified for use with SAP HANA in tailored data center integration (TDI) projects.

This certification is valid for the following models:

- AFF A150, AFF A220, AFF A250, AFF A300, AFF A320, AFF A400, AFF A700s, AFF A700, AFF A800, AFF A900
- AFF C250, AFF C400, AFF C800

> NetApp AFF C-Series requires NetApp ONTAP 9.13.1 or later

A complete list of NetApp certified storage solutions for SAP HANA can be found at the Certified and supported SAP HANA hardware directory.

This document describes the ONTAP configuration requirements for the NFS protocol version 3 (NFSv3) or the NFS protocol version 4 (NFSv4.1).

> The configuration described in this paper is necessary to achieve the required SAP HANA KPIs and the best performance for SAP HANA. Changing any settings or using features not listed herein might cause performance degradation or unexpected behavior and should only be done if advised by NetApp support.

The configuration guides for NetApp AFF systems using FCP and for FAS systems using NFS or FCP can be found at the following links:

- SAP HANA on NetApp FAS Systems with Fibre Channel Protocol
- SAP HANA on NetApp FAS Systems with NFS
- SAP HANA on NetApp AFF Systems with Fibre Channel Protocol

The following table shows the supported combinations for NFS versions, NFS locking, and the required isolation implementations, depending on the SAP HANA database configuration.

For SAP HANA single-host systems or multiple hosts that do not use Host Auto-Failover, NFSv3 and NFSv4 are supported.

For SAP HANA multiple host systems with Host Auto-Failover, NetApp only supports NFSv4, while using NFSv4 locking as an alternative to a server-specific STONITH (SAP HANA HA/DR provider) implementation.

SAP HANA	NFS version	NFS locking	SAP HANA HA/DR provider
SAP HANA single host, multiple hosts without Host Auto-Failover	NFSv3	Off	n/a
	NFSv4	On	n/a
SAP HANA multiple hosts using Host Auto-Failover	NFSv3	Off	Server-specific STONITH implementation mandatory
	NFSv4	On	Not required

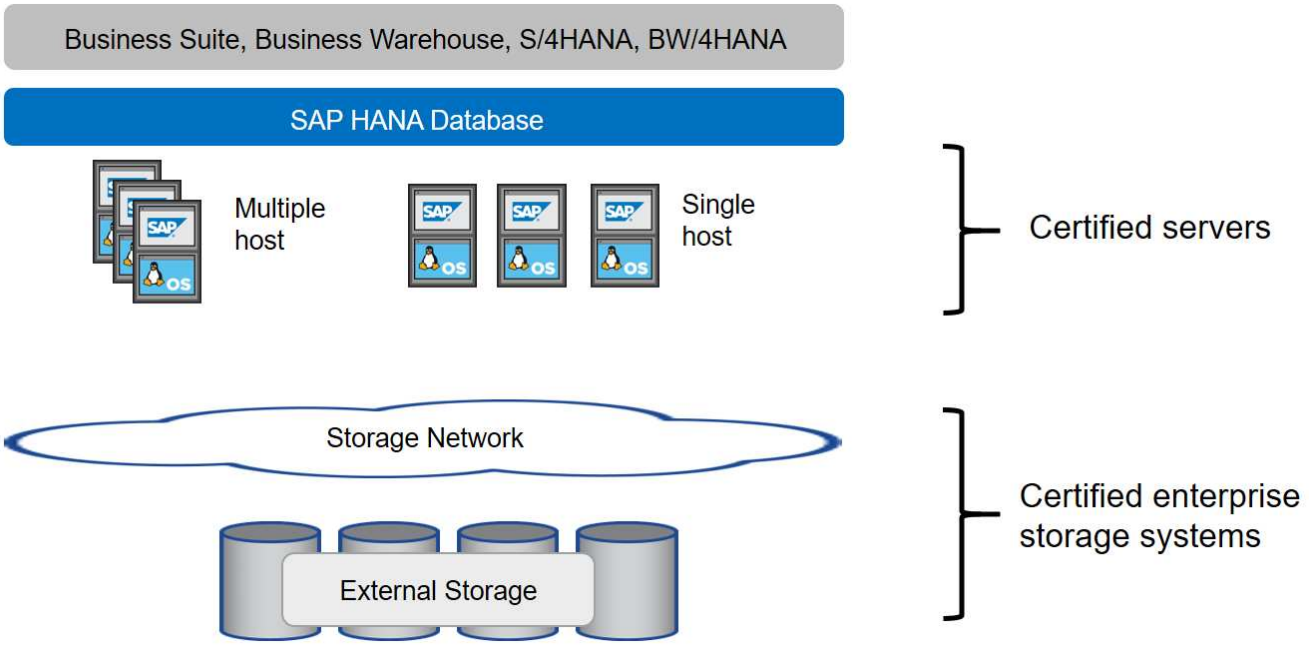
A server-specific STONITH implementation is not part of this guide. Contact your server vendor for such an implementation.

This document covers configuration recommendations for SAP HANA running on physical servers and on virtual servers that use VMware vSphere.

See the relevant SAP notes for operating system configuration guidelines and HANA-specific Linux kernel dependencies. For more information, see SAP note 2235581: SAP HANA Supported Operating Systems.

SAP HANA tailored data center integration

NetApp AFF storage controllers are certified in the SAP HANA TDI program using both NFS (NAS) and FC (SAN) protocols. They can be deployed in any of the current SAP HANA scenarios, such as SAP Business Suite on HANA, S/4HANA, BW/4HANA, or SAP Business Warehouse on HANA in either single-host or multiple-host configurations. Any server that is certified for use with SAP HANA can be combined with NetApp certified storage solutions. See the following figure for an architecture overview of SAP HANA TDI.



For more information regarding the prerequisites and recommendations for producti SAP HANA systems, see the following resource:

- SAP HANA Tailored Data Center Integration Frequently Asked Questions

SAP HANA using VMware vSphere

There are several options for connecting storage to virtual machines (VMs). The preferred option is to connect the storage volumes with NFS directly out of the guest operating system. Using this option, the configuration of hosts and storage does not differ between physical hosts and VMs.

NFS datastores and VVOL datastores with NFS are supported as well. For both options, only one SAP HANA data or log volume must be stored within the datastore for production use cases. In addition, Snapshot-based backup and recovery orchestrated by NetApp SnapCenter and solutions based on this, such as SAP System cloning, cannot be implemented.

This document describes the recommended setup with direct NFS mounts from the guest OS.

For more information about using vSphere with SAP HANA, see the following links:

- SAP HANA on VMware vSphere - Virtualization - Community Wiki
- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere
- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere
- 2161991 - VMware vSphere configuration guidelines - SAP ONE Support Launchpad (Login required)

Architecture

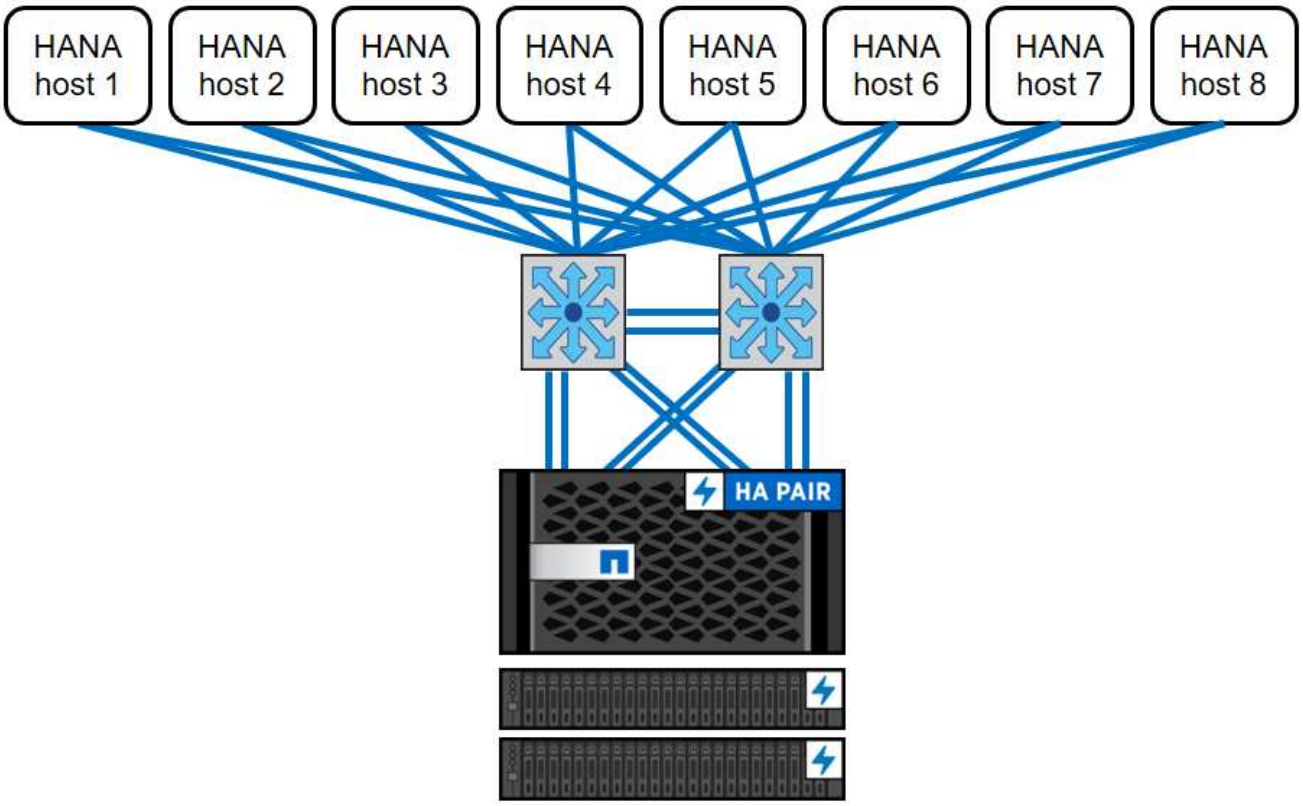
SAP HANA hosts are connected to storage controllers by using a redundant 10GbE or faster network infrastructure. Data communication between SAP HANA hosts and storage controllers is based on the NFS protocol. A redundant switching infrastructure is required to provide fault-tolerant SAP HANA host-to-storage connectivity in case of switch

or network interface card (NIC) failure.

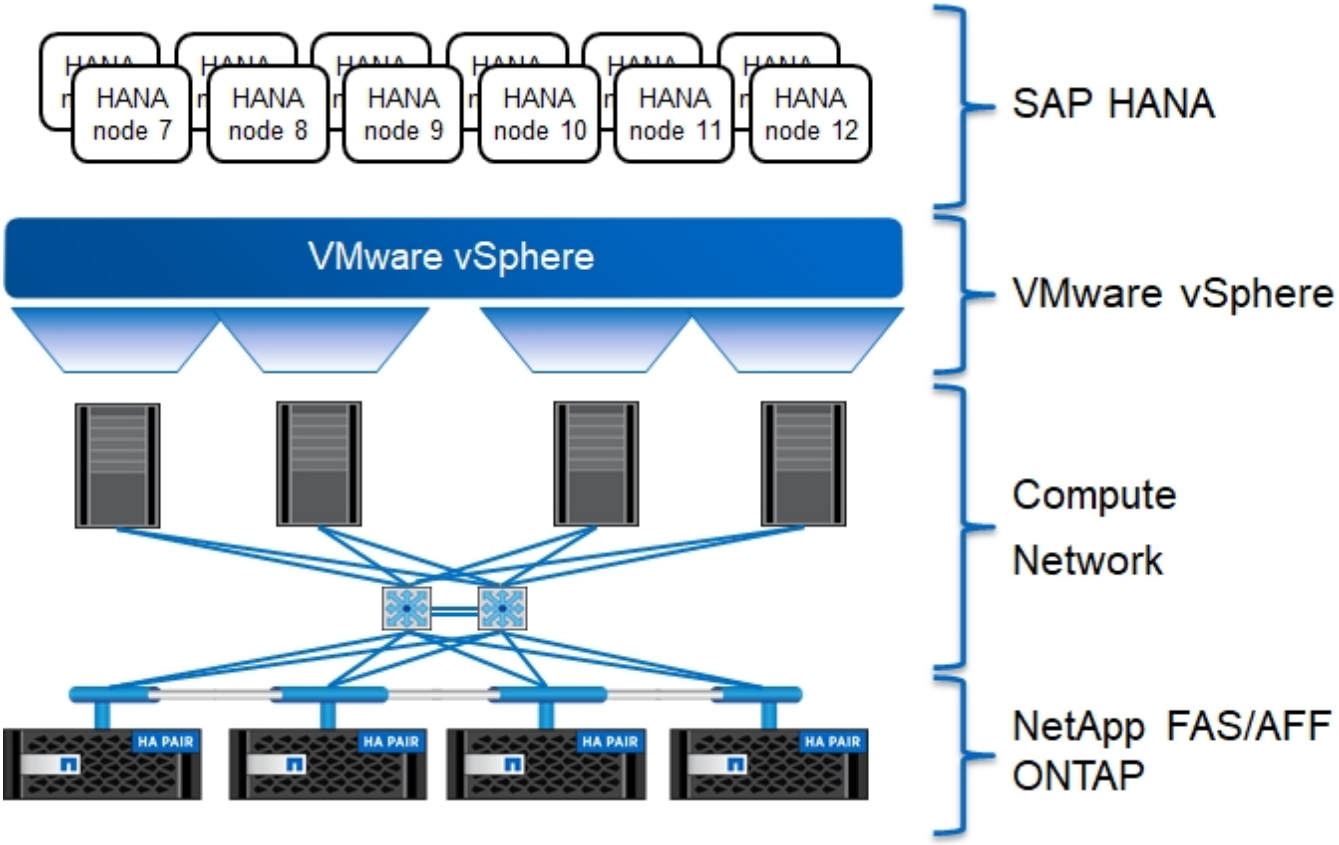
The switches might aggregate individual port performance with port channels in order to appear as a single logical entity at the host level.

Different models of the AFF system product family can be mixed and matched at the storage layer to allow for growth and differing performance and capacity needs. The maximum number of SAP HANA hosts that can be attached to the storage system is defined by the SAP HANA performance requirements and the model of NetApp controller used. The number of required disk shelves is only determined by the capacity and performance requirements of the SAP HANA systems.

The following figure shows an example configuration with eight SAP HANA hosts attached to a storage high availability (HA) pair.



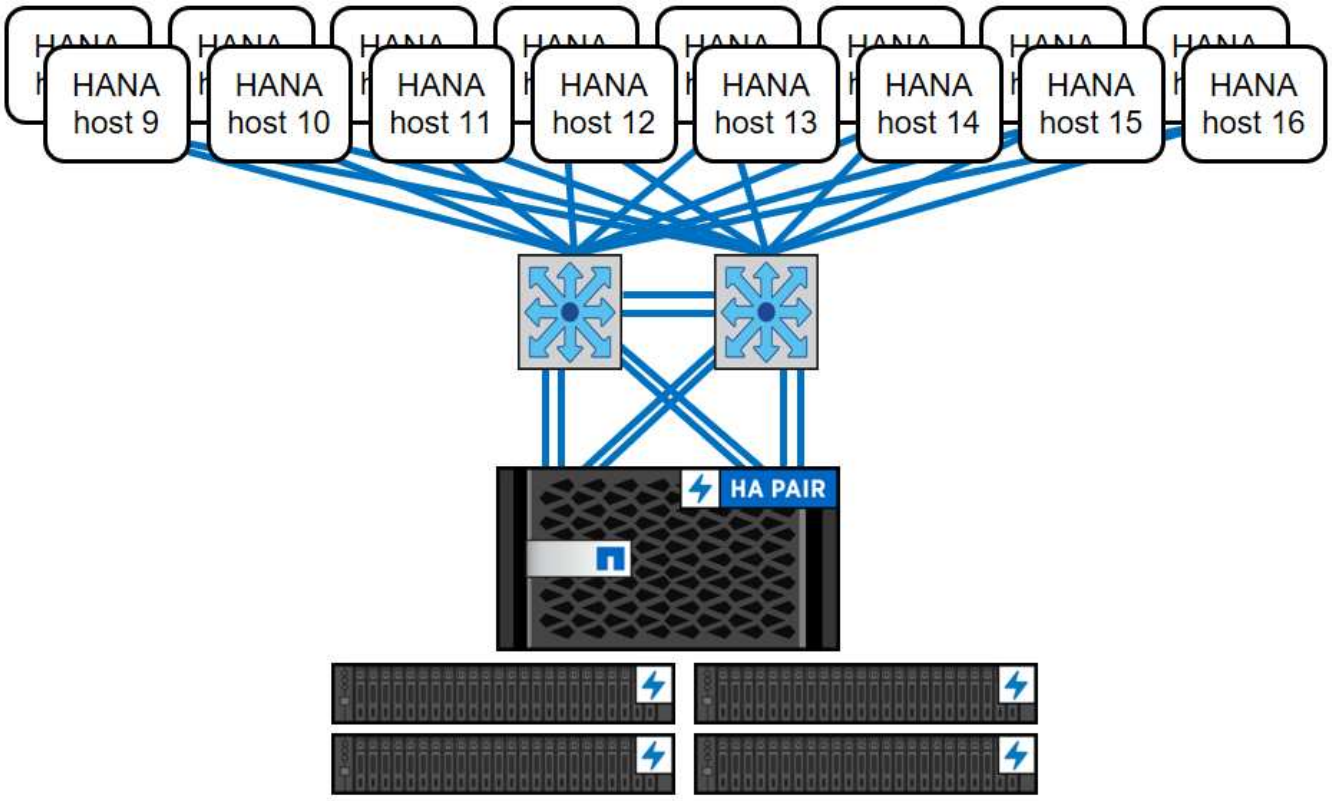
The following figure shows an example of using VMware vSphere as a virtualization layer.



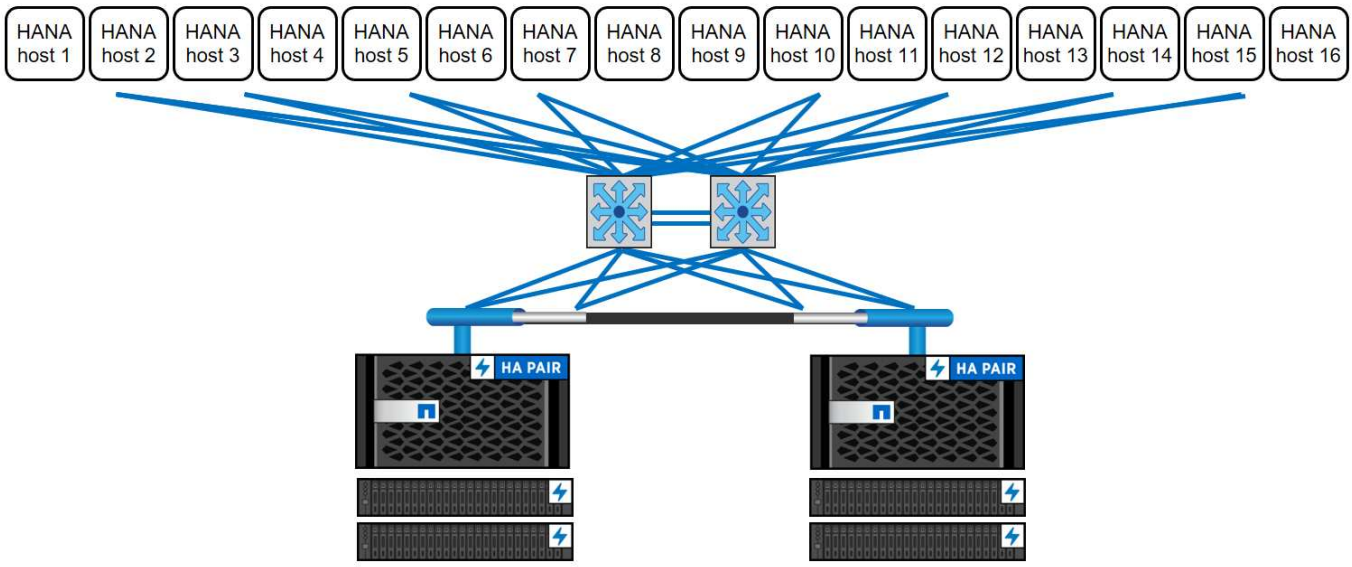
The architecture can be scaled in two dimensions:

- By attaching additional SAP HANA hosts and storage capacity to the existing storage, if the storage controllers provide enough performance to meet the current SAP HANA key performance indicators (KPIs).
- By adding more storage systems with additional storage capacity for the additional SAP HANA hosts

The following figure shows an example configuration in which more SAP HANA hosts are attached to the storage controllers. In this example, more disk shelves are necessary to fulfill the capacity and performance requirements of the 16 SAP HANA hosts. Depending on the total throughput requirements, you must add additional 10GbE or faster connections to the storage controllers.



Independent of the deployed AFF system, the SAP HANA landscape can also be scaled by adding any of the certified storage controllers to meet the desired node density, as shown in the following figure.



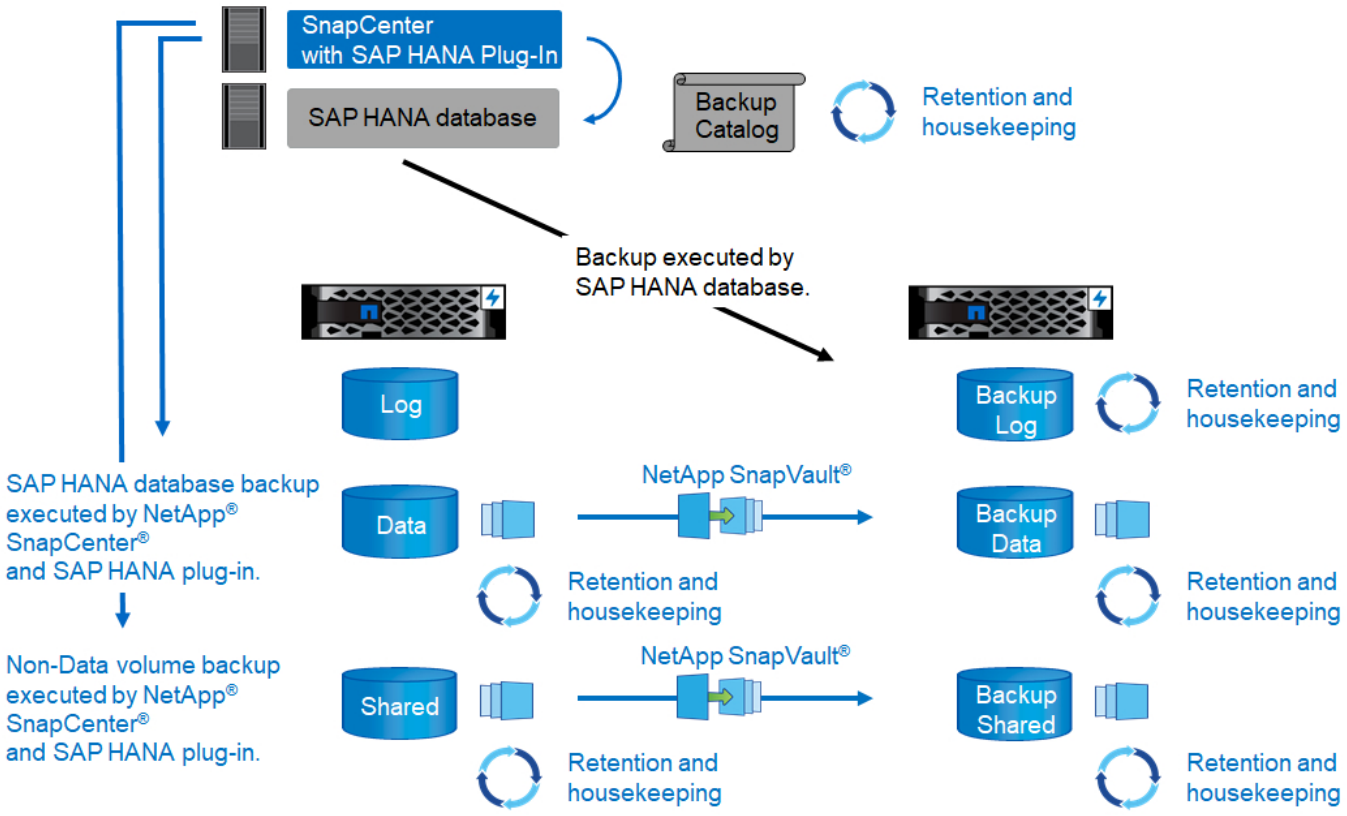
SAP HANA backup

The ONTAP software present on all NetApp storage controllers provides a built-in mechanism to back up SAP HANA databases while in operation with no effect on performance. Storage-based NetApp Snapshot backups are a fully supported and integrated backup solution available for SAP HANA single containers and for SAP HANA Multitenant Database Containers (MDC) systems with a single tenant or multiple tenants.

Storage-based Snapshot backups are implemented by using the NetApp SnapCenter plug-in for SAP HANA. This allows users to create consistent storage-based Snapshot backups by using the interfaces provided natively by SAP HANA databases. SnapCenter registers each of the Snapshot backups into the SAP HANA backup catalog. Therefore, the backups taken by SnapCenter are visible within SAP HANA Studio and Cockpit where they can be selected directly for restore and recovery operations.

NetApp SnapMirror technology enables Snapshot copies that were created on one storage system to be replicated to a secondary backup storage system that is controlled by SnapCenter. Different backup retention policies can then be defined for each of the backup sets on the primary storage and for the backup sets on the secondary storage systems. The SnapCenter Plug-in for SAP HANA automatically manages the retention of Snapshot copy-based data backups and log backups, including the housekeeping of the backup catalog. The SnapCenter Plug-in for SAP HANA also allows the execution of a block integrity check of the SAP HANA database by executing a file-based backup.

The database logs can be backed up directly to the secondary storage by using an NFS mount, as shown in the following figure.



Storage-based Snapshot backups provide significant advantages compared to conventional file-based backups. These advantages include, but are not limited to, the following:

- Faster backup (a few minutes)
- Reduced recovery time objective (RTO) due to a much faster restore time on the storage layer (a few minutes) as well as more frequent backups
- No performance degradation of the SAP HANA database host, network, or storage during backup and recovery operations
- Space-efficient and bandwidth-efficient replication to secondary storage based on block changes

For detailed information about the SAP HANA backup and recovery solution see TR-4614: SAP HANA Backup and Recovery with SnapCenter.

SAP HANA disaster recovery

SAP HANA disaster recovery (DR) can be done either on the database layer by using SAP HANA system replication or on the storage layer by using storage replication technologies. The following section provides an overview of disaster recovery solutions based on storage replication.

For detailed information about SAP HANA disaster recovery solutions, see TR-4646: SAP HANA Disaster Recovery with Storage Replication.

Storage replication based on SnapMirror

The following figure shows a three-site disaster recovery solution using synchronous SnapMirror replication to the local DR datacenter and asynchronous SnapMirror to replicate the data to the remote DR datacenter.

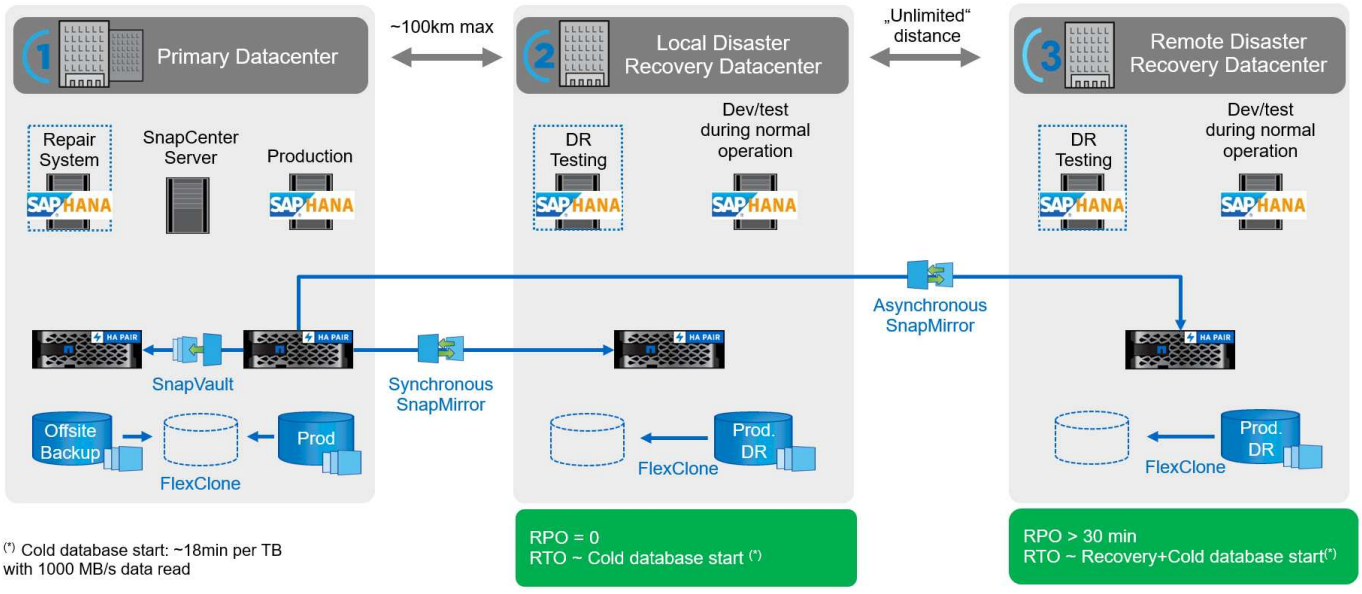
Data replication using synchronous SnapMirror provides an RPO of zero. The distance between the primary and the local DR datacenter is limited to around 100km.

Protection against failures of both the primary and the local DR site is performed by replicating the data to a third remote DR datacenter using asynchronous SnapMirror. The RPO depends on the frequency of replication updates and how fast they can be transferred. In theory, the distance is unlimited, but the limit depends on the amount of data that must be transferred and the connection that is available between the data centers. Typical RPO values are in the range of 30 minutes to multiple hours.

The RTO for both replication methods primarily depends on the time needed to start the HANA database at the DR site and load the data into memory. With the assumption that the data is read with a throughput of 1000MBps, loading 1TB of data would take approximately 18 minutes.

The servers at the DR sites can be used as dev/test systems during normal operation. In the case of a disaster, the dev/test systems would need to be shut down and started as DR production servers.

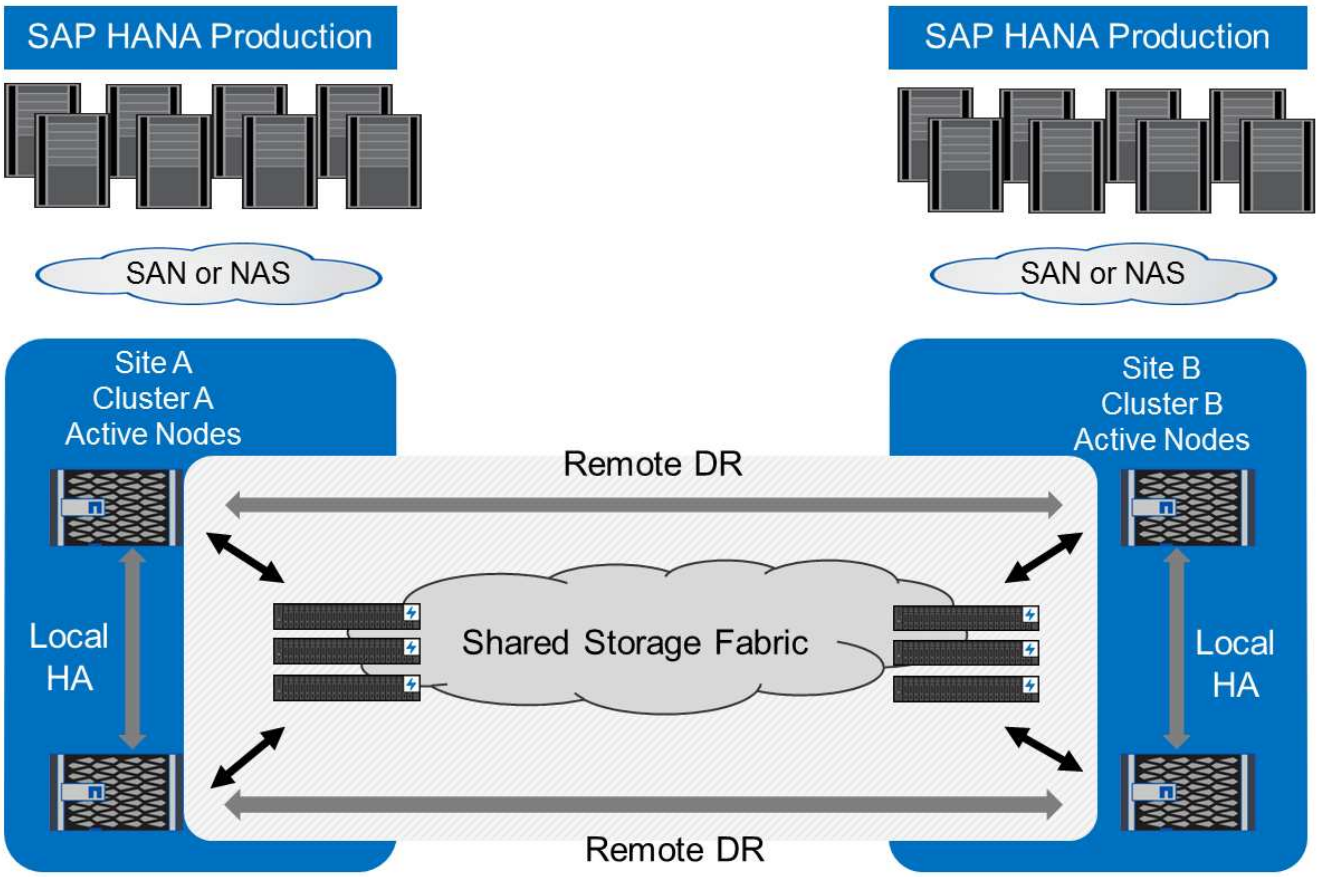
Both replication methods allow to you execute DR workflow testing without influencing the RPO and RTO. FlexClone volumes are created on the storage and are attached to the DR testing servers.



Synchronous replication offers StrictSync mode. If the write to secondary storage is not completed for any reason, the application I/O fails, thereby ensuring that the primary and secondary storage systems are identical. Application I/O to the primary resumes only after the SnapMirror relationship returns to the InSync status. If the primary storage fails, application I/O can be resumed on the secondary storage after failover with no loss of data. In StrictSync mode, the RPO is always zero.

Storage replication based on MetroCluster

The following figure shows a high-level overview of the solution. The storage cluster at each site provides local high availability and is used for the production workload. The data of each site is synchronously replicated to the other location and is available in case of disaster failover.



Storage sizing

The following section provides an overview of the required performance and capacity considerations needed for sizing a storage system for SAP HANA.

Contact NetApp or your NetApp partner sales representative to assist you in creating a properly sized storage environment.

Performance considerations

SAP has defined a static set of storage KPIs. These KPIs are valid for all production SAP HANA environments independent of the memory size of the database hosts and the applications that use the SAP HANA database. These KPIs are valid for single-host, multiple-host, Business Suite on HANA, Business Warehouse on HANA, S/4HANA, and BW/4HANA environments. Therefore, the current performance sizing approach depends on

only the number of active SAP HANA hosts that are attached to the storage system.

> Storage performance KPIs are only mandated for production SAP HANA systems, but you can implement them in for all HANA system.

SAP delivers a performance test tool that must be used to validate the storage system's performance for active SAP HANA hosts attached to the storage.

NetApp tested and predefined the maximum number of SAP HANA hosts that can be attached to a specific storage model while still fulfilling the required storage KPIs from SAP for production-based SAP HANA systems.

The maximum number of SAP HANA hosts that can be run on a disk shelf and the minimum number of SSDs required per SAP HANA host were determined by running the SAP performance test tool. This test does not consider the actual storage capacity requirements of the hosts. You must also calculate the capacity requirements to determine the actual storage configuration needed.

SAS disk shelf

With the 12Gb serial-attached SCSI (SAS) disk shelf (DS224C), performance sizing is performed by using the following fixed disk-shelf configurations:

- Half-loaded disk shelves with 12 SSDs
- Fully loaded disk shelves with 24 SSDs

> Both configurations use Advanced Disk Partitioning (ADPv2). A half-loaded disk shelf supports up to nine SAP HANA hosts, whereas a fully loaded shelf supports up to 14 hosts in a single disk shelf. The SAP HANA hosts must be equally distributed between both storage controllers. The same applies to the internal disks of an AFF A700s system. The DS224C disk shelf must be connected using 12Gb SAS to support the number of SAP HANA hosts.

The 6Gb SAS disk shelf (DS2246) supports a maximum of four SAP HANA hosts. The SSDs and the SAP HANA hosts must be equally distributed between both storage controllers.

The following table summarizes the supported number of SAP HANA hosts per disk shelf.

	6Gb SAS shelves (DS2246)Fully loaded with 24 SSDs	**12Gb SAS shelves (DS224C)Half loaded with 12 SSDs and ADPv2**	**12Gb SAS shelves (DS224C)Fully loaded with 24 SSDs and ADPv2**
Maximum number of SAP HANA hosts per disk shelf	4	9	14

> This calculation is independent of the storage controller used. Adding more disk shelfs do not increase the maximum amount of SAP HANA hosts a storage controller can support.

NS224 NVMe shelf

The minimum number of 12 NVMe SSDs for the first shelf supports up to 18 SAP HANA hosts. A fully populated shelf (24 SSDs) supports up to 48 SAP HANA hosts. The same applies to the internal disks of an AFF A800 system.

Adding more disk shelfs does not increase the maximum amount of SAP HANA hosts a storage controller can support.

Mixed workloads

SAP HANA and other application workloads running on the same storage controller or in the same storage aggregate are supported. However, it is a NetApp best practice to separate SAP HANA workloads from all other application workloads.

You might decide to deploy SAP HANA workloads and other application workloads on either the same storage controller or the same aggregate. If so, you must make sure that adequate performance is available for SAP HANA within the mixed workload environment. NetApp also recommends that you use quality of service (QoS) parameters to regulate the effect these other applications could have on SAP HANA applications and to guarantee throughput for SAP HANA applications.

The SAP performance test tool must be used to check if additional SAP HANA hosts can be run on an existing storage controller that is already in use for other workloads. SAP application servers can be safely placed on the same storage controller and/or aggregate as the SAP HANA databases.

Capacity considerations

A detailed description of the capacity requirements for SAP HANA is in the SAP Note 1900823 white paper.

The capacity sizing of the overall SAP landscape with multiple SAP HANA systems must be determined by using SAP HANA storage sizing tools from NetApp. Contact NetApp or your NetApp partner sales representative to validate the storage sizing process for a properly sized storage environment.

Configuring the performance test tool

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage system used. These parameters must also be set for the performance test tool from SAP when storage performance is being tested with the SAP performance test tool.

NetApp conducted performance tests to define the optimal values. The following table lists the parameters that must be set within the configuration file of the SAP performance test tool.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For more information about the configuration of the different SAP test tools, see SAP note 1943937 for HWCCT (SAP HANA 1.0) and SAP note 2493172 for HCMT/HCOT (SAP HANA 2.0).

The following example shows how variables can be set for the HCMT/HCOT execution plan.

```
…{
          "Comment": "Log Volume: Controls whether read requests are
```

```
submitted asynchronously, default is 'on'",
         "Name": "LogAsyncReadSubmit",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls whether read requests are
submitted asynchronously, default is 'on'",
         "Name": "DataAsyncReadSubmit",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "LogAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "DataAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "LogAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "DataAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "LogExtMaxParallelIoRequests",
```

```
         "Value": "128",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "DataExtMaxParallelIoRequests",
         "Value": "128",
         "Request": "false"
      }, …
```

These variables must be used for the test configuration. This is usually the case with the predefined execution plans SAP delivers with the HCMT/HCOT tool. The following example for a 4k log write test is from an execution plan.

```
…
      {
         "ID": "D664D001-933D-41DE-A904F304AEB67906",
         "Note": "File System Write Test",
         "ExecutionVariants": [
            {
               "ScaleOut": {
                  "Port": "${RemotePort}",
                  "Hosts": "${Hosts}",
                  "ConcurrentExecution": "${FSConcurrentExecution}"
               },
               "RepeatCount": "${TestRepeatCount}",
               "Description": "4K Block, Log Volume 5GB, Overwrite",
               "Hint": "Log",
               "InputVector": {
                  "BlockSize": 4096,
                  "DirectoryName": "${LogVolume}",
                  "FileOverwrite": true,
                  "FileSize": 5368709120,
                  "RandomAccess": false,
                  "RandomData": true,
                  "AsyncReadSubmit": "${LogAsyncReadSubmit}",
                  "AsyncWriteSubmitActive":
"${LogAsyncWriteSubmitActive}",
                  "AsyncWriteSubmitBlocks":
"${LogAsyncWriteSubmitBlocks}",
                  "ExtMaxParallelIoRequests":
"${LogExtMaxParallelIoRequests}",
                  "ExtMaxSubmitBatchSize": "${LogExtMaxSubmitBatchSize}",
                  "ExtMinSubmitBatchSize": "${LogExtMinSubmitBatchSize}",
                  "ExtNumCompletionQueues":
"${LogExtNumCompletionQueues}",
                  "ExtNumSubmitQueues": "${LogExtNumSubmitQueues}",
                  "ExtSizeKernelIoQueue": "${ExtSizeKernelIoQueue}"
               }
            }, …
```

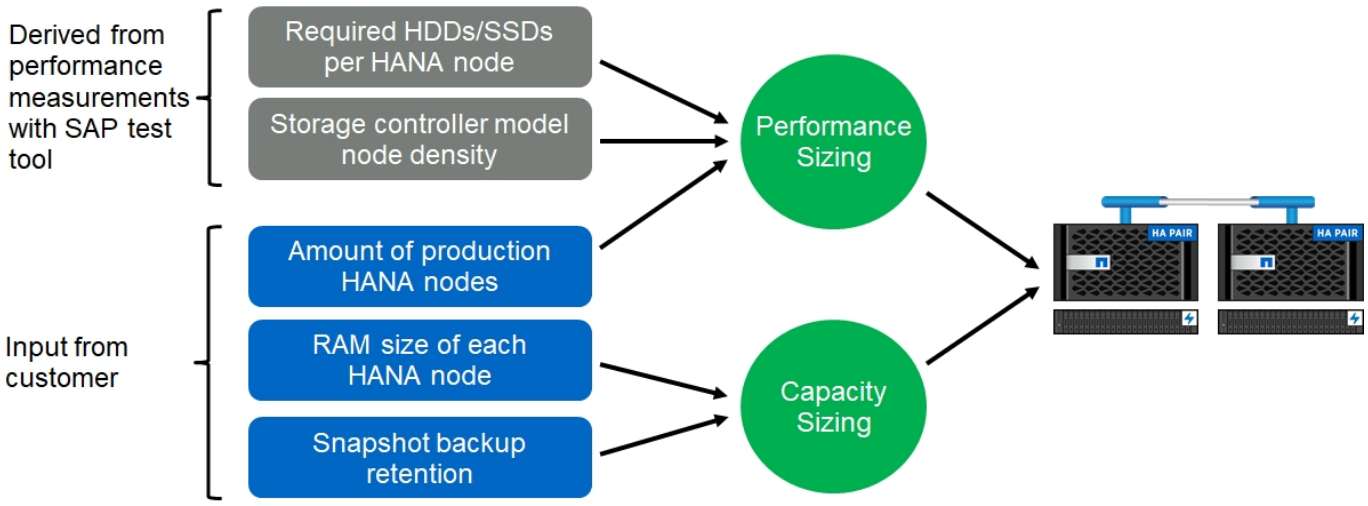
Storage sizing process overview

The number of disks per HANA host and the SAP HANA host density for each storage model were determined with performance test tool.

The sizing process requires details such as the number of production and nonproduction SAP HANA hosts, the RAM size of each host, and backup retention of the storage-based Snapshot copies. The number of SAP HANA hosts determines the storage controller and the number of disks required.

The size of the RAM, net data size on the disk of each SAP HANA host, and the Snapshot copy backup retention period are used as inputs during capacity sizing.

The following figure summarizes the sizing process.



Infrastructure setup and configuration

Network setup

This section describes the dedicated storage network setup for SAP HANA hosts.

Use the following guidelines when configuring the network:

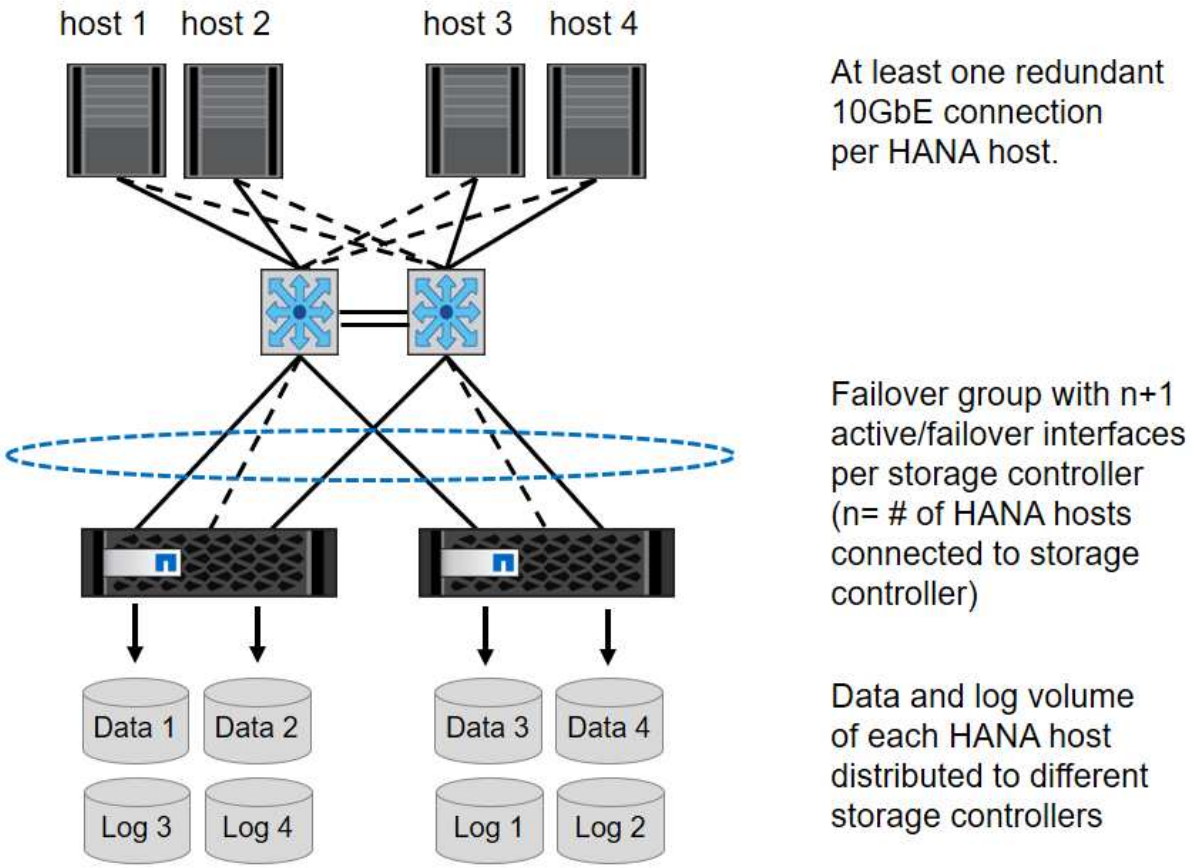
- A dedicated storage network must be used to connect the SAP HANA hosts to the storage controllers with a 10GbE or faster network.
- Use the same connection speed for storage controllers and SAP HANA hosts. If this is not possible, ensure that the network components between the storage controllers and the SAP HANA hosts are able to handle different speeds. For example, you must provide enough buffer space to allow speed negotiation at the NFS level between storage and hosts. Network components are usually switches, but other components within blade chassis, such as the back plane, must be considered as well.
- Disable flow control on all physical ports used for storage traffic on the storage network switch and host layer.
- Each SAP HANA host must have a redundant network connection with a minimum of 10Gb of bandwidth.
- Jumbo frames with a maximum transmission unit (MTU) size of 9,000 must be enabled on all network components between the SAP HANA hosts and the storage controllers.
- In a VMware setup, dedicated VMXNET3 network adapters must be assigned to each running virtual machine. Check the relevant papers mentioned in “Introduction” for further requirements.
- To avoid interference between each other, use separate network/IO paths for the log and data area.

The following figure shows an example with four SAP HANA hosts attached to a storage controller HA pair using a 10GbE network. Each SAP HANA host has an active-passive connection to the redundant fabric.

At the storage layer, four active connections are configured to provide 10Gb throughput for each SAP HANA host. In addition, one spare interface is configured on each storage controller.

At the storage layer, a broadcast domain with an MTU size of 9000 is configured, and all required physical

interfaces are added to this broadcast domain. This approach automatically assigns these physical interfaces to the same failover group. All logical interfaces (LIFs) that are assigned to these physical interfaces are added to this failover group.

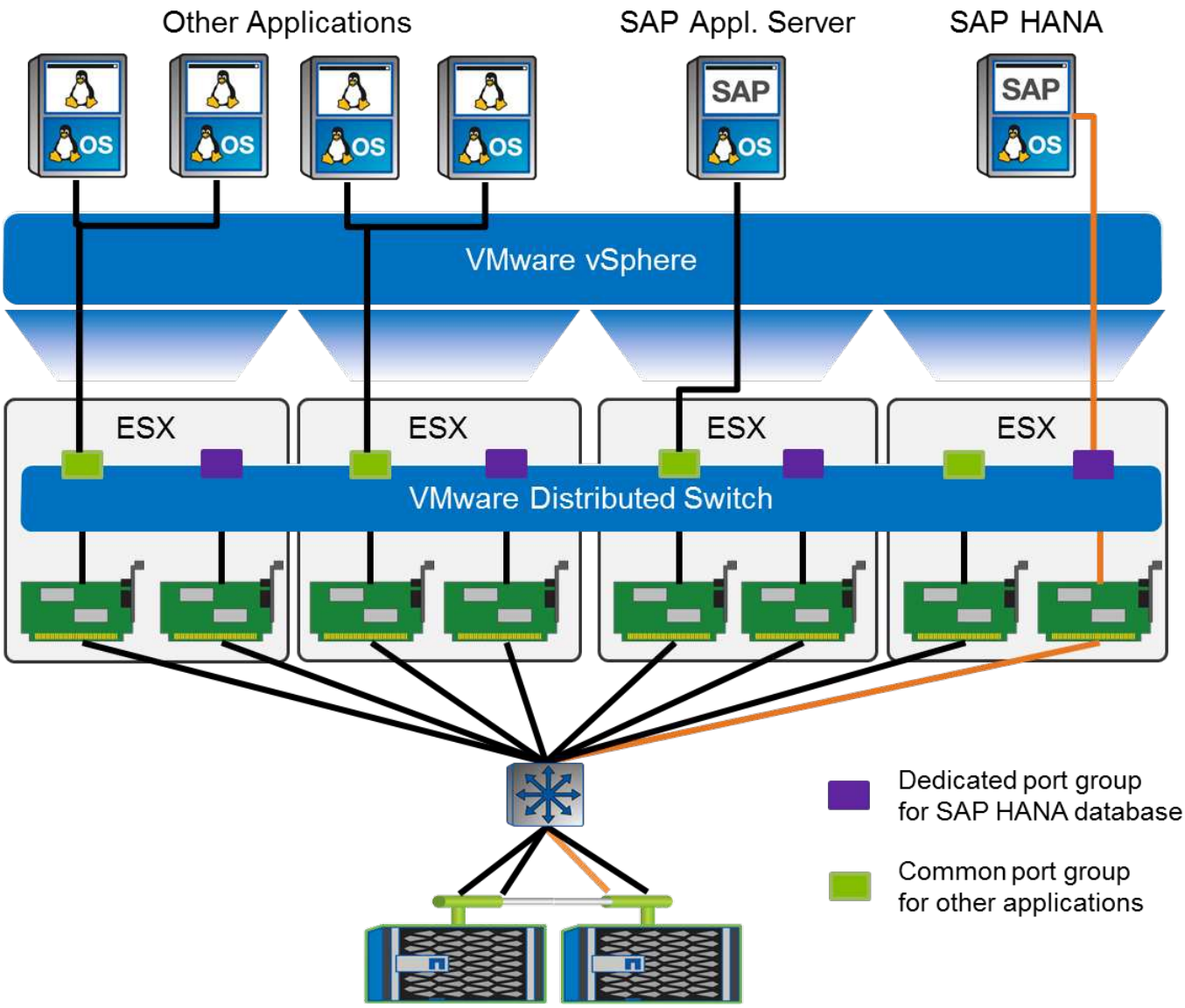


In general, it is also possible to use HA interface groups on the servers (bonds) and the storage systems (for example, Link Aggregation Control Protocol [LACP] and ifgroups). With HA interface groups, verify that the load is equally distributed between all interfaces within the group. The load distribution depends on the functionality of the network switch infrastructure.

Depending on the number of SAP HANA hosts and the connection speed used, different numbers of active physical ports are needed. For details, see the section "LIF configuration".

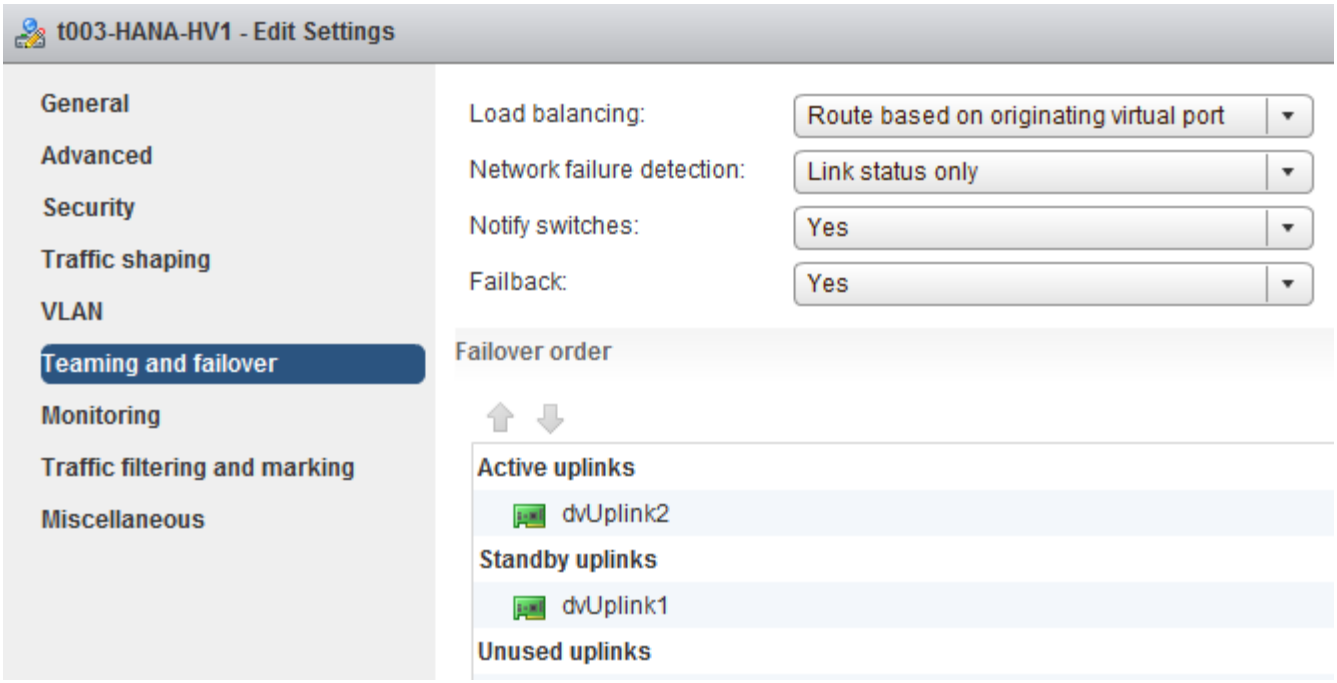
VMware-specific network setup

Proper network design and configuration are crucial because all data for SAP HANA instances, including performance-critical data and log volumes for the database, is provided through NFS in this solution. A dedicated storage network is used to separate the NFS traffic from communication and user access traffic between SAP HANA nodes. Each SAP HANA node requires a redundant dedicated network connection with a minimum of 10Gb of bandwidth. Higher bandwidth is also supported. This network must extend end to end from the storage layer through network switching and computing up to the guest operating system hosted on VMware vSphere. In addition to the physical switching infrastructure, a VMware distributed switch (vDS) is used to provide adequate performance and manageability of network traffic at the hypervisor layer.



As shown in the preceding figure, each SAP HANA node uses a dedicated port group on the VMware distributed switch. This port group allows for enhanced quality of service (QoS) and dedicated assignment of physical network interface cards (NICs) on the ESX hosts. To use dedicated physical NICs while preserving HA capabilities in the event of NIC failure, the dedicated physical NIC is configured as an active uplink. Additional NICs are configured as standby uplinks in the teaming and failover settings of the SAP HANA port group. In addition, jumbo frames (MTU 9,000) must be enabled end to end on physical and virtual switches. In addition, turn off flow control on all ethernet ports used for storage traffic on servers, switches, and storage systems. The following figure shows an example of such a configuration.

LRO (large receive offload) must be turned off for interfaces used for NFS traffic. For all other network configuration guidelines, see the respective VMware best practices guides for SAP HANA.



Time synchronization

You must synchronize the time between the storage controllers and the SAP HANA database hosts. To do so, set the same time server for all storage controllers and all SAP HANA hosts.

Storage controller setup

This section describes the configuration of the NetApp storage system. You must complete the primary installation and setup according to the corresponding ONTAP setup and configuration guides.

Storage efficiency

Inline deduplication, cross-volume inline deduplication, inline compression, and inline compaction are supported with SAP HANA in an SSD configuration.

NetApp Volume and Aggregate Encryption

The use of NetApp Volume Encryption (NVE) and NetApp Aggregate Encryption (NAE) are supported with SAP HANA.

Quality of Service

QoS can be used to limit the storage throughput for specific SAP HANA systems or other applications on a shared-use controller. One use case would be to limit the throughput of development and test systems so that they cannot influence production systems in a mixed setup.

During the sizing process, you should determine the performance requirements of a nonproduction system. Development and test systems can be sized with lower performance values, typically in the range of 20% to 50% of a production- system KPI as defined by SAP.

Starting with ONTAP 9, QoS is configured on the storage volume level and uses maximum values for

throughput (MBps) and the amount of I/O (IOPS).

Large write I/O has the biggest performance effect on the storage system. Therefore, the QoS throughput limit should be set to a percentage of the corresponding write SAP HANA storage performance KPI values in the data and log volumes.

NetApp FabricPool

NetApp FabricPool technology must not be used for active primary file systems in SAP HANA systems. This includes the file systems for the data and log area as well as the `/hana/shared` file system. Doing so results in unpredictable performance, especially during the startup of an SAP HANA system.

Using the “snapshot-only” tiering policy is possible as well as using FabricPool in general at a backup target such as a NetApp SnapVault or SnapMirror destination.

> Using FabricPool for tiering Snapshot copies at primary storage or using FabricPool at a backup target changes the required time for the restore and recovery of a database or other tasks such as creating system clones or repair systems. Take this into consideration for planning your overall lifecycle-management strategy and check to make sure that your SLAs are still being met while using this function.

FabricPool is a good option for moving log backups to another storage tier. Moving backups affects the time needed to recover an SAP HANA database. Therefore, the option “tiering-minimum-cooling-days” should be set to a value that places log backups, which are routinely needed for recovery, on the local fast storage tier.

Storage configuration

The following overview summarizes the required storage configuration steps. Each step is covered in detail in the subsequent sections. In this section, we assume that the storage hardware is set up and that the ONTAP software is already installed. Also, the connections between the storage ports (10GbE or faster) and the network must already be in place.

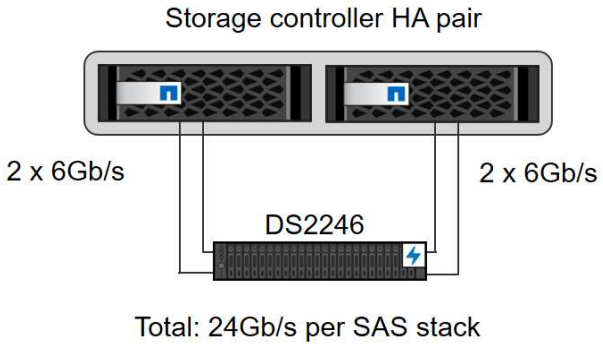
1. Check the correct disk shelf configuration as described in "Disk shelf connection."
2. Create and configure the required aggregates as described in "Aggregate configuration."
3. Create a storage virtual machine (SVM) as described in "SVM configuration."
4. Create LIFs as described in "LIF configuration."
5. Create volumes within the aggregates as described in "[Volume configuration for SAP HANA single host systems]" and "[Volume configuration for SAP HANA multiple host systems]."
6. Set the required volume options as described in "Volume options."
7. Set the required options for NFSv3 as described in "NFS configuration for NFSv3" or for NFSv4 as described in "NFS configuration for NFSv4."
8. Mount the volumes to namespace and set export policies as described in "Mount volumes to namespace and set export policies."

Disk shelf connection

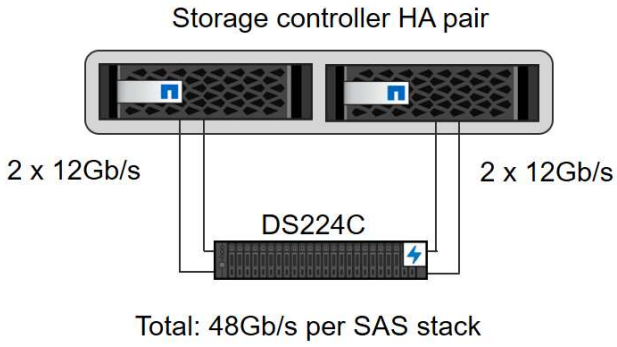
SAS disk shelves

A maximum of one disk shelf can be connected to one SAS stack to provide the required performance for the SAP HANA hosts, as shown in the following figure. The disks within each shelf must be distributed equally to both controllers of the HA pair. ADPv2 is used with ONTAP 9 and the DS224C disk shelves.

With the DS224C disk shelf, quad-path SAS cabling can also be used but is not required.



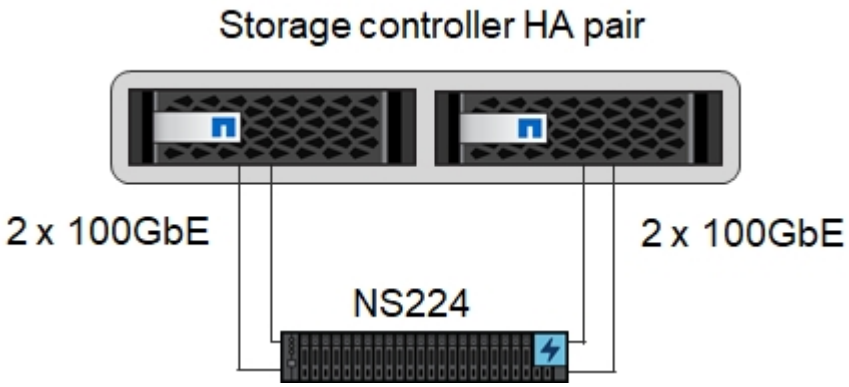
Total: 24Gb/s per SAS stack



Total: 48Gb/s per SAS stack

NVMe (100GbE) disk shelves

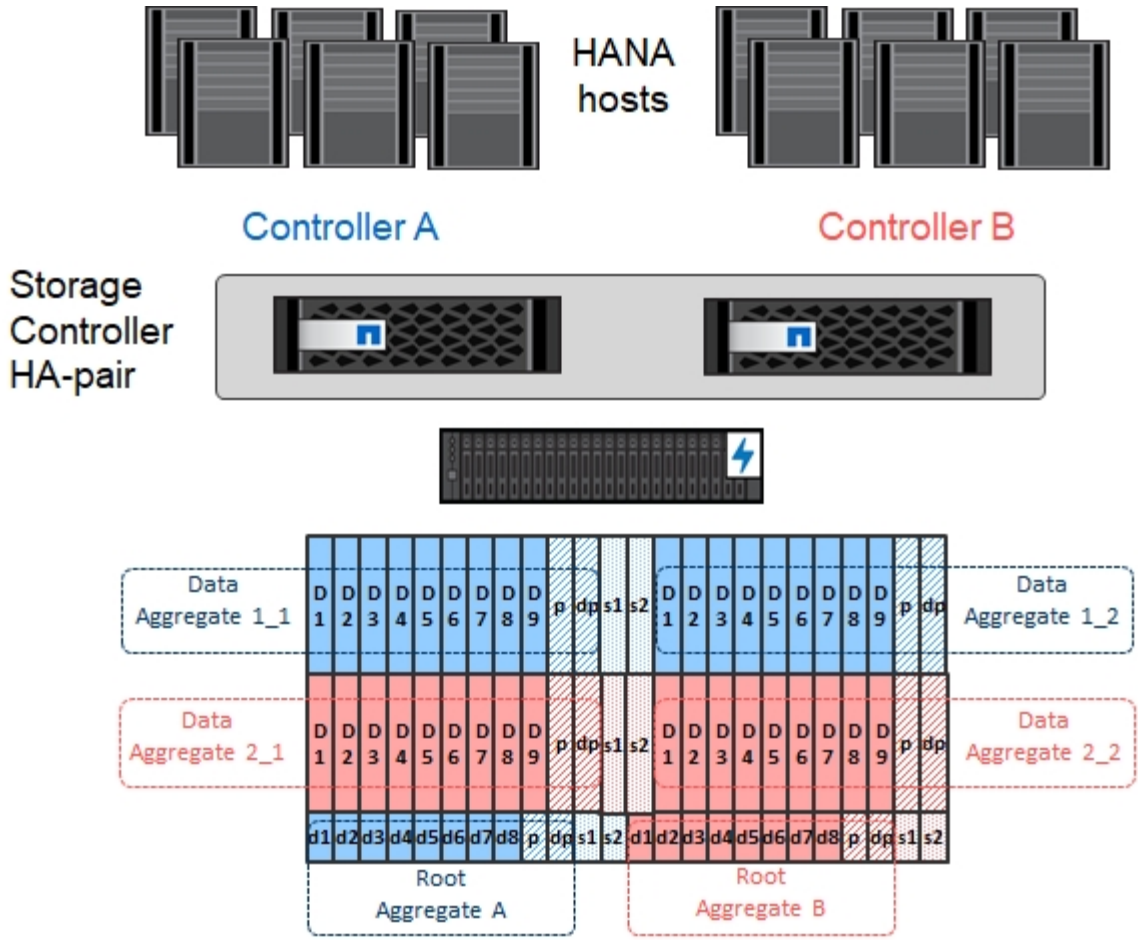
Each NS224 NVMe disk shelf is connected using two 100GbE ports per controller. The disks within each shelf must be distributed equally to both controllers of the HA pair. ADPv2, as described in the aggregate configuration chapter, is also used for the NS224 disk shelf. The following figure depicts the disk shelf connection with an NVMe drive.



Aggregate configuration

In general, you must configure two aggregates per controller, independent of the disk shelf or drive technology (SAS SSDs or NVMe SSDs) that is used. This step is necessary so that you can use all available controller resources. For AFF A200 series systems, one data aggregate is enough.

The following image shows a configuration of 12 SAP HANA hosts running on a 12Gb SAS shelf configured with ADPv2. Six SAP HANA hosts are attached to each storage controller. Four separate aggregates, two at each storage controller, are configured. Each aggregate is configured with 11 disks with nine data and two parity disk partitions. For each controller, two spare partitions are available.



SVM configuration

Multiple SAP landscapes with SAP HANA databases can use a single SVM. An SVM can also be assigned to each SAP landscape, if necessary, in case they are managed by different teams within a company.

If there is a QoS profile automatically created and assigned while creating a new SVM, remove this automatically created profile from the SVM to enable the required performance for SAP HANA:

```
vserver modify -vserver <svm-name> -qos-policy-group none
```

LIF configuration

For SAP HANA production systems, you must use different LIFs to mount the data volume and the log volume from the SAP HANA host. Therefore at least two LIFs are required.

The data and log volume mounts of different SAP HANA hosts can share a physical storage network port by either using the same LIFs or by using individual LIFs for each mount.

The maximum amount of data and log volume mounts per physical interface are shown in the following table.

Ethernet port speed	10GbE	25GbE	40GbE	100GeE
Maximum number of log or data volume mounts per physical port	2	6	12	24

Sharing one LIF between different SAP HANA hosts might require a remount of data or log volumes to a different LIF. This change avoids performance penalties if a volume is moved to a different storage controller.

Development and test systems can use more data and volume mounts or LIFs on a physical network interface.

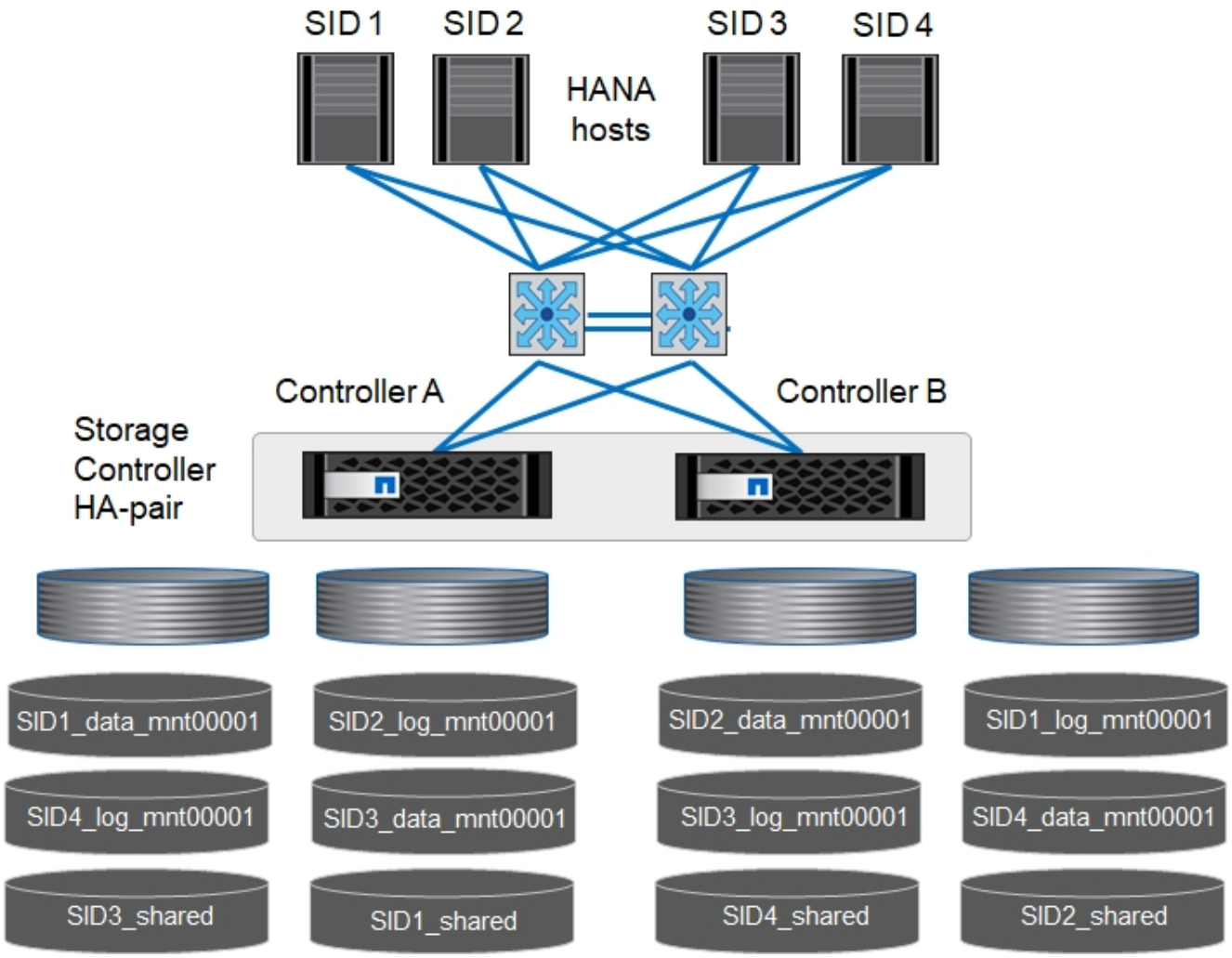
For production, development, and test systems, the `/hana/shared` file system can use the same LIF as the data or log volume.

Volume configuration for SAP HANA single-host systems

The following figure shows the volume configuration of four single-host SAP HANA systems. The data and log volumes of each SAP HANA system are distributed to different storage controllers. For example, volume `SID1_data_mnt00001` is configured on controller A, and volume `SID1_log_mnt00001` is configured on controller B.

If only one storage controller of an HA pair is used for the SAP HANA systems, data and log volumes can also be stored on the same storage controller.

If the data and log volumes are stored on the same controller, access from the server to the storage must be performed with two different LIFs: one LIF to access the data volume and the other to access the log volume.



For each SAP HANA host, a data volume, a log volume, and a volume for `/hana/shared` are configured. The following table shows an example configuration for single-host SAP HANA systems.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller b
Data, log, and shared volumes for system SID1	Data volume: SID1_data_mnt00001	Shared volume: SID1_shared	–	Log volume: SID1_log_mnt00001
Data, log, and shared volumes for system SID2	–	Log volume: SID2_log_mnt00001	Data volume: SID2_data_mnt00001	Shared volume: SID2_shared
Data, log, and shared volumes for system SID3	Shared volume: SID3_shared	Data volume: SID3_data_mnt00001	Log volume: SID3_log_mnt00001	–
Data, log, and shared volumes for system SID4	Log volume: SID4_log_mnt00001	–	Shared volume: SID4_shared	Data volume: SID4_data_mnt00001

The following table shows an example of the mount point configuration for a single-host system. To place the home directory of the `sidadm` user on the central storage, the `/usr/sap/SID` file system should be mounted

from the `SID_shared` volume.

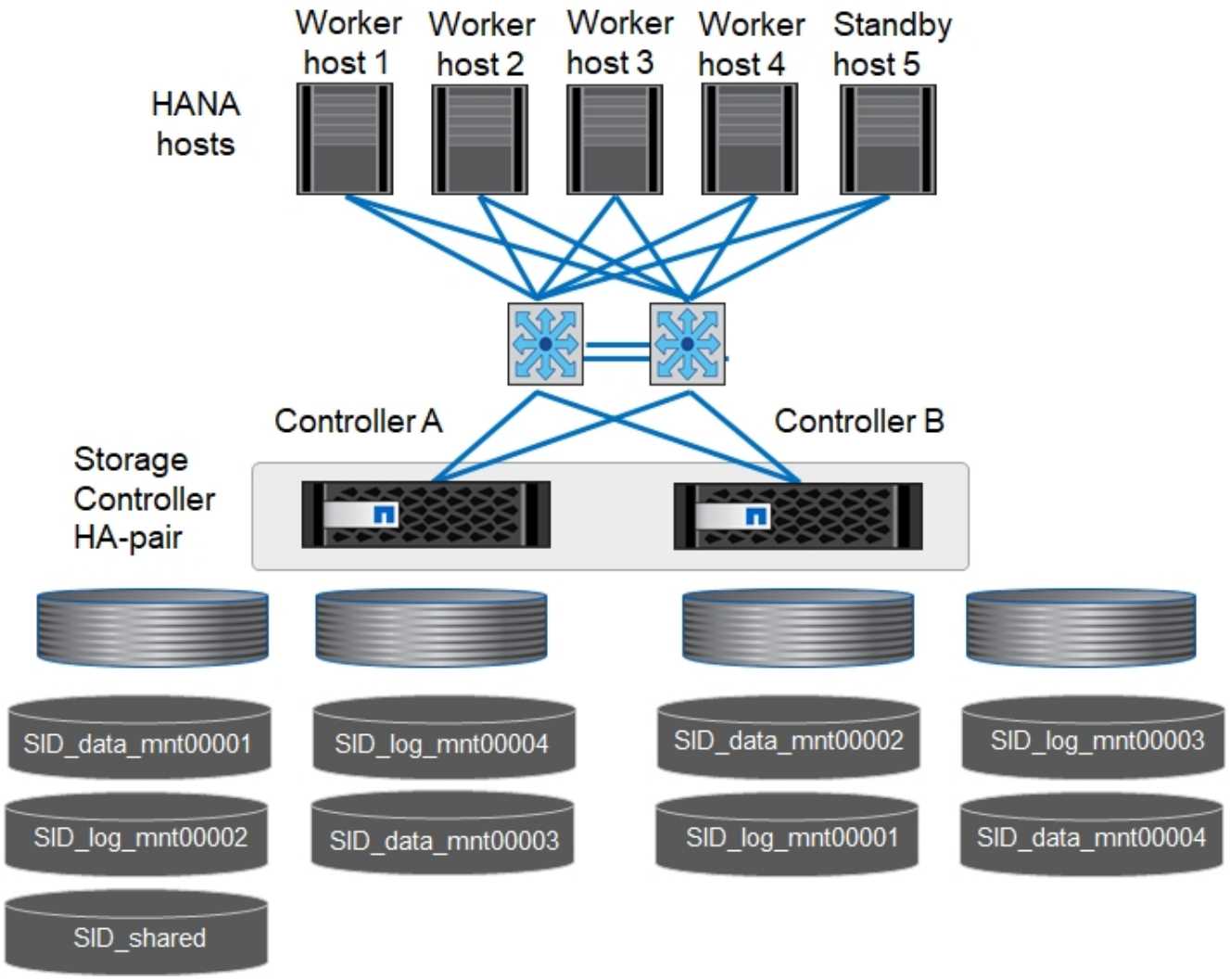
Junction path	Directory	Mount point at HANA host
SID_data_mnt00001		/hana/data/SID/mnt00001
SID_log_mnt00001		/hana/log/SID/mnt00001
SID_shared	usr-sap shared	/usr/sap/SID /hana/shared/

Volume configuration for SAP HANA multiple-host systems

The following figure shows the volume configuration of a 4+1 SAP HANA system. The data and log volumes of each SAP HANA host are distributed to different storage controllers. For example, volume `SID1_data1_mnt00001` is configured on controller A, and volume `SID1_log1_mnt00001` is configured on controller B.

If only one storage controller of an HA pair is used for the SAP HANA system, the data and log volumes can also be stored on the same storage controller.

If the data and log volumes are stored on the same controller, access from the server to the storage must be performed with two different LIFs: one LIF to access the data volume and one to access the log volume.



For each SAP HANA host, a data volume and a log volume are created. The `/hana/shared` volume is used by all hosts of the SAP HANA system. The following table shows an example configuration for a multiple-host SAP HANA system with four active hosts.

Purpose	Aggregate 1 at controller A	Aggregate 2 at controller A	Aggregate 1 at controller B	Aggregate 2 at controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	–	Log volume: SID_log_mnt00001	–
Data and log volumes for node 2	Log volume: SID_log_mnt00002	–	Data volume: SID_data_mnt00002	–
Data and log volumes for node 3	–	Data volume: SID_data_mnt00003	–	Log volume: SID_log_mnt00003
Data and log volumes for node 4	–	Log volume: SID_log_mnt00004	–	Data volume: SID_data_mnt00004
Shared volume for all hosts	Shared volume: SID_shared			

The following table shows the configuration and the mount points of a multiple-host system with four active SAP HANA hosts. To place the home directories of the `sidadm` user of each host on the central storage, the

`/usr/sap/SID` file systems are mounted from the `SID_shared` volume.

Junction path	Directory	Mount point at SAP HANA host	Note
SID_data_mnt00001	–	/hana/data/SID/mnt00001	Mounted at all hosts
SID_log_mnt00001	–	/hana/log/SID/mnt00001	Mounted at all hosts
SID_data_mnt00002	–	/hana/data/SID/mnt00002	Mounted at all hosts
SID_log_mnt00002	–	/hana/log/SID/mnt00002	Mounted at all hosts
SID_data_mnt00003	–	/hana/data/SID/mnt00003	Mounted at all hosts
SID_log_mnt00003	–	/hana/log/SID/mnt00003	Mounted at all hosts
SID_data_mnt00004	–	/hana/data/SID/mnt00004	Mounted at all hosts
SID_log_mnt00004	–	/hana/log/SID/mnt00004	Mounted at all hosts
SID_shared	shared	/hana/shared/SID	Mounted at all hosts
SID_shared	usr-sap-host1	/usr/sap/SID	Mounted at host 1
SID_shared	usr-sap-host2	/usr/sap/SID	Mounted at host 2
SID_shared	usr-sap-host3	/usr/sap/SID	Mounted at host 3
SID_shared	usr-sap-host4	/usr/sap/SID	Mounted at host 4
SID_shared	usr-sap-host5	/usr/sap/SID	Mounted at host 5

Volume options

You must verify and set the volume options listed in the following table on all SVMs. For some of the commands, you must switch to the advanced privilege mode within ONTAP.

Action	Command
Disable visibility of Snapshot directory	vol modify -vserver <vserver-name> -volume <volname> -snapdir-access false
Disable automatic Snapshot copies	vol modify –vserver <vserver-name> -volume <volname> -snapshot-policy none
Disable access time update, except of the SID_shared volume	set advanced vol modify -vserver <vserver-name> -volume <volname> -atime-update false set admin

NFS configuration for NFSv3

The NFS options listed in the following table must be verified and set on all storage controllers. For some of the commands shown in this table, you must switch to the advanced privilege mode.

Action	Command
Enable NFSv3	nfs modify -vserver <vserver-name> v3.0 enabled

Action	Command
ONTAP 9: Set NFS TCP maximum transfer size to 1MB	set advanced nfs modify -vserver <vserver_name> -tcp-max-xfer -size 1048576 set admin
ONTAP 8: Set NFS read and write size to 64KB	set advanced nfs modify -vserver <vserver-name> -v3-tcp-max-read -size 65536 nfs modify -vserver <vserver-name> -v3-tcp-max-write -size 65536 set admin

NFS configuration for NFSv4

The NFS options listed in the following table must be verified and set on all SVMs.

For some of the commands in this table, you must switch to the advanced privilege mode.

Action	Command
Enable NFSv4	nfs modify -vserver <vserver-name> -v4.1 enabled
ONTAP 9: Set NFS TCP maximum transfer size to 1MB	set advanced nfs modify -vserver <vserver_name> -tcp-max-xfer-size 1048576 set admin
ONTAP 8: Set NFS read and write size to 64KB	set advanced nfs modify -vserver <vserver_name> -tcp-max-xfer-size 65536 set admin
Disable NFSv4 access control lists (ACLs)	nfs modify -vserver <vserver_name> -v4.1-acl disabled
Set NFSv4 domain ID	nfs modify -vserver <vserver_name> -v4-id-domain <domain-name>
Disable NFSv4 read delegation	nfs modify -vserver <vserver_name> -v4.1-read -delegation disabled
Disable NFSv4 write delegation	nfs modify -vserver <vserver_name> -v4.1-write -delegation disabled
Disable NFSv4 numeric ids	nfs modify -vserver <vserver_name> -v4-numeric-ids disabled
Change amount of NFSv4.x session slots optional	set advanced nfs modify -vserver hana -v4.x-session-num-slots <value> set admin

Please note that disabling numeric ids requires user management, as described in the section “SAP HANA installation preparations for NFSv4.”

The NFSv4 domain ID must be set to the same value on all Linux servers (`/etc/idmapd.conf`) and SVMs, as described in the section "SAP HANA installation preparations for NFSv4."

If you are using NFSV4.1, then pNFS can be enabled and used.

If SAP HANA multiple-host systems with host auto-failover are being used, the failover parameters need to be adjusted within `nameserver.ini` as shown in the following table.
Keep the default retry interval of 10 seconds within these sections..

Section within nameserver.ini	Parameter	Value
failover	normal_retries	9
distributed_watchdog	deactivation_retries	11
distributed_watchdog	takeover_retries	9

Mount volumes to namespace and set export policies

When a volume is created, the volume must be mounted to the namespace. In this document, we assume that the junction path name is the same as the volume name. By default, the volume is exported with the default policy. The export policy can be adapted if required.

Host setup

All the host-setup steps described in this section are valid for both SAP HANA environments on physical servers and for SAP HANA running on VMware vSphere.

Configuration parameter for SUSE Linux Enterprise Server

Additional kernel and configuration parameters at each SAP HANA host must be adjusted for the workload generated by SAP HANA.

SUSE Linux Enterprise Server 12 and 15

Starting with SUSE Linux Enterprise Server 12 SP1, the kernel parameter must be set in a configuration file in the `/etc/sysctl.d` directory. For example, you must create a configuration file with the name `91-NetApp-HANA.conf`.

```
net.core.rmem_max = 16777216
net.core.wmem_max = 16777216
net.ipv4.tcp_rmem = 4096 131072 16777216
net.ipv4.tcp_wmem = 4096 16384  16777216
net.core.netdev_max_backlog = 300000
net.ipv4.tcp_slow_start_after_idle=0
net.ipv4.tcp_no_metrics_save = 1
net.ipv4.tcp_moderate_rcvbuf = 1
net.ipv4.tcp_window_scaling = 1
net.ipv4.tcp_timestamps = 1
net.ipv4.tcp_sack = 1
```

Saptune, included in SLES for SAP OS versions, can be used to set these values. For more information, see SAP Note 3024346 (requires SAP login).

The `sunrpc.tcp_max_slot_table_entries` parameter must be set in `/etc/modprobe.d/sunrpc.conf`. If the file does not exist, it must first be created by adding the following line:

```
options sunrpc tcp_max_slot_table_entries=128
```

Configuration parameters for Red Hat Enterprise Linux 7.2 or later

You must adjust additional kernel and configuration parameters at each SAP HANA host for the workload generated by SAP HANA.

The `sunrpc.tcp_max_slot_table_entries` parameter must be set in `/etc/modprobe.d/sunrpc.conf`. If the file does not exist, it must first be created by adding the following line:

```
options sunrpc tcp_max_slot_table_entries=128
```

Starting with Red Hat Enterprise Linux 7.2, you must set the kernel parameters in a configuration file in the `/etc/sysctl.d` directory. For example, you must create a configuration file with the name `91-NetApp-HANA.conf`.

```
net.core.rmem_max = 16777216
net.core.wmem_max = 16777216
net.ipv4.tcp_rmem = 4096 131072 16777216
net.ipv4.tcp_wmem = 4096 16384  16777216
net.core.netdev_max_backlog = 300000
net.ipv4.tcp_slow_start_after_idle=0
net.ipv4.tcp_no_metrics_save = 1
net.ipv4.tcp_moderate_rcvbuf = 1
net.ipv4.tcp_window_scaling = 1
net.ipv4.tcp_timestamps = 1
net.ipv4.tcp_sack = 1
```

Since RedHat Enterprise Linux version 8.6, the settings can be also applied by using the RHEL System Roles for SAP (Ansible). See SAP Note 3024346 (requires SAP login).

Create subdirectories in /hana/shared volume

The following examples show an SAP HANA database with SID=NF2.

To create the required subdirectories, take one of the following actions:

- For a single-host system, mount the `/hana/shared` volume and create the `shared` and `usr-sap` subdirectories.

```
sapcc-hana-tst-06:/mnt # mount <storage-hostname>:/NF2_shared /mnt/tmp
sapcc-hana-tst-06:/mnt # cd /mnt/tmp
sapcc-hana-tst-06:/mnt/tmp # mkdir shared
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap
sapcc-hana-tst-06:/mnt/tmp # cd ..
sapcc-hana-tst-06:/mnt # umount /mnt/tmp
```

- For a multiple-host system, mount the `/hana/shared` volume and create the `shared` and the `usr-sap` subdirectories for each host.

  The example commands show a 2+1 multiple-host HANA system.

```
sapcc-hana-tst-06:/mnt # mount <storage-hostname>:/NF2_shared /mnt/tmp
sapcc-hana-tst-06:/mnt # cd /mnt/tmp
sapcc-hana-tst-06:/mnt/tmp # mkdir shared
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap-host1
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap-host2
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap-host3
sapcc-hana-tst-06:/mnt/tmp # cd ..
sapcc-hana-tst-06:/mnt # umount /mnt/tmp
```

Create mount points

The following examples show an SAP HANA database with SID=NF2.

To create the required mount point directories, take one of the following actions:

- For a single-host system, create mount points and set the permissions on the database host.

```
sapcc-hana-tst-06:/ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-06:/ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-06:/ # mkdir -p /hana/shared
sapcc-hana-tst-06:/ # mkdir -p /usr/sap/NF2

sapcc-hana-tst-06:/ # chmod –R 777 /hana/log/NF2
sapcc-hana-tst-06:/ # chmod –R 777 /hana/data/NF2
sapcc-hana-tst-06:/ # chmod -R 777 /hana/shared
sapcc-hana-tst-06:/ # chmod -R 777 /usr/sap/NF2
```

- For a multiple-host system, create mount points and set the permissions on all worker and standby hosts. The following example commands are for a 2+1 multiple-host HANA system.
  - First worker host:

```
sapcc-hana-tst-06:~ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-06:~ # mkdir -p /hana/data/NF2/mnt00002
sapcc-hana-tst-06:~ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-06:~ # mkdir -p /hana/log/NF2/mnt00002
sapcc-hana-tst-06:~ # mkdir -p /hana/shared
sapcc-hana-tst-06:~ # mkdir -p /usr/sap/NF2

sapcc-hana-tst-06:~ # chmod -R 777 /hana/log/NF2
sapcc-hana-tst-06:~ # chmod -R 777 /hana/data/NF2
sapcc-hana-tst-06:~ # chmod -R 777 /hana/shared
sapcc-hana-tst-06:~ # chmod -R 777 /usr/sap/NF2
```

- Second worker host:

```
sapcc-hana-tst-07:~ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-07:~ # mkdir -p /hana/data/NF2/mnt00002
sapcc-hana-tst-07:~ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-07:~ # mkdir -p /hana/log/NF2/mnt00002
sapcc-hana-tst-07:~ # mkdir -p /hana/shared
sapcc-hana-tst-07:~ # mkdir -p /usr/sap/NF2

sapcc-hana-tst-07:~ # chmod -R 777 /hana/log/NF2
sapcc-hana-tst-07:~ # chmod -R 777 /hana/data/NF2
sapcc-hana-tst-07:~ # chmod -R 777 /hana/shared
sapcc-hana-tst-07:~ # chmod -R 777 /usr/sap/NF2
```

- Standby host:

```
sapcc-hana-tst-08:~ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-08:~ # mkdir -p /hana/data/NF2/mnt00002
sapcc-hana-tst-08:~ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-08:~ # mkdir -p /hana/log/NF2/mnt00002
sapcc-hana-tst-08:~ # mkdir -p /hana/shared
sapcc-hana-tst-08:~ # mkdir -p /usr/sap/NF2

sapcc-hana-tst-08:~ # chmod -R 777 /hana/log/NF2
sapcc-hana-tst-08:~ # chmod -R 777 /hana/data/NF2
sapcc-hana-tst-08:~ # chmod -R 777 /hana/shared
sapcc-hana-tst-08:~ # chmod -R 777 /usr/sap/NF2
```

Mount file systems

Different mount options must be used depending on the NFS version and ONTAP release. The following file systems must be mounted to the hosts:

- `/hana/data/SID/mnt0000*`
- `/hana/log/SID/mnt0000*`
- `/hana/shared`
- `/usr/sap/SID`

The following table shows the NFS versions that you must use for the different files systems for single-host and multiple-host SAP HANA databases.

File systems	SAP HANA single host	SAP HANA multiple hosts
/hana/data/SID/mnt0000*	NFSv3 or NFSv4	NFSv4
/hana/log/SID/mnt0000*	NFSv3 or NFSv4	NFSv4

File systems	SAP HANA single host	SAP HANA multiple hosts
/hana/shared	NFSv3 or NFSv4	NFSv3 or NFSv4
/usr/sap/SID	NFSv3 or NFSv4	NFSv3 or NFSv4

The following table shows the mount options for the various NFS versions and ONTAP releases. The common parameters are independent of the NFS and ONTAP versions.

SAP LaMa requires the /usr/sap/SID directory to be local. Therefore, don't mount an NFS volume for /usr/sap/SID if you are using SAP LaMa.

For NFSv3, you must switch off NFS locking to avoid NFS lock cleanup operations in case of a software or server failure.

With ONTAP 9, the NFS transfer size can be configured up to 1MB. Specifically, with 40GbE or faster connections to the storage system, you must set the transfer size to 1MB to achieve the expected throughput values.

Common parameter	NFSv3	NFSv4	NFS transfer size with ONTAP 9	NFS transfer size with ONTAP 8
rw, bg, hard, timeo=600, noatime	nfsvers=3,nolock	nfsvers=4.1,lock	rsize=1048576,wsize=262144	rsize=65536,wsize=65536

To improve read performance with NFSv3, NetApp recommends that you use the `nconnect=n` mount option, which is available with SUSE Linux Enterprise Server 12 SP4 or later and RedHat Enterprise Linux (RHEL) 8.3 or later.

Performance tests showed that `nconnect=4` provides good read results for the data volumes. Log writes might benefit from a lower number of sessions, such as `nconnect=2`. Shared volumes may benefit as well from using the 'nconnect' option. Be aware that the first mount from an NFS server (IP address) defines the amount of sessions being used. Further mounts to the same IP address do not change this even if a different value is used for nconnect.

Starting with ONTAP 9.8 and SUSE SLES15SP2 or RedHat RHEL 8.4 or higher, NetApp supports the nconnect option also for NFSv4.1. For additional information, check the Linux vendor documentation.

If nconnect is being used with NFSV4.x the amount of NFSv4.x session slots should be adjusted according to the following rule:
Amount of session slots equals <nconnect value> x 64.
At the host this will be adjuseted by
`echo options nfs max_session_slots= <calculated value> > /etc/modprobe.d/nfsclient.conf`
followed by a reboot. The server side value must be adjusted as well, set the number of session slots as described in NFS configuration for NFSv4.

The following example shows a single host SAP HANA database with SID=NF2 using NFSv3 and an NFS transfer size of 1MB for reads and 256k for writes. To mount the file systems during system boot with the `/etc/fstab` configuration file, complete the following steps:

1. Add the required file systems to the `/etc/fstab` configuration file.

```
sapcc-hana-tst-06:/ # cat /etc/fstab
<storage-vif-data01>:/NF2_data_mnt00001 /hana/data/NF2/mnt00001 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-log01>:/NF2_log_mnt00001 /hana/log/NF2/mnt00001 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=2,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-data01>:/NF2_shared/usr-sap /usr/sap/NF2 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-data01>:/NF2_shared/shared /hana/shared nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
```

2. Run `mount -a` to mount the file systems on all hosts.

The next example shows a multiple-host SAP HANA database with SID=NF2 using NFSv4.1 for data and log file systems and NFSv3 for the `/hana/shared` and `/usr/sap/NF2` file systems. An NFS transfer size of 1MB for reads and 256k for writes is used.

1. Add the required file systems to the `/etc/fstab` configuration file on all hosts.

The `/usr/sap/NF2` file system is different for each database host. The following example shows `/NF2_shared/usr-sap-host1`.

```
stlrx300s8-5:/ # cat /etc/fstab
<storage-vif-data01>:/NF2_data_mnt00001 /hana/data/NF2/mnt00001 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-data02>:/NF2_data_mnt00002 /hana/data/NF2/mnt00002 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-log01>:/NF2_log_mnt00001 /hana/log/NF2/mnt00001 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=2,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-log02>:/NF2_log_mnt00002 /hana/log/NF2/mnt00002 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=2,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-data02>:/NF2_shared/usr-sap-host1 /usr/sap/NF2 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-data02>:/NF2_shared/shared /hana/shared nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
```

2. Run `mount -a` to mount the file systems on all hosts.

SAP HANA installation preparations for NFSv4

NFS version 4 and higher requires user authentication. This authentication can be accomplished by using a central user management tool such as a Lightweight Directory Access Protocol (LDAP) server or with local user accounts. The following sections describe how to configure local user accounts.

The administration user `<sidadm>` and the `sapsys` group must be created manually on the SAP HANA hosts and the storage controllers before the installation of the SAP HANA software begins.

SAP HANA hosts

If it does not already exist, you must create the `sapsys` group on the SAP HANA host. Choose a unique group ID that does not conflict with the existing group IDs on the storage controllers.

The user `<sidadm>` is created on the SAP HANA host. A unique ID must be chosen that does not conflict with existing user IDs on the storage controllers.

For a multiple-host SAP HANA system, the user and group ID must be the same on all SAP HANA hosts. The group and user are created on the other SAP HANA hosts by copying the affected lines in `/etc/group` and `/etc/passwd` from the source system to all other SAP HANA hosts.

The NFSv4 domain must be set to the same value on all Linux servers and SVMs. Set the domain parameter "`Domain = <domain_name>`" in file `/etc/idmapd.conf` for the Linux hosts.

Enable and start the NFS idmapd service:

```
systemctl enable nfs-idmapd.service
systemctl start nfs-idmapd.service
```

The latest Linux kernels do not require this step. You can safely ignore warning messages.

Storage controllers

The user ID and group ID must be the same on the SAP HANA hosts and the storage controllers. The group and user are created by entering the following commands on the storage cluster:

```
vserver services unix-group create -vserver <vserver> -name <group name>
-id <group id>
vserver services unix-user create -vserver <vserver> -user <user name> -id
<user-id> -primary-gid <group id>
```

Additionally, set the group ID of the UNIX user root of the SVM to 0.

```
vserver services unix-user modify -vserver <vserver> -user root -primary
-gid 0
```

I/O stack configuration for SAP HANA

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage systems used.

NetApp conducted performance tests to define the ideal values. The following table lists the optimal values inferred from the performance tests.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For SAP HANA 1.0 versions up to SPS12, these parameters can be set during the installation of the SAP HANA database, as described in SAP note 2267798: Configuration of the SAP HANA Database During Installation Using hdbparam.

Alternatively, the parameters can be set after SAP HANA database installation by using the `hdbparam` framework.

```
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.max_parallel_io_requests=128
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.async_write_submit_active=on
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.async_read_submit=on
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.async_write_submit_blocks=all
```

Starting with SAP HANA 2.0, `hdbparam` was deprecated and the parameters were moved to `global.ini`. The parameters can be set using SQL commands or SAP HANA Studio. For more details, see SAP note 2399079: Elimination of hdbparam in HANA 2. The parameters can also be set within the global.ini as shown below:

```
nf2adm@stlrx300s8-6: /usr/sap/NF2/SYS/global/hdb/custom/config> cat
global.ini
…
[fileio]
async_read_submit = on
async_write_submit_active = on
max_parallel_io_requests = 128
async_write_submit_blocks = all
…
```

As of SAP HANA 2.0 SPS5, you can use the `setParameter.py` script to set the correct parameters:

```
nf2adm@sapcc-hana-tst-03:/usr/sap/NF2/HDB00/exe/python_support>
python setParameter.py
-set=SYSTEM/global.ini/fileio/max_parallel_io_requests=128
python setParameter.py -set=SYSTEM/global.ini/fileio/async_read_submit=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_active=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_blocks=all
```

SAP HANA data volume size

As the default, SAP HANA uses only one data volume per SAP HANA service. Due to the maximum file size limitation of the file system, NetApp recommends limiting the maximum data volume size.

To do so automatically, set the following parameter in `global.ini` in the section `[persistence]`:

```
datavolume_striping = true
datavolume_striping_size_gb = 8000
```

This creates a new data volume after the 8,000GB limit is reached. SAP note 240005 question 15 provides more information.

SAP HANA software installation

This section describes how to configure a system for the installation of SAP HANA software on single-host and multiple-host systems.

Install on a single-host system

SAP HANA software installation does not require any additional preparation for a single-host system.

Install on a multiple-host system

To install SAP HANA on a multiple-host system, complete the following steps:

1. Using the SAP `hdbclm` installation tool, start the installation by running the following command at one of the worker hosts. Use the `addhosts` option to add the second worker (`sapcc-hana-tst-07`) and the standby host (`sapcc-hana-tst-08`).

```
sapcc-hana-tst-06:/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_LCM_LINUX_X86_64 # ./hdblcm --action=install
--addhosts=sapcc-hana-tst-07:role=worker,sapcc-hana-tst-08:role=standby



SAP HANA Lifecycle Management - SAP HANA Database 2.00.052.00.1599235305
************************************************************************


Scanning software locations...
Detected components:
    SAP HANA AFL (incl.PAL,BFL,OFL) (2.00.052.0000.1599259237) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_AFL_LINUX_X86_64/packages
    SAP HANA Database (2.00.052.00.1599235305) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_SERVER_LINUX_X86_64/server
    SAP HANA Database Client (2.5.109.1598303414) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_CLIENT_LINUX_X86_64/client
    SAP HANA Smart Data Access (2.00.5.000.0) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/SAP_HANA_SDA_20_LINUX_X86_64/packages
    SAP HANA Studio (2.3.54.000000) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_STUDIO_LINUX_X86_64/studio
```

```
    SAP HANA Local Secure Store (2.4.24.0) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HANA_LSS_24_LINUX_X86_64/packages
    SAP HANA XS Advanced Runtime (1.0.130.519) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_RT_10_LINUX_X86_64/packages
    SAP HANA EML AFL (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_EML_AFL_10_LINUX_X86_64/packages
    SAP HANA EPM-MDS (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/SAP_HANA_EPM-MDS_10/packages
    GUI for HALM for XSA (including product installer) Version 1
(1.014.1) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACALMPIUI14_1.zip
    XSAC FILEPROCESSOR 1.0 (1.000.85) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACFILEPROC00_85.zip
    SAP HANA tools for accessing catalog content, data preview, SQL
console, etc. (2.012.20341) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_HRTT_20/XSACHRTT12_20341.zip
    XS Messaging Service 1 (1.004.10) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACMESSSRV04_10.zip
    Develop and run portal services for customer apps on XSA (1.005.1)
in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACPORTALSERV05_1.zip
    SAP Web IDE Web Client (4.005.1) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_SAP_WEB_IDE_20/XSACSAPWEBIDE05_1.zip
    XS JOB SCHEDULER 1.0 (1.007.12) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACSERVICES07_12.zip
    SAPUI5 FESV6 XSA 1 - SAPUI5 1.71 (1.071.25) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5FESV671_25.zip
    SAPUI5 SERVICE BROKER XSA 1 - SAPUI5 Service Broker 1.0 (1.000.3) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5SB00_3.zip
    XSA Cockpit 1 (1.001.17) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACXSACOCKPIT01_17.zip


SAP HANA Database version '2.00.052.00.1599235305' will be installed.

Select additional components for installation:
```

```
  Index | Components | Description

-------------------------------------------------------------------------
---------------------
  1     | all        | All components
  2     | server     | No additional components
  3     | client     | Install SAP HANA Database Client version
2.5.109.1598303414
  4     | lss        | Install SAP HANA Local Secure Store version
2.4.24.0
  5     | studio     | Install SAP HANA Studio version 2.3.54.000000
  6     | smartda    | Install SAP HANA Smart Data Access version
2.00.5.000.0
  7     | xs         | Install SAP HANA XS Advanced Runtime version
1.0.130.519
  8     | afl        | Install SAP HANA AFL (incl.PAL,BFL,OFL) version
2.00.052.0000.1599259237
  9     | eml        | Install SAP HANA EML AFL version
2.00.052.0000.1599259237
  10    | epmmds     | Install SAP HANA EPM-MDS version
2.00.052.0000.1599259237

Enter comma-separated list of the selected indices [3]: 2,3
Enter Installation Path [/hana/shared]:
```

2. Verify that the installation tool installed all selected components at all worker and standby hosts.

Adding additional data volume partitions

Starting with SAP HANA 2.0 SPS4, additional data volume partitions can be configured. This allows you to configure two or more volumes for the data volume of an SAP HANA tenant database and scale beyond the size and performance limits of a single volume.

> Using two or more individual volumes for the data volume is available for SAP HANA single-host and SAP HANA multiple-host systems. You can add additional data volume partitions at any time.

Enabling additional data volume partitions

To enable additional data volume partitions, add the following entry within `global.ini` by using SAP HANA Studio or Cockpit in the SYSTEMDB configuration.

```
[customizable_functionalities]
persistence_datavolume_partition_multipath = true
```

Adding the parameter manually to the `global.ini` file requires the restart of the database.

Volume configuration for single-host SAP HANA systems

The layout of volumes for a single-host SAP HANA system with multiple partitions is like the layout for a system with one data volume partition but with an additional data volume stored on a different aggregate as the log volume and the other data volume. The following table shows an example configuration of an SAP HANA single-host system with two data volume partitions.

Aggregate 1 at controller A	Aggregate 2 at controller A	Aggregate 1 at controller B	Aggregate 2 at controller b
Data volume: SID_data_mnt00001	Shared volume: SID_shared	Data volume: SID_data2_mnt00001	Log volume: SID_log_mnt00001

The following table shows an example of the mount point configuration for a single-host system with two data volume partitions.

Junction path	Directory	Mount point at HANA host
SID_data_mnt00001	–	/hana/data/SID/mnt00001
SID_data2_mnt00001	–	/hana/data2/SID/mnt00001
SID_log_mnt00001	–	/hana/log/SID/mnt00001
SID_shared	usr-sap shared	/usr/sap/SID /hana/shared

You can create the new data volume and mount it to the namespace using either NetApp ONTAP System Manager or the ONTAP CLI.

Volume configuration for multiple-host SAP HANA systems

The layout of volumes is like the layout for a multiple- host SAP HANA system with one data volume partition but with an additional data volume stored on a different aggregate as log volume and the other data volume. The following table shows an example configuration of an SAP HANA multiple-host system with two data volume partitions.

Purpose	Aggregate 1 at controller A	Aggregate 2 at controller A	Aggregate 1 at controller B	Aggregate 2 at controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	–	Log volume: SID_log_mnt00001	Data2 volume: SID_data2_mnt00001
Data and log volumes for node 2	Log volume: SID_log_mnt00002	Data2 volume: SID_data2_mnt00002	Data volume: SID_data_mnt00002	–
Data and log volumes for node 3	–	Data volume: SID_data_mnt00003	Data2 volume: SID_data2_mnt00003	Log volume: SID_log_mnt00003

Purpose	Aggregate 1 at controller A	Aggregate 2 at controller A	Aggregate 1 at controller B	Aggregate 2 at controller B
Data and log volumes for node 4	Data2 volume: SID_data2_mnt00004	Log volume: SID_log_mnt00004	–	Data volume: SID_data_mnt00004
Shared volume for all hosts	Shared volume: SID_shared	–	–	–

The following table shows an example of the mount point configuration for a single-host system with two data volume partitions.

Junction path	Directory	Mount point at SAP HANA host	Note
SID_data_mnt00001	–	/hana/data/SID/mnt00001	Mounted at all hosts
SID_data2_mnt00001	–	/hana/data2/SID/mnt00001	Mounted at all hosts
SID_log_mnt00001	–	/hana/log/SID/mnt00001	Mounted at all hosts
SID_data_mnt00002	–	/hana/data/SID/mnt00002	Mounted at all hosts
SID_data2_mnt00002	–	/hana/data2/SID/mnt00002	Mounted at all hosts
SID_log_mnt00002	–	/hana/log/SID/mnt00002	Mounted at all hosts
SID_data_mnt00003	–	/hana/data/SID/mnt00003	Mounted at all hosts
SID_data2_mnt00003		/hana/data2/SID/mnt00003	Mounted at all hosts
SID_log_mnt00003		/hana/log/SID/mnt00003	Mounted at all hosts
SID_data_mnt00004		/hana/data/SID/mnt00004	Mounted at all hosts
SID_data2_mnt00004	–	/hana/data2/SID/mnt00004	Mounted at all hosts
SID_log_mnt00004	–	/hana/log/SID/mnt00004	Mounted at all hosts
SID_shared	shared	/hana/shared/SID	Mounted at all hosts
SID_shared	usr-sap-host1	/usr/sap/SID	Mounted at host 1
SID_shared	usr-sap-host2	/usr/sap/SID	Mounted at host 2
SID_shared	usr-sap-host3	/usr/sap/SID	Mounted at host 3
SID_shared	usr-sap-host4	/usr/sap/SID	Mounted at host 4
SID_shared	usr-sap-host5	/usr/sap/SID	Mounted at host 5

You can create the new data volume and mount it to the namespace using either ONTAP System Manager or the ONTAP CLI.

Host configuration

In addition to the tasks described in the section "Host Setup," the additional mount points and `fstab` entries for the new additional data volume/s must be created and the new volumes must be mounted.

1. Create additional mount points.
   - For a single-host system, create mount points and set the permissions on the database host:

     ```
     sapcc-hana-tst-06:/ # mkdir -p /hana/data2/SID/mnt00001
     sapcc-hana-tst-06:/ # chmod –R 777 /hana/data2/SID
     ```

   - For a multiple-host system, create mount points and set the permissions on all worker and standby hosts.

     The following example commands are for a 2-plus-1 multiple-host HANA system.

     - First worker host:

       ```
       sapcc-hana-tst-06:~ # mkdir -p /hana/data2/SID/mnt00001
       sapcc-hana-tst-06:~ # mkdir -p /hana/data2/SID/mnt00002
       sapcc-hana-tst-06:~ # chmod -R 777 /hana/data2/SID
       ```

     - Second worker host:

       ```
       sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00001
       sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00002
       sapcc-hana-tst-07:~ # chmod -R 777 /hana/data2/SID
       ```

     - Standby host:

       ```
       sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00001
       sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00002
       sapcc-hana-tst-07:~ # chmod -R 777 /hana/data2/SID
       ```

2. Add the additional file systems to the `/etc/fstab` configuration file on all hosts.

   See the following example for a single-host system using NFSv4.1:

   ```
   <storage-vif-data02>:/SID_data2_mnt00001 /hana/data2/SID/mnt00001 nfs
   rw, vers=4
   minorversion=1,hard,timeo=600,rsize=1048576,wsize=262144,bg,noatime,lock
   0 0
   ```

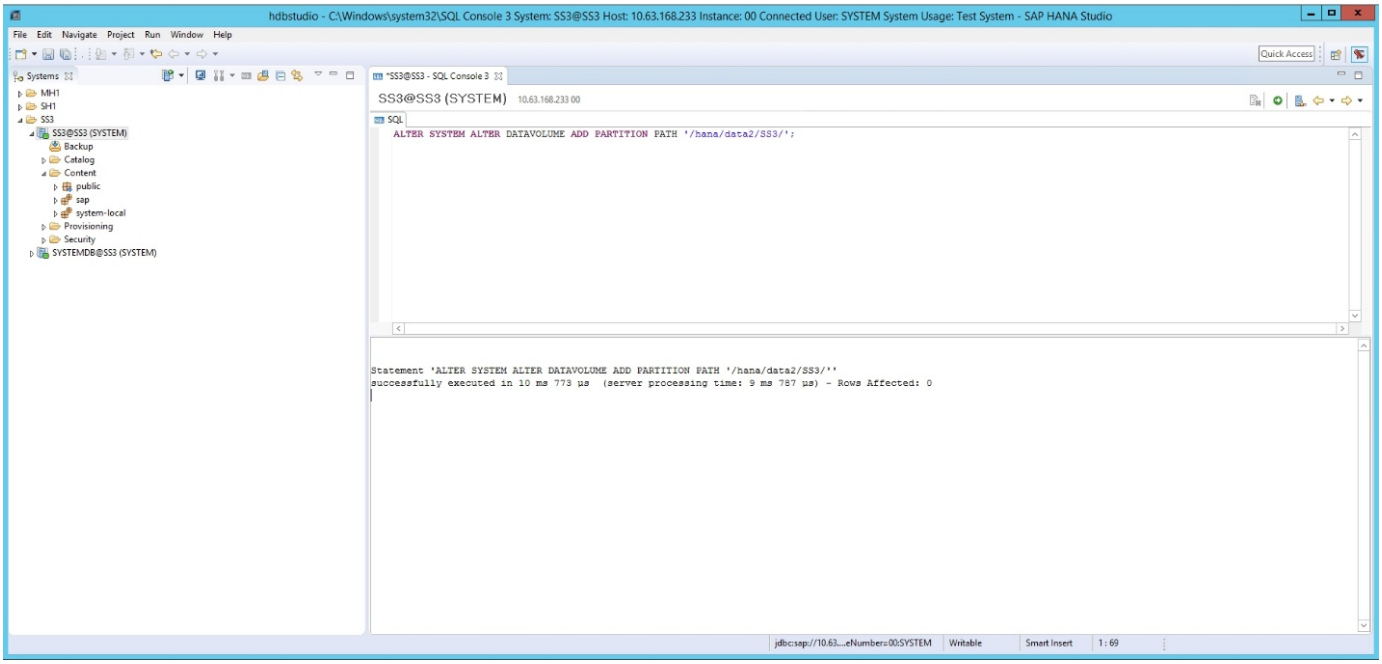
Use a different storage virtual interface for connecting each data volume to ensure that you are using different TCP sessions for each volume or use the nconnect mount option, if available for your OS.

3. Mount the file systems by running the `mount -a` command.

Adding an additional data volume partition

Execute the following SQL statement against the tenant database to add an additional data volume partition to your tenant database. Use the path to additional volumes:

```
ALTER SYSTEM ALTER DATAVOLUME ADD PARTITION PATH '/hana/data2/SID/';
```



Where to find additional information

To learn more about the information described in this document, refer to the following documents and/or websites:

- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere
  www.vmware.com/files/pdf/SAP_HANA_on_vmware_vSphere_best_practices_guide.pdf
- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere
  http://www.vmware.com/files/pdf/sap-hana-scale-out-deployments-on-vsphere.pdf
- SAP Certified Enterprise Storage Hardware for SAP HANA
  http://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/enterprise-storage.html
- SAP HANA Storage Requirements
  http://go.sap.com/documents/2015/03/74cdb554-5a7c-0010-82c7-eda71af511fa.html
- SAP HANA Tailored Data Center Integration Frequently Asked Questions
  https://www.sap.com/documents/2016/05/e8705aae-717c-0010-82c7-eda71af511fa.html

- TR-4646: SAP HANA Disaster Recovery with Storage Replication
  https://www.netapp.com/us/media/tr-4646.pdf
- TR-4614: SAP HANA Backup and Recovery with SnapCenter
  https://www.netapp.com/us/media/tr-4614.pdf
- TR-4338: SAP HANA on VMware vSphere with NetApp FAS and AFF Systems
  www.netapp.com/us/media/tr-4338.pdf
- TR-4667: Automating SAP System Copies Using the SnapCenter 4.0 SAP HANA Plug-In
  https://docs.netapp.com/us-en/netapp-solutions-sap/lifecycle/sc-copy-clone-introduction.html
- NetApp Documentation Centers
  https://www.netapp.com/us/documentation/index.aspx
- NetApp FAS Storage System Resources
  https://mysupport.netapp.com/info/web/ECMLP2676498.html
- SAP HANA Software Solutions
  www.netapp.com/us/solutions/applications/sap/index.aspx#sap-hana

SAP HANA on NetApp FAS Systems with NFS Configuration Guide

TR-4290: SAP HANA on NetApp FAS systems with NFS Configuration guide

Nils Bauer and Marco Schön, NetApp

The NetApp FAS product family has been certified for use with SAP HANA in tailored data center integration (TDI) projects. The certified enterprise storage system is characterized by the NetApp ONTAP software.

This certification is currently only valid for the following models:

- FAS2720, FAS2750, FAS8300, FAS8700, FAS9000, and FAS9500. A complete list of NetApp certified storage solutions for SAP HANA can be found at the Certified and Supported SAP HANA Hardware Directory.

This document describes the ONTAP configuration requirements for the NFS version 3 (NFSv3) protocol or the NFS version 4 (NFSv4.1) protocol.

The configuration described in this paper is necessary to achieve the required SAP HANA KPIs and the best performance for SAP HANA. Changing any settings or using features not listed herein might cause performance degradation or unexpected behavior and should only be performed if advised by NetApp support.

The configuration guides for NetApp FAS systems using FCP and for AFF systems using NFS or FC can be found at the following links:

- SAP HANA on NetApp FAS Systems with Fibre Channel Protocol
- SAP HANA on NetApp AFF Systems with NFS
- SAP HANA on NetApp AFF Systems with Fibre Channel Protocol

The following table shows the supported combinations for NFS versions, NFS locking, and the required isolation implementations, depending on the SAP HANA database configuration.

For SAP HANA single-host systems or multiple hosts without Host Auto-Failover, NFSv3 and NFSv4 are supported.

For SAP HANA multiple host systems with Host Auto-Failover, NetApp only supports NFSv4, while using NFSv4 locking as an alternative to a server-specific STONITH (SAP HANA HA/DR provider) implementation.

SAP HANA	NFS Version	NFS Locking	SAP HANA HA/DR Provider
SAP HANA single host, multiple hosts without Host Auto-Failover	NFSv3	Off	n/a
	NFSv4	On	n/a
SAP HANA multiple hosts with Host Auto-Failover	NFSv3	Off	Server-specific STONITH implementation mandatory
	NFSv4	On	Not required

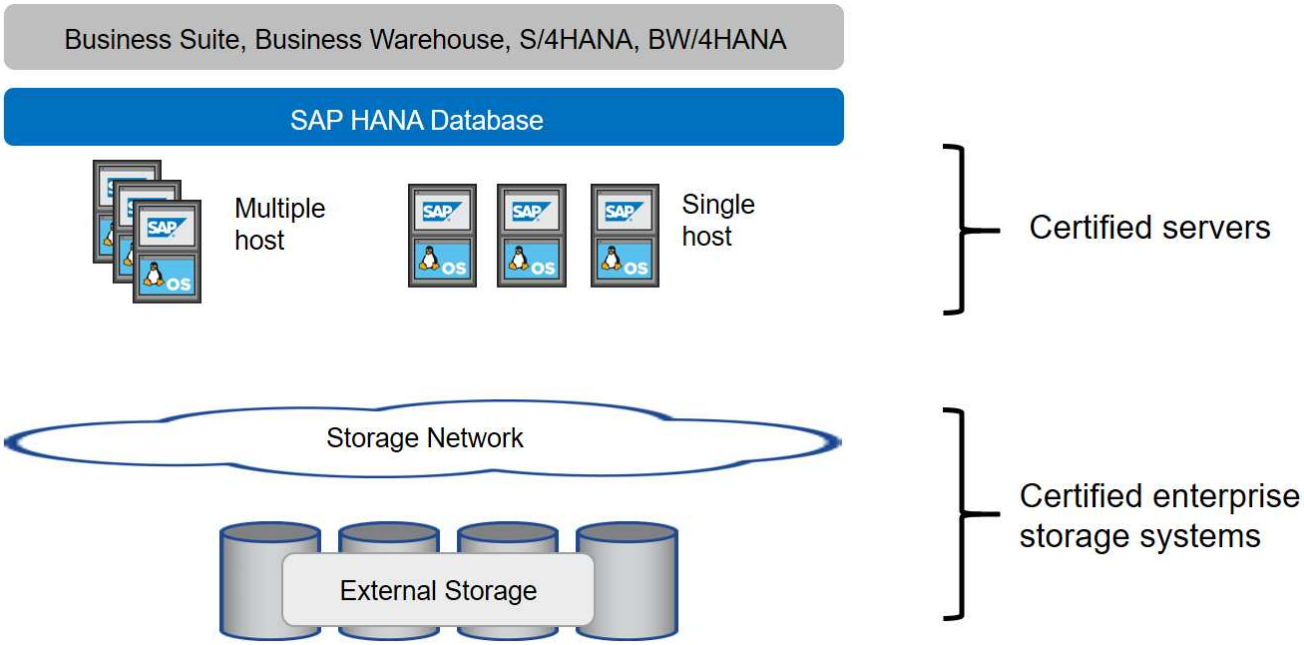
A server-specific STONITH implementation is not part of this guide. Contact your server vendor for such an implementation.

This document covers configuration recommendations for SAP HANA running on physical servers and on virtual servers that use VMware vSphere.

Always refer to the relevant SAP notes for operating system configuration guidelines and HANA-specific Linux kernel dependencies. For more information, see SAP note 2235581: SAP HANA Supported Operating Systems.

SAP HANA Tailored Data Center integration

NetApp FAS storage controllers are certified in the SAP HANA TDI program using both NFS (NAS) and FC (SAN) protocols. They can be deployed in any of the current SAP HANA scenarios such as SAP Business Suite on HANA, S/4HANA, BW/4HANA, or SAP Business Warehouse on HANA in either single- host or multiple-host configurations. Any server that is certified for use with SAP HANA can be combined with NetApp certified storage solutions. See the following figure for an architecture overview.



For more information regarding the prerequisites and recommendations for production SAP HANA systems, see the following SAP resource:

- SAP HANA Tailored Data Center Integration Frequently Asked Questions

SAP HANA using VMware vSphere

There are several options to connect the storage to virtual machines (VMs). The preferred one is to connect the storage volumes with NFS directly out of the guest operating system. Using this option, the configuration of hosts and storages do not differ between physical hosts and VMs.

NFS datastores or VVOL datastores with NFS are supported as well. For both options, only one SAP HANA data or log volume must be stored within the datastore for production use cases. In addition, Snapshot copy-based backup and recovery orchestrated by SnapCenter and solutions based on this, such as SAP System cloning, cannot be implemented.

This document describes the recommended setup with direct NFS mounts from the guest OS.

For more information about using vSphere with SAP HANA, see the following links:

- SAP HANA on VMware vSphere - Virtualization - Community Wiki
- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere
- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere
- 2161991 - VMware vSphere configuration guidelines - SAP ONE Support Launchpad (Login required)

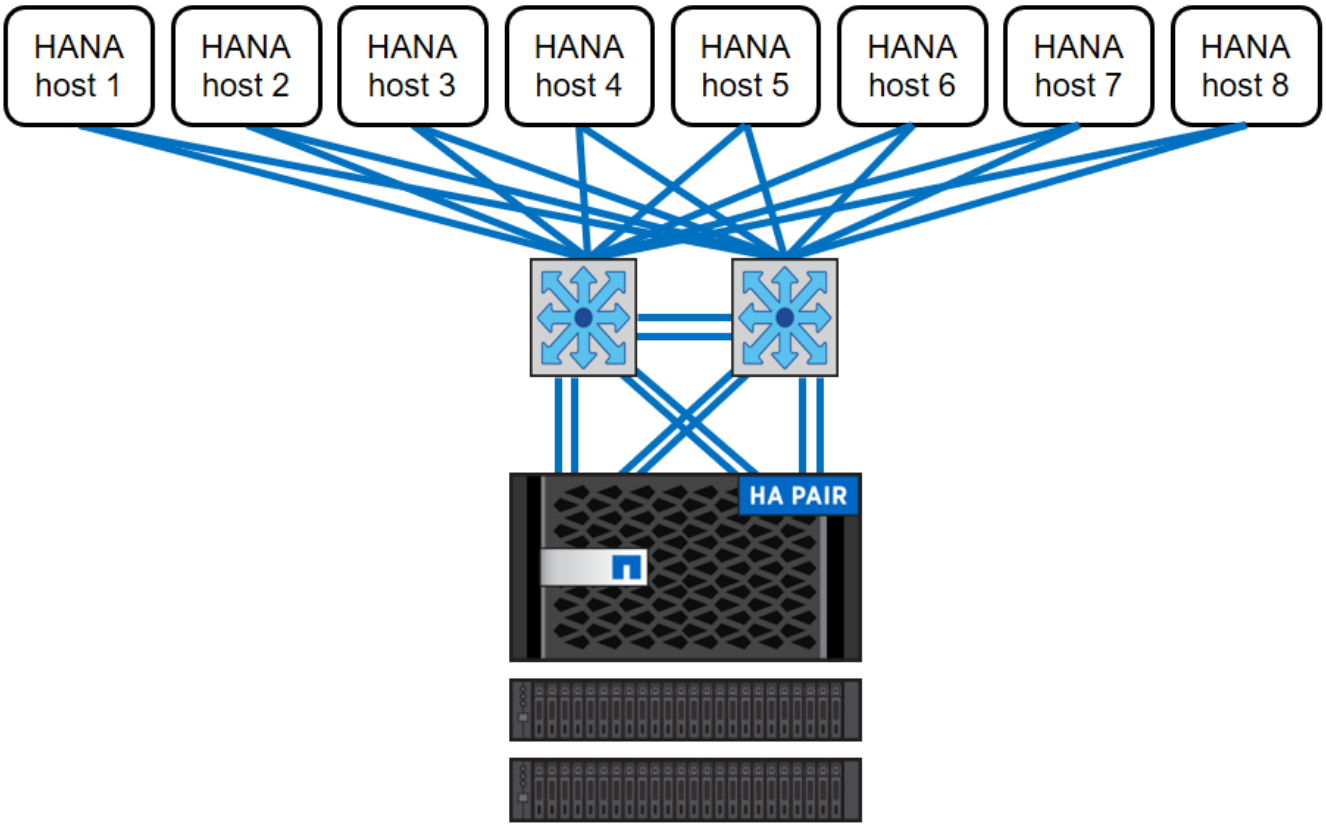
Architecture

SAP HANA hosts are connected to storage controllers by using a redundant 10GbE or faster network infrastructure. Data communication between SAP HANA hosts and storage controllers is based on the NFS protocol.

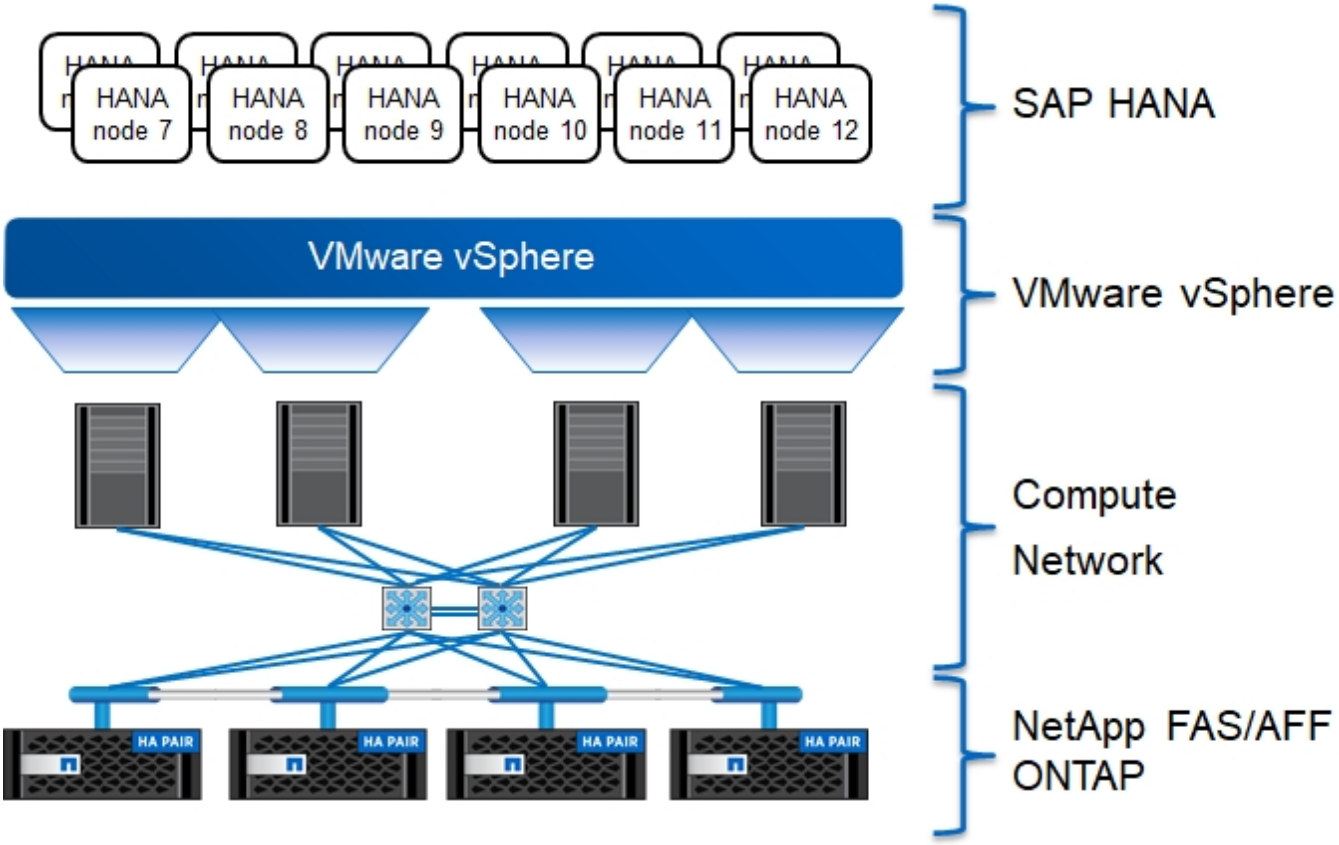
A redundant switching infrastructure is recommended to provide fault-tolerant SAP HANA host- to- storage

connectivity in case of switch or network interface card (NIC) failure. The switches might aggregate individual port performance with port channels in order to appear as a single logical entity at the host level.

Different models of the FAS system product family can be mixed and matched at the storage layer to allow for growth and differing performance and capacity needs. The maximum number of SAP HANA hosts that can be attached to the storage system is defined by the SAP HANA performance requirements and the model of NetApp controller used. The number of required disk shelves is only determined by the capacity and performance requirements of the SAP HANA systems. The following figure shows an example configuration with eight SAP HANA hosts attached to a storage high availability (HA) pair.



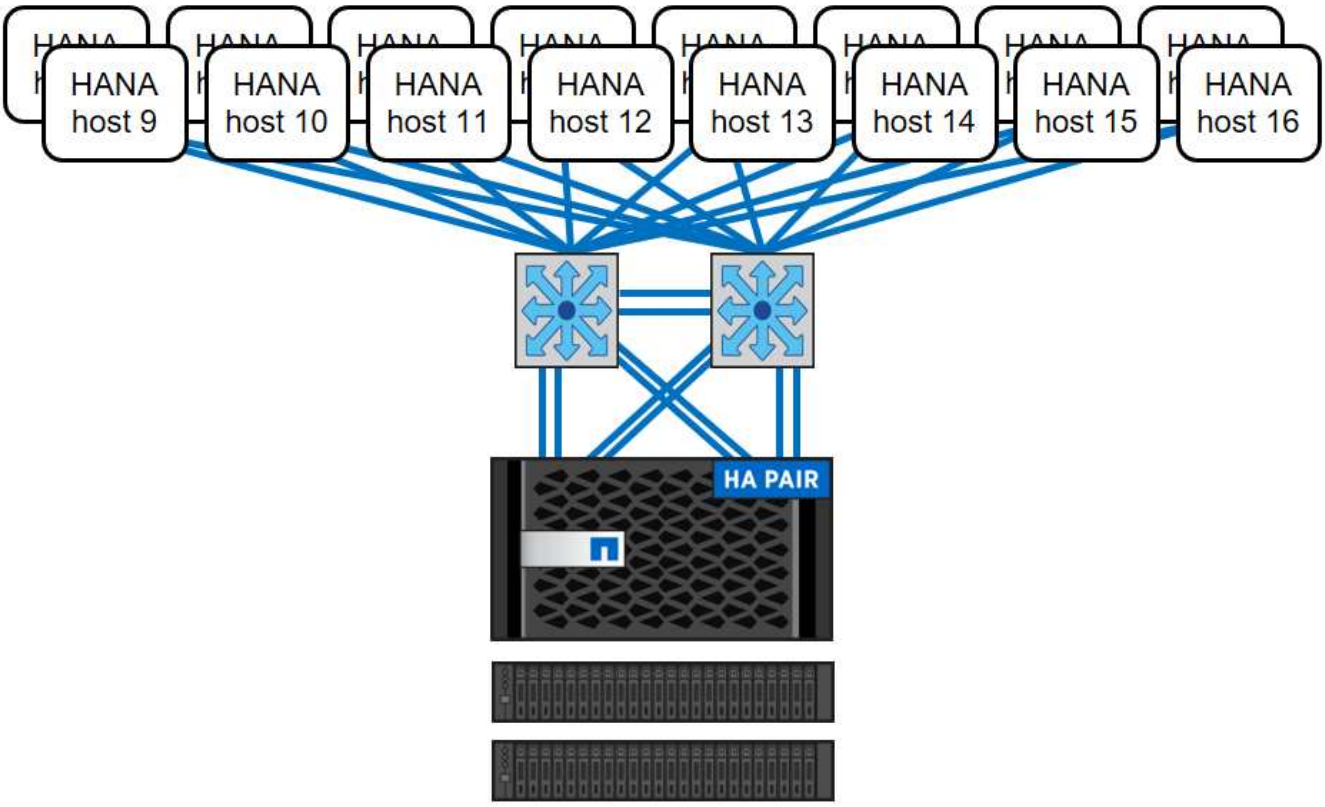
The following figure shows an example of using VMware vSphere as virtualization layer.



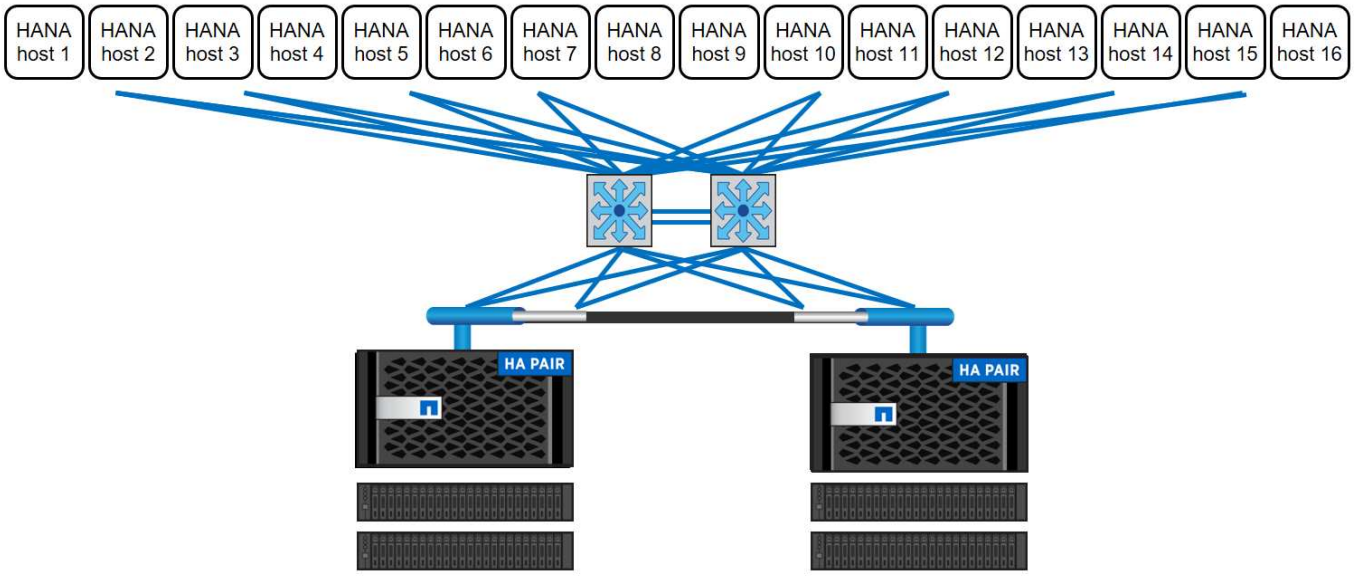
The architecture can be scaled in two dimensions:

- By attaching additional SAP HANA hosts and/or storage capacity to the existing storage, if the storage controllers provide enough performance to meet the current SAP key performance indicators (KPIs)
- By adding more storage systems with additional storage capacity for the additional SAP HANA hosts

The following figure shows an example configuration in which more SAP HANA hosts are attached to the storage controllers. In this example, more disk shelves are necessary to fulfill both the capacity and performance requirements of 16 SAP HANA hosts. Depending on the total throughput requirements, additional 10GbE (or faster) connections to the storage controllers must be added.



Independent of the deployed FAS system, the SAP HANA landscape can also be scaled by adding any of the certified storage controllers to meet the desired node density (the following figure).



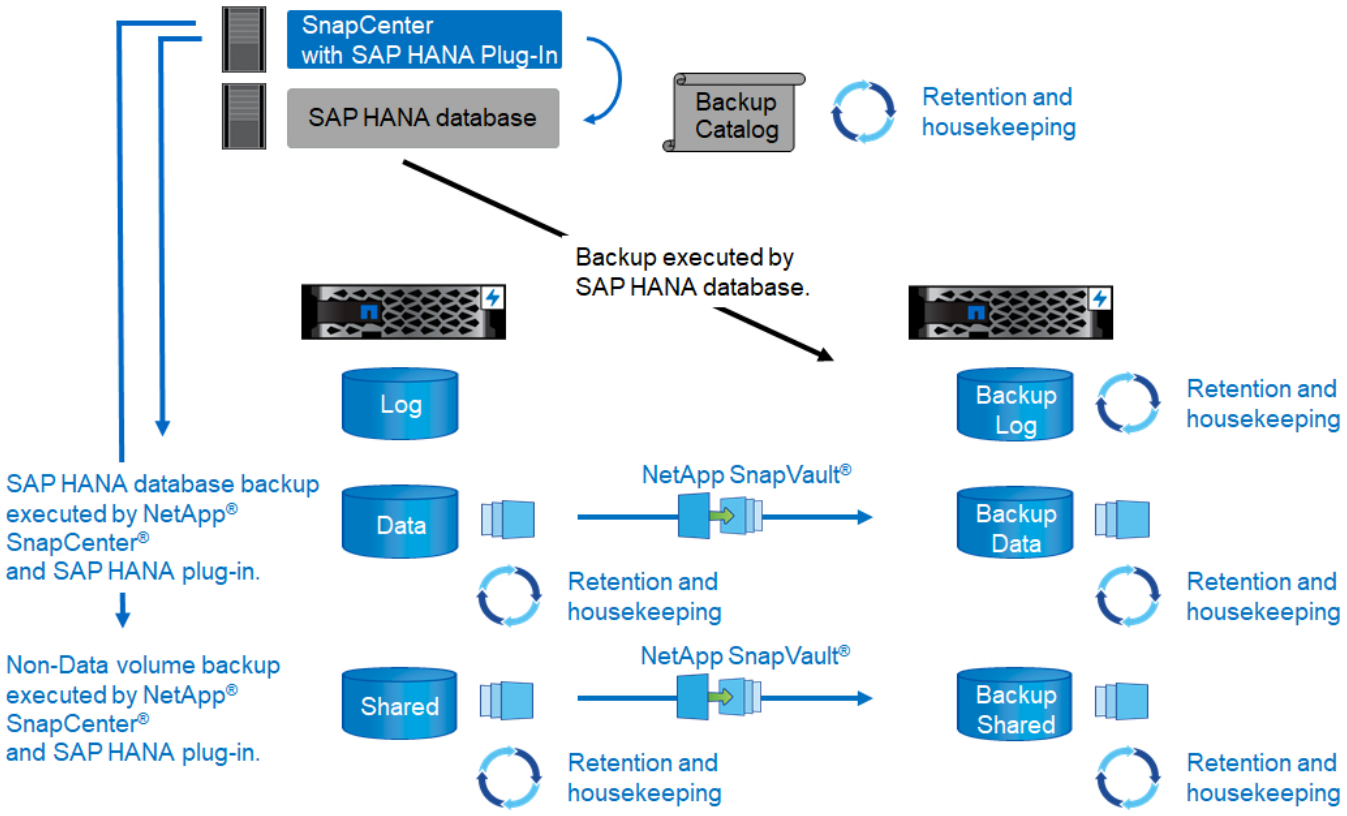
SAP HANA backup

The ONTAP software present on all NetApp storage controllers provides a built-in mechanism to back up SAP HANA databases while in operation with no effect on performance. Storage-based NetApp Snapshot backups are a fully supported and integrated backup solution available for SAP HANA single containers and for SAP HANA Multitenant Database Container (MDC) systems with a single tenant or multiple tenants.

Storage-based Snapshot backups are implemented by using the NetApp SnapCenter plug-in for SAP HANA. This allows users to create consistent storage-based Snapshot backups by using the interfaces provided natively by SAP HANA databases. SnapCenter registers each of the Snapshot backups into the SAP HANA backup catalog. Therefore, the backups taken by SnapCenter are visible within SAP HANA Studio and Cockpit where they can be selected directly for restore and recovery operations.

NetApp SnapMirror technology allows Snapshot copies that were created on one storage system to be replicated to a secondary backup storage system that is controlled by SnapCenter. Different backup retention policies can then be defined for each of the backup sets on the primary storage and for the backup sets on the secondary storage systems. The SnapCenter Plug-in for SAP HANA automatically manages the retention of Snapshot copy-based data backups and log backups, including the housekeeping of the backup catalog. The SnapCenter Plug-in for SAP HANA also allows the execution of a block integrity check of the SAP HANA database by executing a file-based backup.

The database logs can be backed up directly to the secondary storage by using an NFS mount, as shown in the following figure.



Storage-based Snapshot backups provide significant advantages when compared to conventional file-based backups. These advantages include, but are not limited to, the following:

- Faster backup (a few minutes)
- Reduced recovery time objective (RTO) due to a much faster restore time on the storage layer (a few minutes) as well as more frequent backups
- No performance degradation of the SAP HANA database host, network, or storage during backup and recovery operations
- Space-efficient and bandwidth-efficient replication to secondary storage based on block changes

For detailed information about the SAP HANA backup and recovery solution using SnapCenter, see TR-4614: SAP HANA Backup and Recovery with SnapCenter.

SAP HANA disaster recovery

SAP HANA disaster recovery can be performed either on the database layer by using SAP HANA system replication or on the storage layer by using storage replication technologies. The following section provides an overview of disaster recovery solutions based on storage replication.

For detailed information about the SAP HANA disaster recovery solutions, see TR-4646: SAP HANA Disaster Recovery with Storage Replication.

Storage replication based on SnapMirror

The following figure shows a three-site disaster recovery solution that uses synchronous SnapMirror replication to the local disaster recovery data center and asynchronous SnapMirror to replicate data to the remote disaster recovery data center.

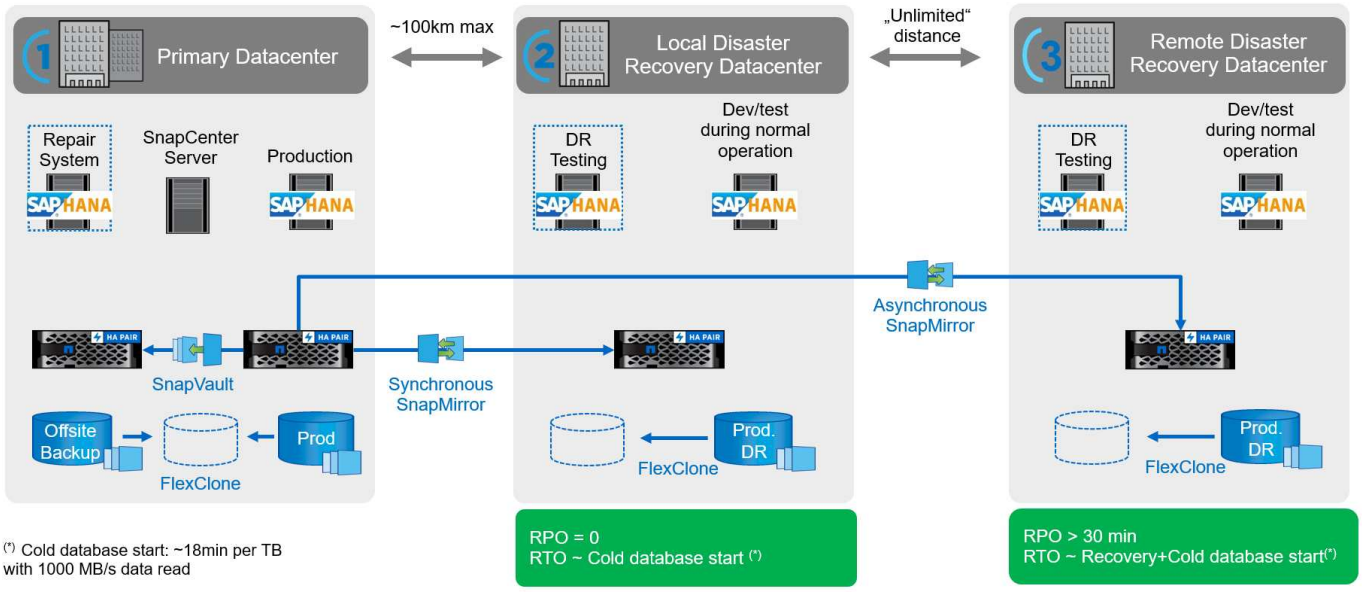
Data replication using synchronous SnapMirror provides an RPO of zero. The distance between the primary and the local disaster recovery data center is limited to around 100km.

Protection against failures of both the primary and the local disaster recovery site is performed by replicating the data to a third remote disaster recovery data center using asynchronous SnapMirror. The RPO depends on the frequency of replication updates and how fast they can be transferred. In theory, the distance is unlimited, but the limit depends on the amount of data that must be transferred and the connection that is available between the data centers. Typical RPO values are in the range of 30 minutes to multiple hours.

The RTO for both replication methods primarily depends on the time needed to start the HANA database at the disaster recovery site and load the data into memory. With the assumption that the data is read with a throughput of 1000MBps, loading 1TB of data would take approximately 18 minutes.

The servers at the disaster recovery sites can be used as dev/test systems during normal operation. In the case of a disaster, the dev/test systems would need to be shut down and started as disaster recovery production servers.

Both replication methods allow to you execute disaster recovery workflow testing without influencing the RPO and RTO. FlexClone volumes are created on the storage and are attached to the disaster recovery testing servers.

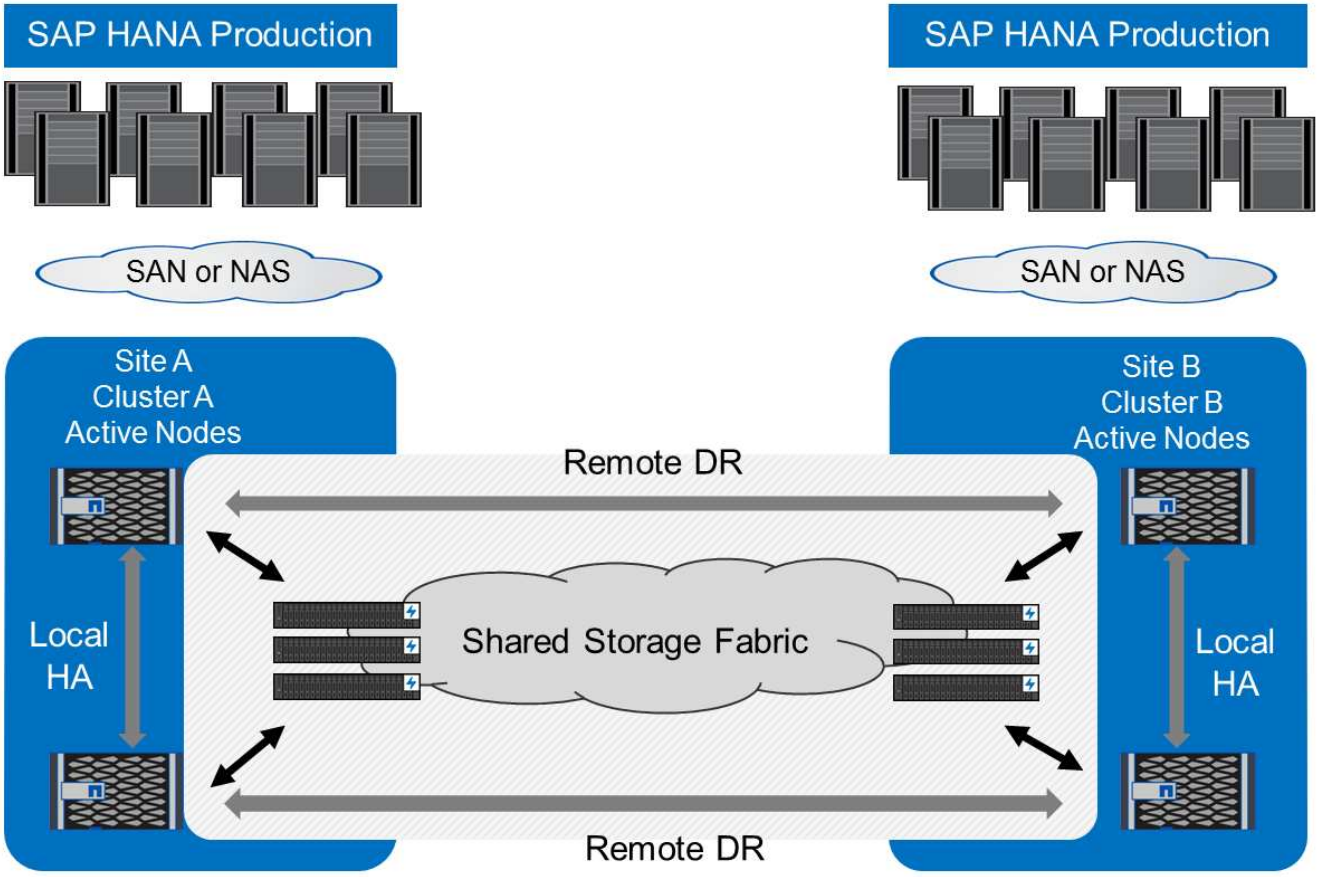


Synchronous replication offers StrictSync mode. If the write to secondary storage is not completed for any

reason, the application I/O fails, thereby ensuring that the primary and secondary storage systems are identical. Application I/O to the primary resumes only after the SnapMirror relationship returns to InSync status. If the primary storage fails, application I/O can be resumed on the secondary storage after failover, with no loss of data. In StrictSync mode, the RPO is always zero.

Storage replication based on MetroCluster

The following figure shows a high-level overview of the solution. The storage cluster at each site provides local high availability and is used for the production workload. The data of each site is synchronously replicated to the other location and is available if there is disaster failover.



Storage sizing

The following section provides an overview of the required performance and capacity considerations needed for sizing a storage system for SAP HANA.

Contact NetApp or your NetApp partner sales representative to assist you in creating a properly sized storage environment.

Performance considerations

SAP has defined a static set of storage KPIs that are valid for all production SAP HANA environments independent of the memory size of the database hosts and the applications that use the SAP HANA database. These KPIs are valid for single-host, multiple-host, Business Suite on HANA, Business Warehouse on HANA, S/4HANA, and BW/4HANA environments. Therefore, the current performance sizing approach only depends on the number of active SAP HANA hosts that are attached to the storage system.

Storage performance KPIs are only mandated for production SAP HANA systems, but you can implement them in all HANA systems.

SAP delivers a performance test tool used to validate the performance of the storage system for active SAP HANA hosts attached to the storage.

NetApp tested and predefined the maximum number of SAP HANA hosts that can be attached to a specific storage model, while still fulfilling the required storage KPIs from SAP for production- based SAP HANA systems.

The storage controllers of the certified FAS product family can also be used for SAP HANA with other disk types or disk back-end solutions. However, they must be supported by NetApp and fulfill SAP HANA TDI performance KPIs. Examples include NetApp Storage Encryption (NSE) and NetApp FlexArray technology.

This document describes disk sizing for SAS HDDs and solid-state drives (SSDs).

HDDs

A minimum of 10 data disks (10k RPM SAS) per SAP HANA node is required to fulfill the storage performance KPIs from SAP.

This calculation is independent of the storage controller and disk shelf used as well as the capacity requirements of the database. Adding more disk shelfs does not increase the maximum amount of SAP HANA hosts a storage controller can support.

Solid-state drives

With SSDs, the number of data disks is determined by the SAS connection throughput from the storage controllers to the SSD shelf.

The maximum number of SAP HANA hosts that can be run on a single disk shelf and the minimum number of SSDs required per SAP HANA host were determined by running the SAP performance test tool. This test does not consider the actual storage capacity requirements of the hosts. In addition, you must also calculate the capacity requirements to determine the actual storage configuration needed.

- The 12Gb SAS disk shelf (DS224C) with 24 SSDs supports up to 14 SAP HANA hosts when the disk shelf is connected with 12Gb.
- The 6Gb SAS disk shelf (DS2246) with 24 SSDs supports up to 4 SAP HANA hosts.

The SSDs and the SAP HANA hosts must be equally distributed between both storage controllers.

The following table summarizes the supported number of SAP HANA hosts per disk shelf.

	6Gb SAS shelves (DS2246)fully loaded with 24 SSDs	**12Gb SAS shelves (DS224C)fully loaded with 24 SSDs**
Maximum number of SAP HANA hosts per disk shelf	4	14

This calculation is independent of the storage controller used. Adding more disk shelfs do not increase the maximum amount of SAP HANA hosts a storage controller can support.

Mixed workloads

SAP HANA and other application workloads running on the same storage controller or in the same storage aggregate are supported. However, it is a NetApp best practice to separate SAP HANA workloads from all other application workloads.

You might decide to deploy SAP HANA workloads and other application workloads on either the same storage controller or the same aggregate. If so, you must make sure that adequate performance is available for SAP HANA within the mixed workload environment. NetApp also recommends that you use quality of service (QoS) parameters to regulate the effect these other applications could have and to guarantee throughput for SAP HANA applications.

The SAP performance test tool must be used to check if additional SAP HANA hosts can be run on an existing storage controller that is already in use for other workloads. SAP application servers can be safely placed on the same storage controller and/or aggregate as the SAP HANA databases.

Capacity considerations

A detailed description of the capacity requirements for SAP HANA is in the SAP Note 1900823 attached white paper.

> The capacity sizing of the overall SAP landscape with multiple SAP HANA systems must be determined by using SAP HANA storage sizing tools from NetApp. Contact NetApp or your NetApp partner sales representative to validate the storage sizing process for a properly sized storage environment.

Configuration of performance test tool

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage system used. These parameters must also be set when storage performance is being tested with the SAP performance test tool.

NetApp conducted performance tests to define the optimal values. The following table lists the parameters that must be set within the configuration file of the SAP performance test tool.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For more information about the configuration of the SAP test tool, see SAP note 1943937 for HWCCT (SAP HANA 1.0) and SAP note 2493172 for HCMT/HCOT (SAP HANA 2.0).

The following example shows how variables can be set for the HCMT/HCOT execution plan.

```
…{
          "Comment": "Log Volume: Controls whether read requests are
submitted asynchronously, default is 'on'",
          "Name": "LogAsyncReadSubmit",
```

```
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls whether read requests are
submitted asynchronously, default is 'on'",
         "Name": "DataAsyncReadSubmit",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "LogAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "DataAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "LogAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "DataAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "LogExtMaxParallelIoRequests",
         "Value": "128",
         "Request": "false"
```

```
      },
      {
         "Comment": "Data Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "DataExtMaxParallelIoRequests",
         "Value": "128",
         "Request": "false"
      }, …
```

These variables must be used for the test configuration. This is usually the case with the predefined execution plans SAP delivers with the HCMT/HCOT tool. The following example for a 4k log write test is from an execution plan.

```
…
      {
         "ID": "D664D001-933D-41DE-A904F304AEB67906",
         "Note": "File System Write Test",
         "ExecutionVariants": [
            {
               "ScaleOut": {
                  "Port": "${RemotePort}",
                  "Hosts": "${Hosts}",
                  "ConcurrentExecution": "${FSConcurrentExecution}"
               },
               "RepeatCount": "${TestRepeatCount}",
               "Description": "4K Block, Log Volume 5GB, Overwrite",
               "Hint": "Log",
               "InputVector": {
                  "BlockSize": 4096,
                  "DirectoryName": "${LogVolume}",
                  "FileOverwrite": true,
                  "FileSize": 5368709120,
                  "RandomAccess": false,
                  "RandomData": true,
                  "AsyncReadSubmit": "${LogAsyncReadSubmit}",
                  "AsyncWriteSubmitActive":
"${LogAsyncWriteSubmitActive}",
                  "AsyncWriteSubmitBlocks":
"${LogAsyncWriteSubmitBlocks}",
                  "ExtMaxParallelIoRequests":
"${LogExtMaxParallelIoRequests}",
                  "ExtMaxSubmitBatchSize": "${LogExtMaxSubmitBatchSize}",
                  "ExtMinSubmitBatchSize": "${LogExtMinSubmitBatchSize}",
                  "ExtNumCompletionQueues":
"${LogExtNumCompletionQueues}",
                  "ExtNumSubmitQueues": "${LogExtNumSubmitQueues}",
                  "ExtSizeKernelIoQueue": "${ExtSizeKernelIoQueue}"
               }
            }, …
```

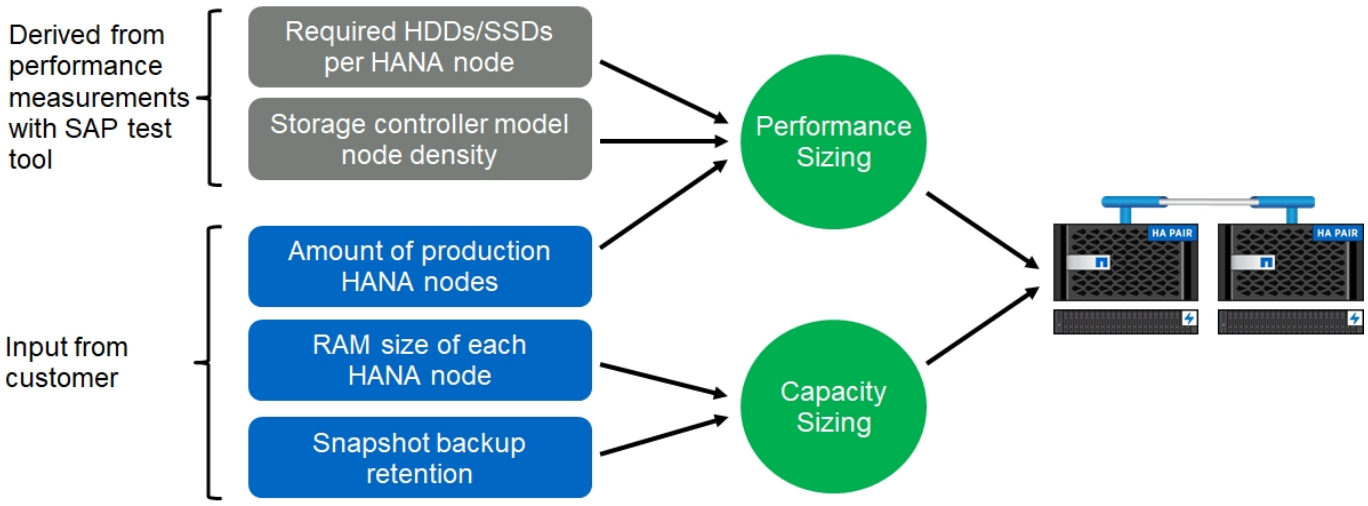
Storage sizing process overview

The number of disks per HANA host and the SAP HANA host density for each storage model were determined with the SAP performance test tool.

The sizing process requires details such as the number of production and nonproduction SAP HANA hosts, the RAM size of each host, and the backup retention of the storage-based Snapshot copies. The number of SAP HANA hosts determines the storage controller and the number of disks required.

The size of the RAM, net data size on the disk of each SAP HANA host, and the Snapshot copy backup retention period are used as inputs during capacity sizing.

The following figure summarizes the sizing process.



Infrastructure setup and configuration

Network setup

Use the following guidelines when configuring the network:

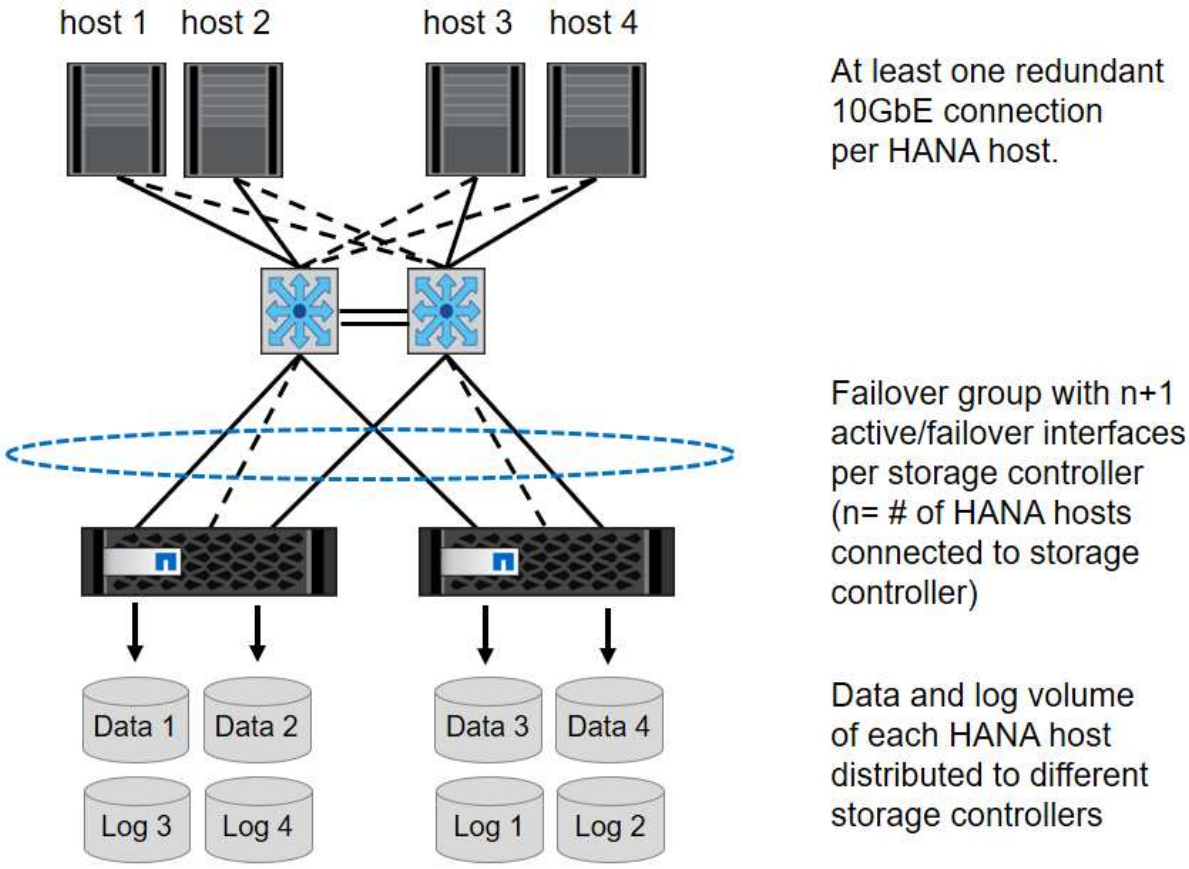
- A dedicated storage network must be used to connect the SAP HANA hosts to the storage controllers with a 10GbE or faster network.
- Use the same connection speed for storage controllers and SAP HANA hosts. If this is not possible, ensure that the network components between the storage controllers and the SAP HANA hosts are able to handle different speeds. For example, you must provide enough buffer space to allow speed negotiation at the NFS level between storage and hosts. Network components are usually switches, but other components within blade chassis, such as the back plane, must be considered as well.
- Disable flow control on all physical ports used for storage traffic on the storage network switch and host layer.
- Each SAP HANA host must have a redundant network connection with a minimum of 10Gb of bandwidth.
- Jumbo frames with a maximum transmission unit (MTU) size of 9,000 must be enabled on all network components between the SAP HANA hosts and the storage controllers.
- In a VMware setup, dedicated VMXNET3 network adapters must be assigned to each running virtual machine. Check the relevant papers mentioned in the Introduction for further requirements.
- To avoid interference between each other, use separate network/IO paths for the log and data area.

The following figure shows an example with four SAP HANA hosts attached to a storage controller HA pair using a 10GbE network. Each SAP HANA host has an active-passive connection to the redundant fabric.

At the storage layer, four active connections are configured to provide 10Gb throughput for each SAP HANA host. In addition, one spare interface is configured on each storage controller.

At the storage layer, a broadcast domain with an MTU size of 9000 is configured, and all required physical interfaces are added to this broadcast domain. This approach automatically assigns these physical interfaces to the same failover group. All logical interfaces (LIFs) that are assigned to these physical interfaces are added

to this failover group.



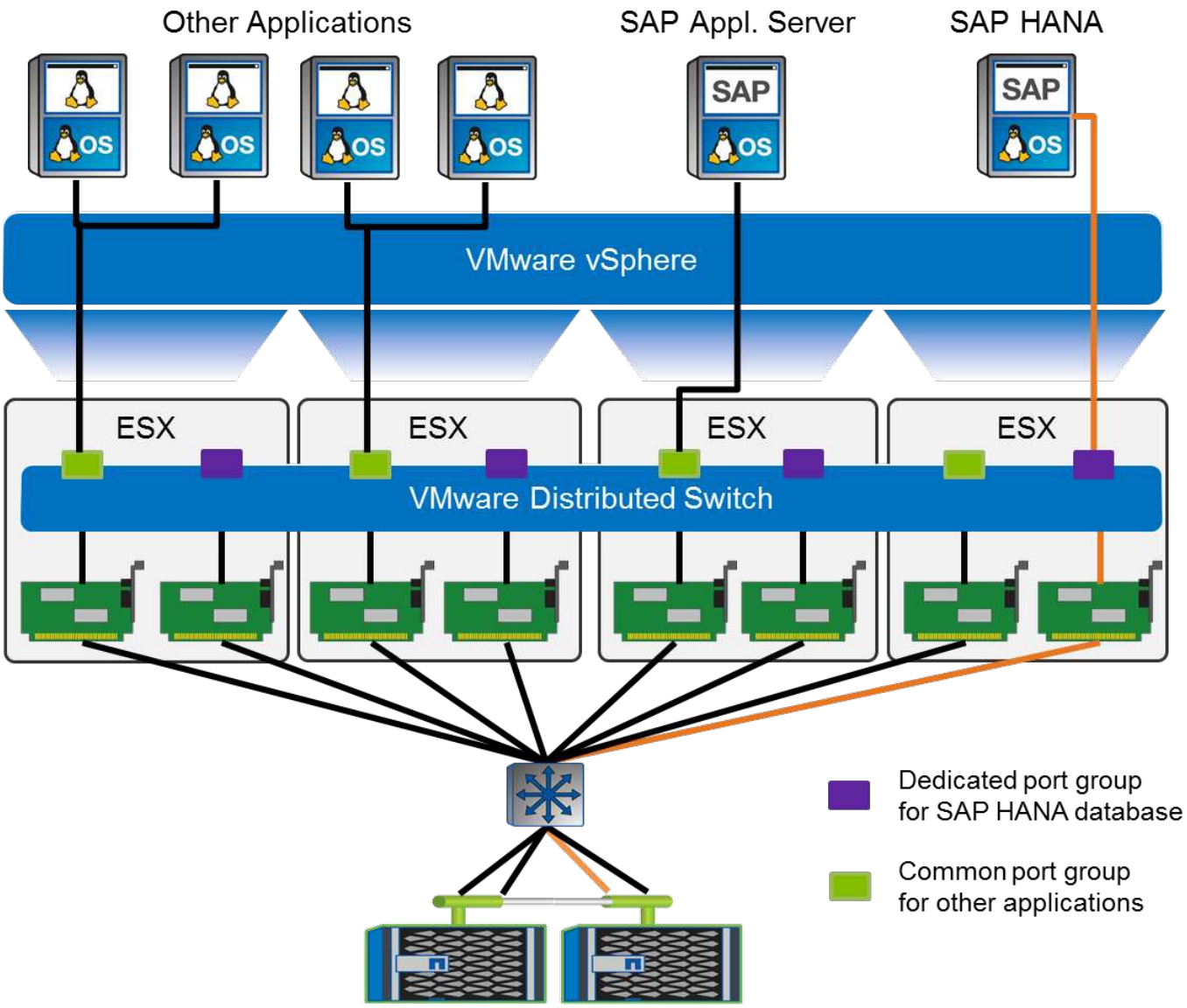
In general, it is also possible to use HA interface groups on the servers (bonds) and the storage systems (for example, Link Aggregation Control Protocol [LACP] and ifgroups). With HA interface groups, verify that the load is equally distributed between all interfaces within the group. The load distribution depends on the functionality of the network switch infrastructure.

Depending on the number of SAP HANA hosts and the connection speed used, different numbers of active physical ports are needed.

VMware-specific network setup

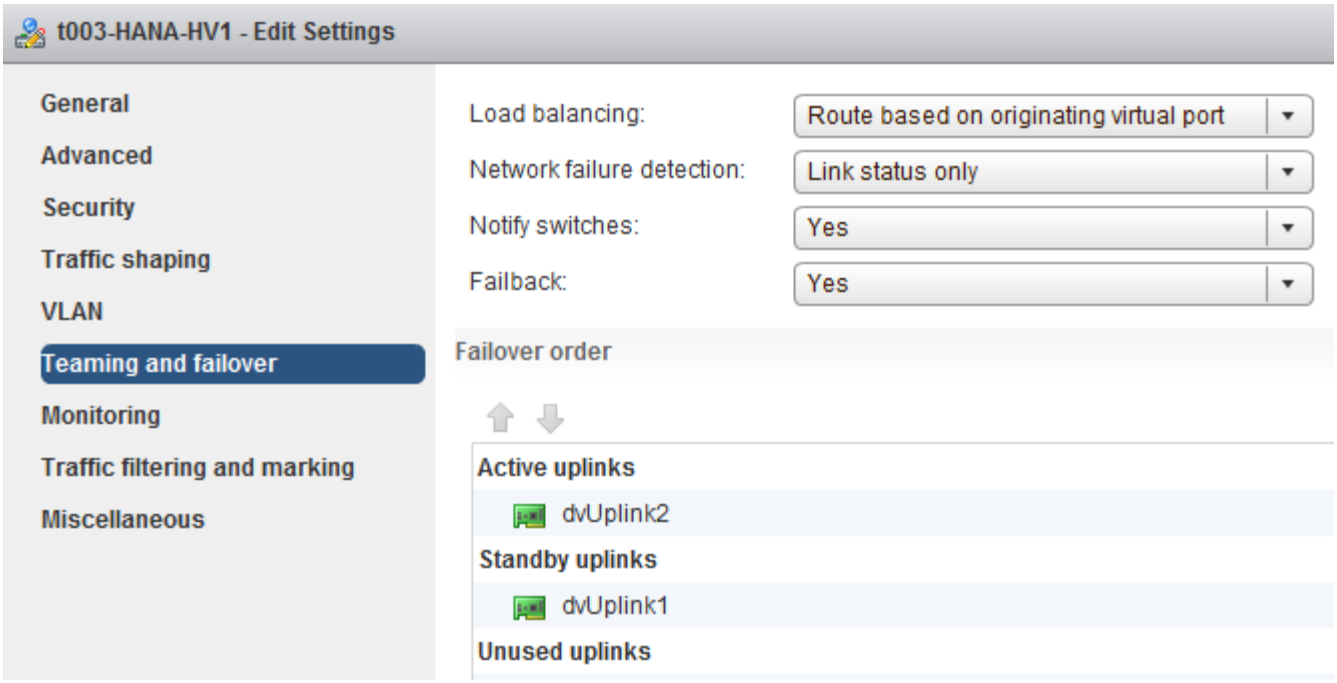
Because all data for SAP HANA instances, including performance-critical data and log volumes for the database, is provided through NFS in this solution, proper network design and configuration are crucial. A dedicated storage network is used to separate the NFS traffic from communication and user access traffic between SAP HANA nodes. Each SAP HANA node requires a redundant dedicated network connection with a minimum of 10Gb of bandwidth. Higher bandwidth is also supported. This network must extend end to end from the storage layer through network switching and computing up to the guest operating system hosted on VMware vSphere. In addition to the physical switching infrastructure, a VMware distributed switch (vDS) is used to provide adequate performance and manageability of network traffic at the hypervisor layer.

The following figure provide a network overview.



Each SAP HANA node uses a dedicated port group on the VMware distributed switch. This port group allows for enhanced quality of service (QoS) and dedicated assignment of physical network interface cards (NICs) on the ESX hosts. To use dedicated physical NICs while preserving HA capabilities if there was a NIC failure, the dedicated physical NIC is configured as an active uplink. Additional NICs are configured as standby uplinks in the teaming and failover settings of the SAP HANA port group. In addition, jumbo frames (MTU 9,000) must be enabled end to end on physical and virtual switches. In addition, turn off flow control on all ethernet ports used for storage traffic on servers, switches, and storage systems. The following figure shows an example of such a configuration.

LRO (large receive offload) must be turned off for interfaces used for NFS traffic. For all other network configuration guidelines, see the respective VMware best practices guides for SAP HANA.



Time synchronization

You must synchronize the time between the storage controllers and the SAP HANA database hosts. To do so, set the same time server for all storage controllers and all SAP HANA hosts.

Storage controller setup

This section describes the configuration of the NetApp storage system. You must complete the primary installation and setup according to the corresponding ONTAP setup and configuration guides.

Storage efficiency

Inline deduplication, cross- volume inline deduplication, inline compression, and inline compaction are supported with SAP HANA in an SSD configuration.

Enabling storage efficiency features in an HDD-based configuration is not supported.

NetApp volume and aggregate encryption

The use of NetApp Volume Encryption (NVE) and NetApp Aggregate Encryption (NAE) are supported with SAP HANA.

Quality of service

QoS can be used to limit the storage throughput for specific SAP HANA systems or other applications on a shared-use controller. One use case would be to limit the throughput of development and test systems so that they cannot influence production systems in a mixed setup.

During the sizing process, you should determine the performance requirements of a nonproduction system. Development and test systems can be sized with lower performance values, typically in the range of 20% to 50% of a production-system KPI as defined by SAP.

Starting with ONTAP 9, QoS is configured on the storage volume level and uses maximum values for throughput (MBps) and the amount of I/O (IOPS).

Large write I/O has the biggest performance effect on the storage system. Therefore, the QoS throughput limit should be set to a percentage of the corresponding write SAP HANA storage performance KPI values in the data and log volumes.

NetApp FabricPool

NetApp FabricPool technology must not be used for active primary file systems in SAP HANA systems. This includes the file systems for the data and log area as well as the `/hana/shared` file system. Doing so results in unpredictable performance, especially during the startup of an SAP HANA system.

Using the “snapshot-only” tiering policy is possible as well as using FabricPool in general at a backup target such as a SnapVault or SnapMirror destination.

> Using FabricPool for tiering Snapshot copies at primary storage or using FabricPool at a backup target changes the required time for the restore and recovery of a database or other tasks such as creating system clones or repair systems. Take this into consideration for planning your overall lifecycle- management strategy and check to make sure that your SLAs are still being met while using this function.

FabricPool is a good option for moving log backups to another storage tier. Moving backups affects the time needed to recover an SAP HANA database. Therefore, the option “tiering-minimum-cooling-days” should be set to a value that places log backups, which are routinely needed for recovery, on the local fast storage tier.

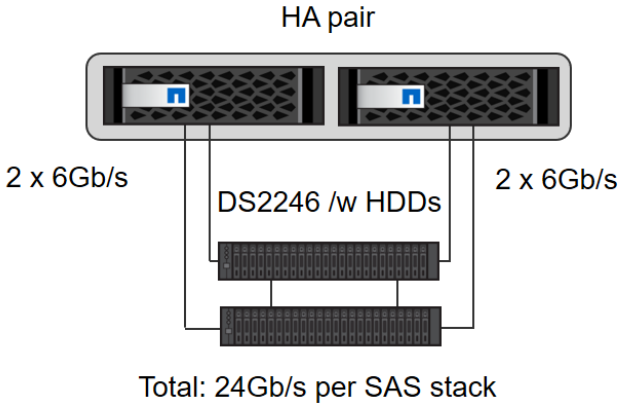
Storage configuration

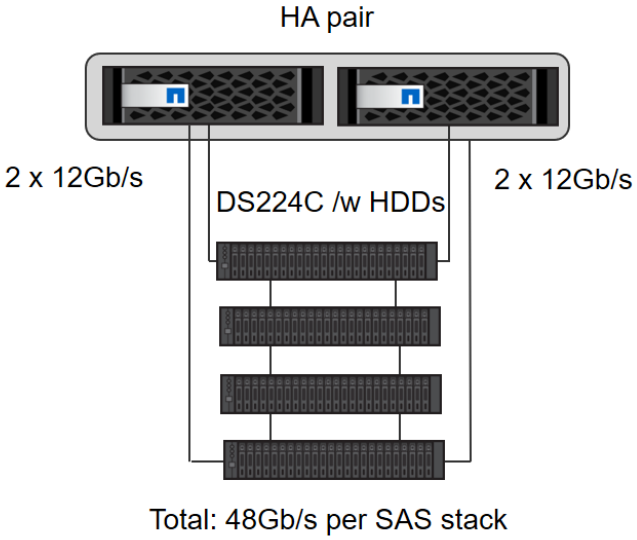
The following overview summarizes the required storage configuration steps. Each step is covered in detail in the subsequent sections. In this section, we assume that the storage hardware is set up and that the ONTAP software is already installed. Also, the connections between the storage ports (10GbE or faster) and the network must already be in place.

1. Check the correct SAS stack configuration as described in Disk shelf connection.
2. Create and configure the required aggregates as described in Aggregate configuration.
3. Create a storage virtual machine (SVM) as described in Storage virtual machine configuration.
4. Create LIFs as described in Logical interface configuration.
5. Create volumes within the aggregates as described in Volume configuration for SAP HANA single-host systems and Volume configuration for SAP HANA multiple-host systems.
6. Set the required volume options as described in Volume options.
7. Set the required options for NFSv3 as described in NFS configuration for NFSv3 or for NFSv4 as described in NFS configuration for NFSv4.
8. Mount the volumes to namespace and set export policies as described in Mount volumes to namespace and set export policies.

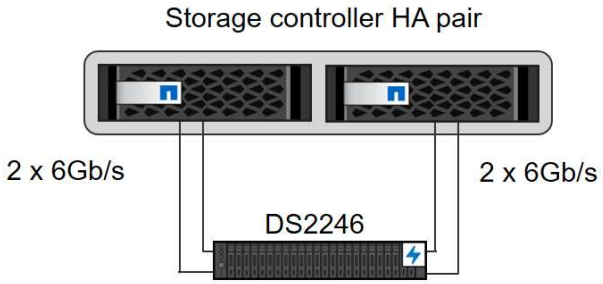
Disk shelf connection

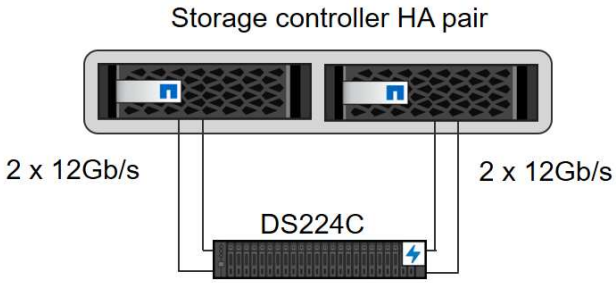
With HDDs, a maximum of two DS2246 disk shelves or four DS224C disk shelves can be connected to one SAS stack to provide the required performance for the SAP HANA hosts, as shown in the following figure. The disks within each shelf must be distributed equally to both controllers of the HA pair.





With SSDs, a maximum of one disk shelf can be connected to one SAS stack to provide the required performance for the SAP HANA hosts, as shown in the following figure. The disks within each shelf must be distributed equally to both controllers of the HA pair. With the DS224C disk shelf, quad- path SAS cabling can also be used, but is not required.



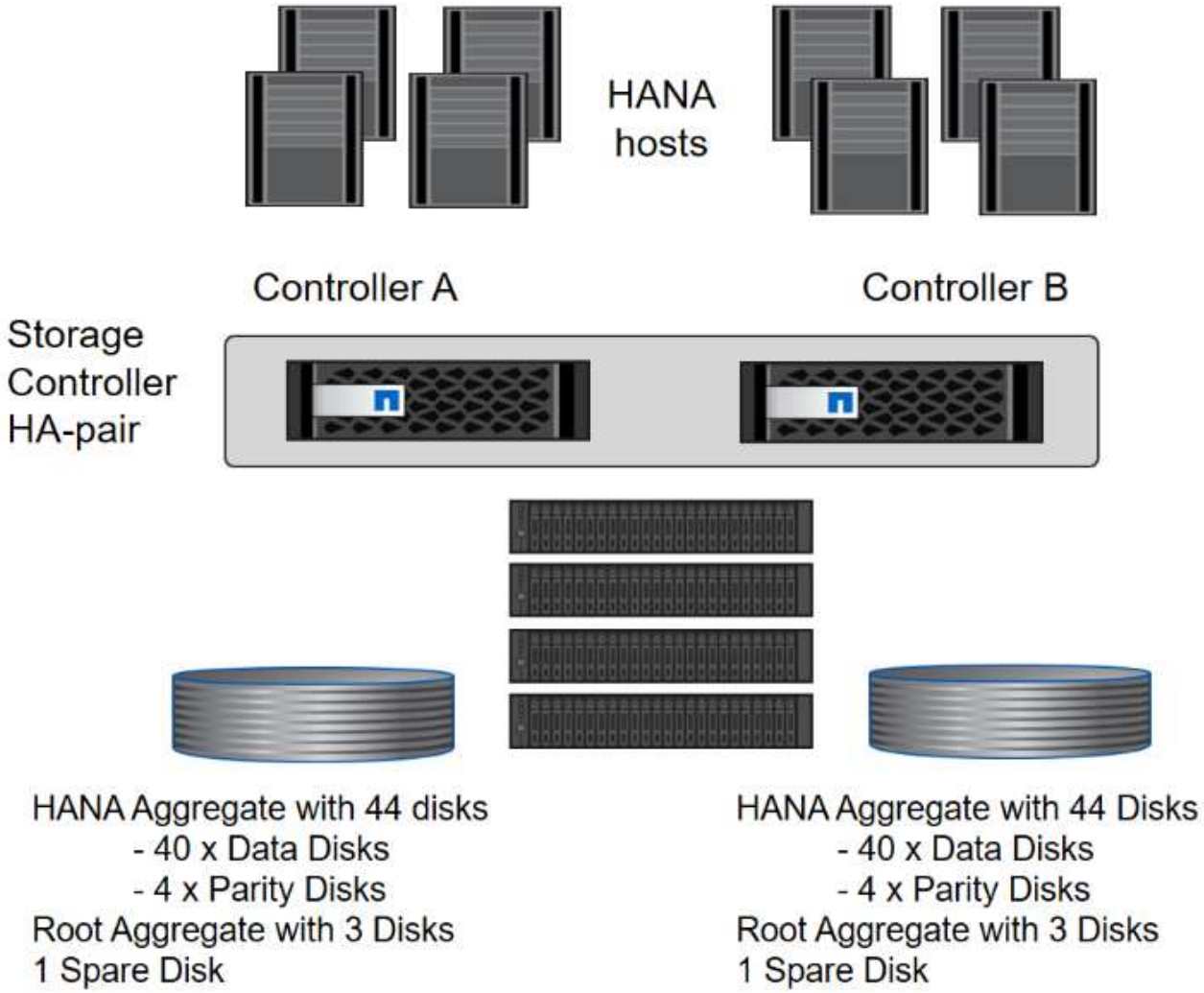


Aggregate configuration

In general, you must configure two aggregates per controller, independent of the disk shelf or drive technology (SSD or HDD) that is used. For FAS2000 series systems, one data aggregate is enough.

Aggregate configuration with HDDs

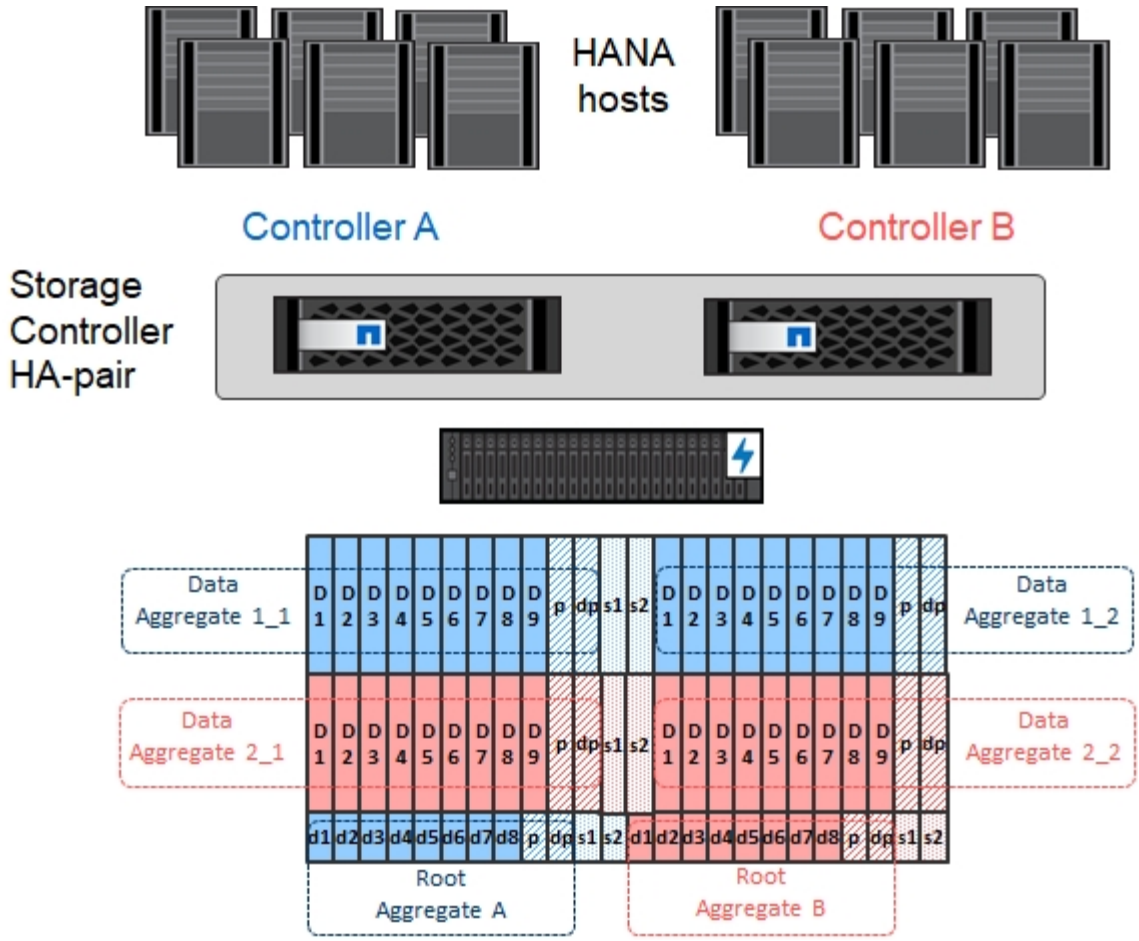
The following figure shows a configuration for eight SAP HANA hosts. Four SAP HANA hosts are attached to each storage controller. Two separate aggregates, one at each storage controller, are configured. Each aggregate is configured with 4 × 10 = 40 data disks (HDDs).



Aggregate configuration with SDD-only systems

In general, you must configure two aggregates per controller, independent of which disk shelf or disk technology (SSDs or HDDs) is used. For FAS2000 series systems, one data aggregate is enough.

The following figure shows a configuration of 12 SAP HANA hosts running on a 12Gb SAS shelf configured with ADPv2. Six SAP HANA hosts are attached to each storage controller. Four separate aggregates, two at each storage controller, are configured. Each aggregate is configured with 11 disks with nine data and two parity disk partitions. For each controller, two spare partitions are available.



Storage virtual machine configuration

Multiple SAP landscapes with SAP HANA databases can use a single SVM. An SVM can also be assigned to each SAP landscape, if necessary, in case they are managed by different teams within a company.

If a QoS profile was automatically created and assigned during new SVM creation, remove the automatically created profile from the SVM to provide the required performance for SAP HANA:

```
vserver modify -vserver <svm-name> -qos-policy-group none
```

Logical interface configuration

For SAP HANA production systems, you must use different LIFs for mounting the data volume and the log volume from the SAP HANA host. Therefore at least two LIFs are required.

The data and log volume mounts of different SAP HANA hosts can share a physical storage network port by using either the same LIFs or by using individual LIFs for each mount.

The maximum number of data and log volume mounts per physical interface are shown in the following table.

Ethernet port speed	10GbE	25GbE	40GbE	100GeE
Maximum number of log or data volume mounts per physical port	2	6	12	24

Sharing one LIF between different SAP HANA hosts might require a remount of data or log volumes to a different LIF. This change avoids performance penalties if a volume is moved to a different storage controller.

Development and test systems can use more data and volume mounts or LIFs on a physical network interface.

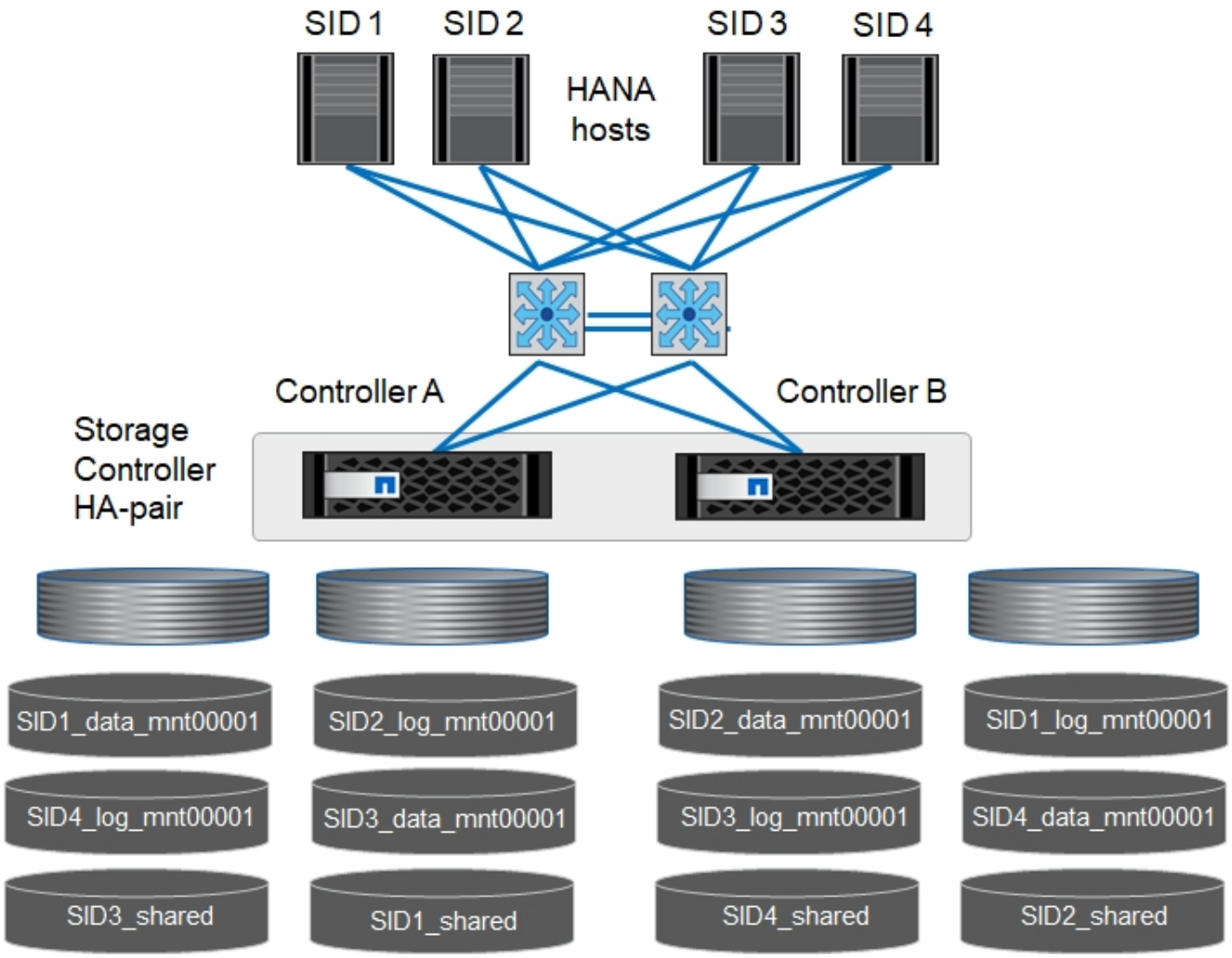
For production, development, and test systems, the `/hana/shared` file system can use the same LIF as the data or log volume.

Volume configuration for SAP HANA single-host systems

The following figure shows the volume configuration of four single-host SAP HANA systems. The data and log volumes of each SAP HANA system are distributed to different storage controllers. For example, volume `SID1_data_mnt00001` is configured on controller A, and volume `SID1_log_mnt00001` is configured on controller B.

If only one storage controller of an HA pair is used for the SAP HANA systems, data and log volumes can also be stored on the same storage controller.

If the data and log volumes are stored on the same controller, access from the server to the storage must be performed with two different LIFs: one LIF to access the data volume and one to access the log volume.



For each SAP HANA DB host, a data volume, a log volume, and a volume for `/hana/shared` are configured. The following table shows an example configuration for single-host SAP HANA systems.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller b
Data, log, and shared volumes for system SID1	Data volume: SID1_data_mnt00001	Shared volume: SID1_shared	–	Log volume: SID1_log_mnt00001
Data, log, and shared volumes for system SID2	–	Log volume: SID2_log_mnt00001	Data volume: SID2_data_mnt00001	Shared volume: SID2_shared
Data, log, and shared volumes for system SID3	Shared volume: SID3_shared	Data volume: SID3_data_mnt00001	Log volume: SID3_log_mnt00001	–
Data, log, and shared volumes for system SID4	Log volume: SID4_log_mnt00001	–	Shared volume: SID4_shared	Data volume: SID4_data_mnt00001

The following table shows an example of the mount point configuration for a single-host system. To place the home directory of the `sidadm` user on the central storage, the `/usr/sap/SID` file system should be mounted

from the `SID_shared` volume.

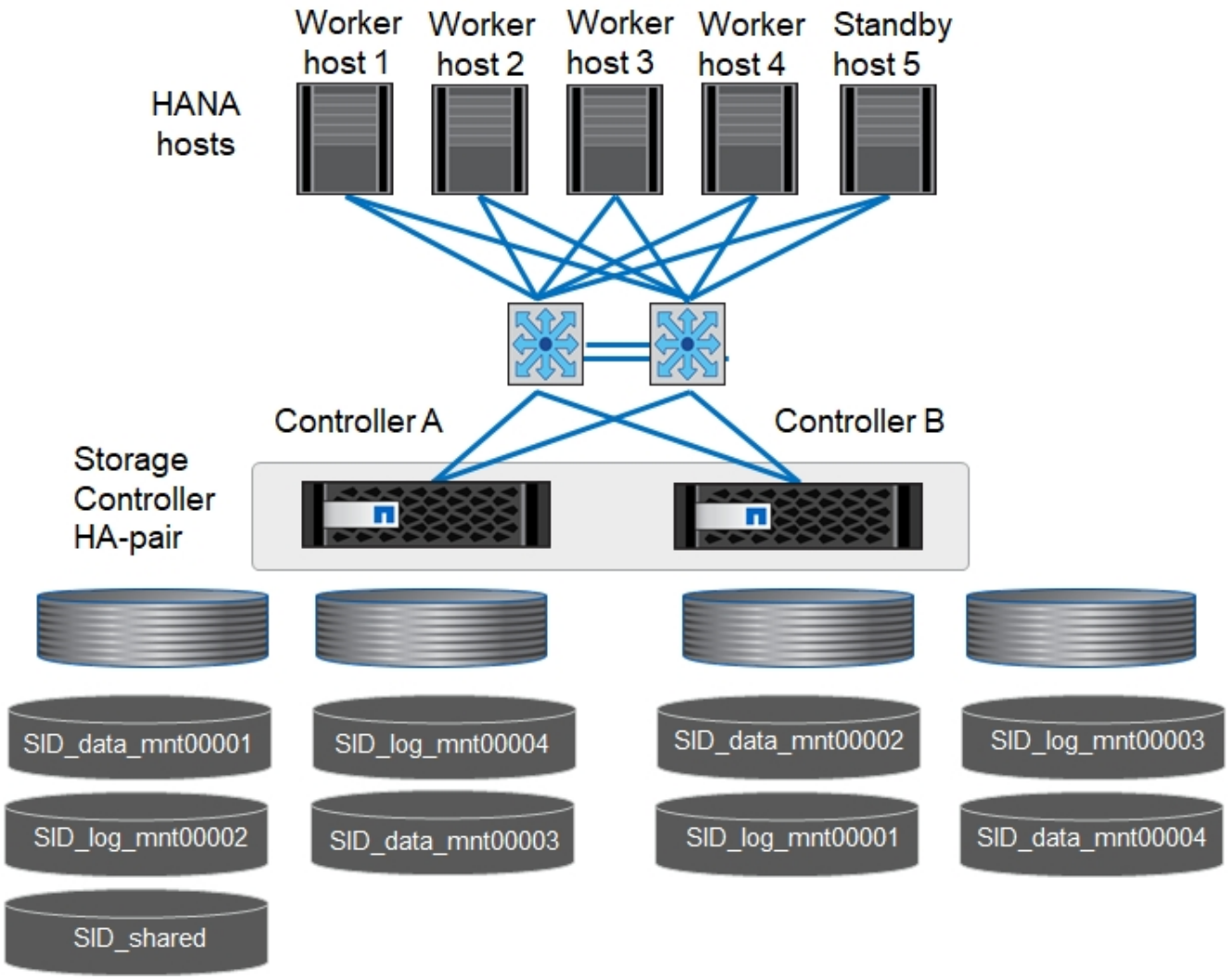
Junction Path	Directory	Mount point at HANA host
SID_data_mnt00001	–	/hana/data/SID/mnt00001
SID_log_mnt00001	–	/hana/log/SID/mnt00001
SID_shared	usr-sap shared	/usr/sap/SID /hana/shared

Volume configuration for SAP HANA multiple-host systems

The following figure shows the volume configuration of a 4+1 SAP HANA system. The data and log volumes of each SAP HANA host are distributed to different storage controllers. For example, volume `SID1_data1_mnt00001` is configured on controller A, and volume `SID1_log1_mnt00001` is configured on controller B.

If only one storage controller of an HA pair is used for the SAP HANA system, the data and log volumes can also be stored on the same storage controller.

If the data and log volumes are stored on the same controller, access from the server to the storage must be performed with two different LIFs: one to access the data volume and one to access the log volume.



For each SAP HANA host, a data volume and a log volume are created. The `/hana/shared` volume is used by all hosts of the SAP HANA system. The following table shows an example configuration for a multiple-host SAP HANA system with four active hosts.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	–	Log volume: SID_log_mnt00001	–
Data and log volumes for node 2	Log volume: SID_log_mnt00002	–	Data volume: SID_data_mnt00002	–
Data and log volumes for node 3	–	Data volume: SID_data_mnt00003	–	Log volume: SID_log_mnt00003
Data and log volumes for node 4	–	Log volume: SID_log_mnt00004	–	Data volume: SID_data_mnt00004
Shared volume for all hosts	Shared volume: SID_shared	–	–	–

The following table shows the configuration and the mount points of a multiple-host system with four active SAP HANA hosts. To place the home directories of the `sidadm` user of each host on the central storage, the

`/usr/sap/SID` file systems are mounted from the `SID_shared` volume.

Junction path	Directory	Mount point at SAP HANA host	Note
SID_data_mnt00001	–	/hana/data/SID/mnt00001	Mounted at all hosts
SID_log_mnt00001	–	/hana/log/SID/mnt00001	Mounted at all hosts
SID_data_mnt00002	–	/hana/data/SID/mnt00002	Mounted at all hosts
SID_log_mnt00002	–	/hana/log/SID/mnt00002	Mounted at all hosts
SID_data_mnt00003	–	/hana/data/SID/mnt00003	Mounted at all hosts
SID_log_mnt00003	–	/hana/log/SID/mnt00003	Mounted at all hosts
SID_data_mnt00004	–	/hana/data/SID/mnt00004	Mounted at all hosts
SID_log_mnt00004	–	/hana/log/SID/mnt00004	Mounted at all hosts
SID_shared	shared	/hana/shared/	Mounted at all hosts
SID_shared	usr-sap-host1	/usr/sap/SID	Mounted at host 1
SID_shared	usr-sap-host2	/usr/sap/SID	Mounted at host 2
SID_shared	usr-sap-host3	/usr/sap/SID	Mounted at host 3
SID_shared	usr-sap-host4	/usr/sap/SID	Mounted at host 4
SID_shared	usr-sap-host5	/usr/sap/SID	Mounted at host 5

Volume options

You must verify and set the volume options listed in the following table on all SVMs. For some of the commands, you must switch to the advanced privilege mode within ONTAP.

Action	Command
Disable visibility of Snapshot directory	vol modify -vserver <vserver-name> -volume <volname> -snapdir-access false
Disable automatic Snapshot copies	vol modify –vserver <vserver-name> -volume <volname> -snapshot-policy none
Disable access time update except of the SID_shared volume	set advanced vol modify -vserver <vserver-name> -volume <volname> -atime-update false set admin

NFS configuration for NFSv3

The NFS options listed in the following table must be verified and set on all storage controllers.

For some of the commands shown, you must switch to the advanced privilege mode within ONTAP.

Action	Command
Enable NFSv3	nfs modify -vserver <vserver-name> v3.0 enabled

Action	Command
ONTAP 9: Set NFS TCP maximum transfer size to 1MB	set advanced nfs modify -vserver <vserver_name> -tcp-max-xfer -size 1048576 set admin
ONTAP 8: Set NFS read and write size to 64KB	set advanced nfs modify -vserver <vserver-name> -v3-tcp-max-read -size 65536 nfs modify -vserver <vserver-name> -v3-tcp-max -write-size 65536 set admin

NFS configuration for NFSv4

The NFS options listed in the following table must be verified and set on all SVMs.

For some of the commands, you must switch to the advanced privilege mode within ONTAP.

Action	Command
Enable NFSv4	nfs modify -vserver <vserver-name> -v4.1 enabled
ONTAP 9: Set NFS TCP maximum transfer size to 1MB	set advanced nfs modify -vserver <vserver_name> -tcp-max-xfer -size 1048576 set admin
ONTAP 8: Set NFS read and write size to 64KB	set advanced nfs modify -vserver <vserver_name> -tcp-max-xfer -size 65536 set admin
Disable NFSv4 access control lists (ACLs)	nfs modify -vserver <vserver_name> -v4.1-acl disabled
Set NFSv4 domain ID	nfs modify -vserver <vserver_name> -v4-id-domain <domain-name>
Disable NFSv4 read delegation	nfs modify -vserver <vserver_name> -v4.1-read -delegation disabled
Disable NFSv4 write delegation	nfs modify -vserver <vserver_name> -v4.1-write -delegation disabled
Disable NFSv4 numeric ids	nfs modify -vserver <vserver_name> -v4-numeric-ids disabled
Change amount of NFSv4.x session slots optional	set advanced nfs modify -vserver hana -v4.x-session-num-slots <value> set admin

Please note that disabling numering ids requires user management as described in SAP HANA installation preparations for NFSv4.

The NFSv4 domain ID must be set to the same value on all Linux servers (`/etc/idmapd.conf`) and SVMs, as described in SAP HANA installation preparations for NFSv4.

If you are using NFSV4.1, then pNFS can be enabled and used.

If SAP HANA multiple-host systems with host auto-failover are being used, the failover parameters need to be adjusted within `nameserver.ini` as shown in the following table. Keep the default retry interval of 10 seconds within these sections.

Section within nameserver.ini	Parameter	Value
failover	normal_retries	9
distributed_watchdog	deactivation_retries	11
distributed_watchdog	takeover_retries	9

Mount volumes to namespace and set export policies

When a volume is created, the volume must be mounted to the namespace. In this document, we assume that the junction path name is the same as the volume name. By default, the volume is exported with the default policy. The export policy can be adapted if required.

Host setup

All the steps described in this section are valid for both SAP HANA environments on physical servers and for SAP HANA running on VMware vSphere.

Configuration parameter for SUSE Linux Enterprise Server

Additional kernel and configuration parameters at each SAP HANA host must be adjusted for the workload generated by SAP HANA.

SUSE Linux Enterprise Server 12 and 15

Starting with SUSE Linux Enterprise Server (SLES) 12 SP1, the kernel parameter must be set in a configuration file in the `/etc/sysctl.d` directory. For example, a configuration file with the name `91-NetApp-HANA.conf` must be created.

```
net.core.rmem_max = 16777216
net.core.wmem_max = 16777216
net.ipv4.tcp_rmem = 4096 131072 16777216
net.ipv4.tcp_wmem = 4096 16384 16777216
net.core.netdev_max_backlog = 300000
net.ipv4.tcp_slow_start_after_idle=0
net.ipv4.tcp_no_metrics_save = 1
net.ipv4.tcp_moderate_rcvbuf = 1
net.ipv4.tcp_window_scaling = 1
net.ipv4.tcp_timestamps = 1
net.ipv4.tcp_sack = 1
```

Saptune, which is included in SLES for SAP OS versions, can be used to set these values. See SAP Note 3024346 (requires SAP login).

The `sunrpc.tcp_max_slot_table_entries` parameter must be set in `/etc/modprobe.d/sunrpc.conf`. If the file does not exist, it must first be created by adding the following line:

```
options sunrpc tcp_max_slot_table_entries=128
```

Configuration parameter for Red Hat Enterprise Linux 7.2 or later

You must adjust additional kernel and configuration parameters at each SAP HANA host for the workload generated by SAP HANA.

The `sunrpc.tcp_max_slot_table_entries` parameter must be set in `/etc/modprobe.d/sunrpc.conf`. If the file does not exist, it must first be created by adding the following line:

```
options sunrpc tcp_max_slot_table_entries=128
```

Starting with Red Hat Enterprise Linux 7.2, you must set the kernel parameters in a configuration file in the `/etc/sysctl.d` directory. For example, a configuration file with the name `91-NetApp-HANA.conf` must be created.

```
net.core.rmem_max = 16777216
net.core.wmem_max = 16777216
net.ipv4.tcp_rmem = 4096 131072 16777216
net.ipv4.tcp_wmem = 4096 16384  16777216
net.core.netdev_max_backlog = 300000
net.ipv4.tcp_slow_start_after_idle=0
net.ipv4.tcp_no_metrics_save = 1
net.ipv4.tcp_moderate_rcvbuf = 1
net.ipv4.tcp_window_scaling = 1
net.ipv4.tcp_timestamps = 1
net.ipv4.tcp_sack = 1
```

Since RedHat Enterprise Linux version 8.6, these settings can also be applied by using RHEL System Roles for SAP (Ansible). See SAP Note 3024346 (requires SAP login).

Create subdirectories in /hana/shared volume

The examples show an SAP HANA database with SID=NF2.

To create the required subdirectories, take one of the following actions:

- For a single-host system, mount the `/hana/shared` volume and create the `shared` and `usr-sap` subdirectories.

```
sapcc-hana-tst-06:/mnt # mount <storage-hostname>:/NF2_shared /mnt/tmp
sapcc-hana-tst-06:/mnt # cd /mnt/tmp
sapcc-hana-tst-06:/mnt/tmp # mkdir shared
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap
sapcc-hana-tst-06:mnt/tmp # cd ..
sapcc-hana-tst-06:/mnt # umount /mnt/tmp
```

- For a multiple-host system, mount the `/hana/shared` volume and create the `shared` and the `usr-sap` subdirectories for each host.

  The example commands show a 2+1 multiple-host HANA system.

```
sapcc-hana-tst-06:/mnt # mount <storage-hostname>:/NF2_shared /mnt/tmp
sapcc-hana-tst-06:/mnt # cd /mnt/tmp
sapcc-hana-tst-06:/mnt/tmp # mkdir shared
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap-host1
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap-host2
sapcc-hana-tst-06:/mnt/tmp # mkdir usr-sap-host3
sapcc-hana-tst-06:/mnt/tmp # cd ..
sapcc-hana-tst-06:/mnt # umount /mnt/tmp
```

Create mount points

The examples show an SAP HANA database with SID=NF2.

To create the required mount point directories, take one of the following actions:

- For a single-host system, create mount points and set the permissions on the database host.

```
sapcc-hana-tst-06:/ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-06:/ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-06:/ # mkdir -p /hana/shared
sapcc-hana-tst-06:/ # mkdir -p /usr/sap/NF2
sapcc-hana-tst-06:/ # chmod –R 777 /hana/log/NF2
sapcc-hana-tst-06:/ # chmod –R 777 /hana/data/NF2
sapcc-hana-tst-06:/ # chmod -R 777 /hana/shared
sapcc-hana-tst-06:/ # chmod -R 777 /usr/sap/NF2
```

- For a multiple-host system, create mount points and set the permissions on all worker and standby hosts.

  The following example commands are for a 2+1 multiple-host HANA system.

  - First worker host:

```
sapcc-hana-tst-06:~ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-06:~ # mkdir -p /hana/data/NF2/mnt00002
sapcc-hana-tst-06:~ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-06:~ # mkdir -p /hana/log/NF2/mnt00002
sapcc-hana-tst-06:~ # mkdir -p /hana/shared
sapcc-hana-tst-06:~ # mkdir -p /usr/sap/NF2
sapcc-hana-tst-06:~ # chmod -R 777 /hana/log/NF2
sapcc-hana-tst-06:~ # chmod -R 777 /hana/data/NF2
sapcc-hana-tst-06:~ # chmod -R 777 /hana/shared
sapcc-hana-tst-06:~ # chmod -R 777 /usr/sap/NF2
```

- Second worker host:

```
sapcc-hana-tst-07:~ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-07:~ # mkdir -p /hana/data/NF2/mnt00002
sapcc-hana-tst-07:~ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-07:~ # mkdir -p /hana/log/NF2/mnt00002
sapcc-hana-tst-07:~ # mkdir -p /hana/shared
sapcc-hana-tst-07:~ # mkdir -p /usr/sap/NF2
sapcc-hana-tst-07:~ # chmod -R 777 /hana/log/NF2
sapcc-hana-tst-07:~ # chmod -R 777 /hana/data/NF2
sapcc-hana-tst-07:~ # chmod -R 777 /hana/shared
sapcc-hana-tst-07:~ # chmod -R 777 /usr/sap/NF2
```

- Standby host:

```
sapcc-hana-tst-08:~ # mkdir -p /hana/data/NF2/mnt00001
sapcc-hana-tst-08:~ # mkdir -p /hana/data/NF2/mnt00002
sapcc-hana-tst-08:~ # mkdir -p /hana/log/NF2/mnt00001
sapcc-hana-tst-08:~ # mkdir -p /hana/log/NF2/mnt00002
sapcc-hana-tst-08:~ # mkdir -p /hana/shared
sapcc-hana-tst-08:~ # mkdir -p /usr/sap/NF2
sapcc-hana-tst-08:~ # chmod -R 777 /hana/log/NF2
sapcc-hana-tst-08:~ # chmod -R 777 /hana/data/NF2
sapcc-hana-tst-08:~ # chmod -R 777 /hana/shared
sapcc-hana-tst-08:~ # chmod -R 777 /usr/sap/NF2
```

Mount file systems

Different mount options are used depending on the NFS version and ONTAP release. The following file systems must be mounted to the hosts:

- `/hana/data/SID/mnt0000*`
- `/hana/log/SID/mnt0000*`
- `/hana/shared`
- `/usr/sap/SID`

The following table shows the NFS versions that must be used for the different file systems for single-host and multiple-host SAP HANA databases.

File systems	SAP HANA single host	SAP HANA multiple hosts
/hana/data/SID/mnt0000*	NFSv3 or NFSv4	NFSv4
/hana/log/SID/mnt0000*	NFSv3 or NFSv4	NFSv4
/hana/shared	NFSv3 or NFSv4	NFSv3 or NFSv4
/usr/sap/SID	NFSv3 or NFSv4	NFSv3 or NFSv4

The following table shows the mount options for the various NFS versions and ONTAP releases. The common parameters are independent of the NFS and ONTAP versions.

SAP LaMa requires the /usr/sap/SID directory to be local. Therefore, do not mount an NFS volume for /usr/sap/SID if you are using SAP LaMa.

For NFSv3, you must switch off NFS locking to avoid NFS lock cleanup operations if there is a software or server failure.

With ONTAP 9, the NFS transfer size can be configured up to 1MB. Specifically, with 40GbE or faster connections to the storage system, you must set the transfer size to 1MB to achieve the expected throughput values.

Common parameter	NFSv3	NFSv4	NFS transfer size with ONTAP 9	NFS transfer size with ONTAP 8
rw, bg, hard, timeo=600, noatime,	nfsvers=3,nolock,	nfsvers=4.1,lock	rsize=1048576,wsize=262144,	rsize=65536,wsize=65536,

To improve read performance with NFSv3, NetApp recommends that you use the `nconnect=n` mount option, which is available with SUSE Linux Enterprise Server 12 SP4 or later and RedHat Enterprise Linux (RHEL) 8.3 or later.

Performance tests show that `nconnect=4` provides good read results especially for the data volumes. Log writes might benefit from a lower number of sessions, such as `nconnect=2`. Shared volumes might benefit as well from using the 'nconnect' option. Be aware that the first mount from an NFS server (IP address) defines the amount of sessions being used. Further mounts to the same IP address do not change this even if a different value is used for nconnect.

Starting with ONTAP 9.8 and SUSE SLES15SP2 or RedHat RHEL 8.4 or higher, NetApp supports the nconnect option also for NFSv4.1.

If nconnect is being used with NFSV4.x the amount of NFSv4.x session slots should be adjusted according to the following rule:
Amount of session slots equals <nconnect value> x 64.
At the host this will be adjuseted by
`echo options nfs max_session_slots= <calculated value> > /etc/modprobe.d/nfsclient.conf`
followed by a reboot. The server side value must be adjusted as well, set the number of session slots as described in NFS configuration for NFSv4.

To mount the file systems during system boot with the `/etc/fstab` configuration file, complete the following steps:

The following example shows a single host SAP HANA database with SID=NF2 using NFSv3 and an NFS transfer size of 1MB for reads and 256k for writes.

1. Add the required file systems to the `/etc/fstab` configuration file.

```
sapcc-hana-tst-06:/ # cat /etc/fstab
<storage-vif-data01>:/NF2_data_mnt00001 /hana/data/NF2/mnt00001 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-log01>:/NF2_log_mnt00001 /hana/log/NF2/mnt00001 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=2,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-data01>:/NF2_shared/usr-sap /usr/sap/NF2 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-data01>:/NF2_shared/shared /hana/shared nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
```

2. Run `mount -a` to mount the file systems on all hosts.

The next example shows a multiple-host SAP HANA database with SID=NF2 using NFSv4.1 for data and log file systems and NFSv3 for the `/hana/shared` and `/usr/sap/NF2` file systems. An NFS transfer size of 1MB for reads and 256k for writes is used.

1. Add the required file systems to the `/etc/fstab` configuration file on all hosts.

> The `/usr/sap/NF2` file system is different for each database host. The following example shows `/NF2_shared/usr-sap-host1`.

```
sapcc-hana-tst-06:/ # cat /etc/fstab
<storage-vif-data01>:/NF2_data_mnt00001 /hana/data/NF2/mnt00001 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-data02>:/NF2_data_mnt00002 /hana/data/NF2/mnt00002 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-log01>:/NF2_log_mnt00001 /hana/log/NF2/mnt00001 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=2,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-log02>:/NF2_log_mnt00002 /hana/log/NF2/mnt00002 nfs
rw,nfsvers=4.1,hard,timeo=600,nconnect=2,rsize=1048576,wsize=262144,bg,n
oatime,lock 0 0
<storage-vif-data02>:/NF2_shared/usr-sap-host1 /usr/sap/NF2 nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
<storage-vif-data02>:/NF2_shared/shared /hana/shared nfs
rw,nfsvers=3,hard,timeo=600,nconnect=4,rsize=1048576,wsize=262144,bg,noa
time,nolock 0 0
```

2. Run `mount -a` to mount the file systems on all hosts.

SAP HANA installation preparations for NFSv4

NFS version 4 and higher requires user authentication. This authentication can be accomplished by using a central user management tool such as a Lightweight Directory Access Protocol (LDAP) server or with local user accounts. The following sections describe how to configure local user accounts.

The administration user `<sidadm>` and the `sapsys` group must be created manually on the SAP HANA hosts and the storage controllers before the installation of the SAP HANA software begins.

SAP HANA hosts

If it doesn't exist, the `sapsys` group must be created on the SAP HANA host. A unique group ID must be chosen that does not conflict with the existing group IDs on the storage controllers.

The user `<sidadm>` is created on the SAP HANA host. A unique ID must be chosen that does not conflict with existing user IDs on the storage controllers.

For a multiple-host SAP HANA system, the user and group ID must be the same on all SAP HANA hosts. The group and user are created on the other SAP HANA hosts by copying the affected lines in `/etc/group` and `/etc/passwd` from the source system to all other SAP HANA hosts.

The NFSv4 domain must be set to the same value on all Linux servers (`/etc/idmapd.conf`) and SVMs. Set the domain parameter "Domain = <domain-name>" in the file `/etc/idmapd.conf` for the Linux hosts.

Enable and start the NFS IDMAPD service.

```
systemctl enable nfs-idmapd.service
systemctl start nfs-idmapd.service
```

The latest Linux kernels do not require this step. Warning messages can be safely ignored.

Storage controllers

The user ID and group ID must be the same on the SAP HANA hosts and the storage controllers. The group and user are created by entering the following commands on the storage cluster:

```
vserver services unix-group create -vserver <vserver> -name <group name>
-id <group id>
vserver services unix-user create -vserver <vserver> -user <user name> -id
<user-id> -primary-gid <group id>
```

Additionally, set the group ID of the UNIX user root of the SVM to 0.

```
vserver services unix-user modify -vserver <vserver> -user root -primary
-gid 0
```

I/O stack configuration for SAP HANA

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage systems used.

NetApp conducted performance tests to define the ideal values. The following table lists the optimal values inferred from the performance tests.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For SAP HANA 1.0 versions up to SPS12, these parameters can be set during the installation of the SAP HANA database, as described in SAP note 2267798: Configuration of the SAP HANA Database During Installation Using hdbparam.

Alternatively, the parameters can be set after the SAP HANA database installation by using the `hdbparam` framework.

```
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.max_parallel_io_requests=128
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.async_write_submit_active=on
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.async_read_submit=on
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00> hdbparam --paramset
fileio.async_write_submit_blocks=all
```

Starting with SAP HANA 2.0, `hdbparam` has been deprecated, and the parameters have been moved to `global.ini`. The parameters can be set using SQL commands or SAP HANA Studio. For more details, see SAP note 2399079: Elimination of hdbparam in HANA 2. You can also set the parameters within global.ini as shown in the following text:

```
nf2adm@stlrx300s8-6: /usr/sap/NF2/SYS/global/hdb/custom/config> cat
global.ini
…
[fileio]
async_read_submit = on
async_write_submit_active = on
max_parallel_io_requests = 128
async_write_submit_blocks = all
…
```

Since SAP HANA 2.0 SPS5, the `setParameter.py` script can be used the set the correct parameters:

```
nf2adm@sapcc-hana-tst-06:/usr/sap/NF2/HDB00/exe/python_support>
python setParameter.py
-set=SYSTEM/global.ini/fileio/max_parallel_io_requests=128
python setParameter.py -set=SYSTEM/global.ini/fileio/async_read_submit=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_active=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_blocks=all
```

SAP HANA data volume size

As the default, SAP HANA uses only one data volume per SAP HANA service. Due to the maximum file size limitation of the file system, we recommend limiting the maximum data volume size.

To do so automatically, set the following parameter in `global.ini` in the section `[persistence]`:

```
datavolume_striping = true
datavolume_striping_size_gb = 8000
```

This creates a new data volume after the 8, 000GB limit is reached. SAP note 240005 question 15 provides more information.

SAP HANA software installation

The following are requirements for software installation for SAP HANA.

Install on single-host system

The SAP HANA software installation does not require any additional preparation for a single-host system.

Install on multiple-host system

To install SAP HANA on a multiple-host system, complete the following steps:

1. Using the SAP `hdbclm` installation tool, start the installation by running the following command at one of the worker hosts. Use the `addhosts` option to add the second worker (`sapcc-hana-tst-07`) and the standby host (`sapcc-hana-tst-08`).

```
sapcc-hana-tst-06:/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_LCM_LINUX_X86_64 # ./hdblcm --action=install
--addhosts=sapcc-hana-tst-07:role=worker,sapcc-hana-tst-08:role=standby



SAP HANA Lifecycle Management - SAP HANA Database 2.00.052.00.1599235305
************************************************************************


Scanning software locations...
Detected components:
    SAP HANA AFL (incl.PAL,BFL,OFL) (2.00.052.0000.1599259237) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_AFL_LINUX_X86_64/packages
    SAP HANA Database (2.00.052.00.1599235305) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_SERVER_LINUX_X86_64/server
    SAP HANA Database Client (2.5.109.1598303414) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_CLIENT_LINUX_X86_64/client
    SAP HANA Smart Data Access (2.00.5.000.0) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/SAP_HANA_SDA_20_LINUX_X86_64/packages
    SAP HANA Studio (2.3.54.000000) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_STUDIO_LINUX_X86_64/studio
    SAP HANA Local Secure Store (2.4.24.0) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HANA_LSS_24_LINUX_X86_64/packages
    SAP HANA XS Advanced Runtime (1.0.130.519) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_RT_10_LINUX_X86_64/packages
    SAP HANA EML AFL (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_EML_AFL_10_LINUX_X86_64/packages
    SAP HANA EPM-MDS (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/SAP_HANA_EPM-MDS_10/packages
    GUI for HALM for XSA (including product installer) Version 1
(1.014.1) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACALMPIUI14_1.zip
    XSAC FILEPROCESSOR 1.0 (1.000.85) in /mnt/sapcc-
```

```
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACFILEPROC00_85.zip
    SAP HANA tools for accessing catalog content, data preview, SQL
console, etc. (2.012.20341) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_HRTT_20/XSACHRTT12_20341.zip
    XS Messaging Service 1 (1.004.10) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACMESSSRV04_10.zip
    Develop and run portal services for customer apps on XSA (1.005.1)
in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACPORTALSERV05_1.zip
    SAP Web IDE Web Client (4.005.1) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_SAP_WEB_IDE_20/XSACSAPWEBIDE05_1.zip
    XS JOB SCHEDULER 1.0 (1.007.12) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACSERVICES07_12.zip
    SAPUI5 FESV6 XSA 1 - SAPUI5 1.71 (1.071.25) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5FESV671_25.zip
    SAPUI5 SERVICE BROKER XSA 1 - SAPUI5 Service Broker 1.0 (1.000.3) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5SB00_3.zip
    XSA Cockpit 1 (1.001.17) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACXSACOCKPIT01_17.zip


SAP HANA Database version '2.00.052.00.1599235305' will be installed.

Select additional components for installation:

  Index | Components | Description

-------------------------------------------------------------------------
---------------------
  1     | all        | All components
  2     | server     | No additional components
  3     | client     | Install SAP HANA Database Client version
2.5.109.1598303414
  4     | lss        | Install SAP HANA Local Secure Store version
2.4.24.0
  5     | studio     | Install SAP HANA Studio version 2.3.54.000000
  6     | smartda    | Install SAP HANA Smart Data Access version
2.00.5.000.0
  7     | xs         | Install SAP HANA XS Advanced Runtime version
1.0.130.519
```

```
  8     | afl         | Install SAP HANA AFL (incl.PAL,BFL,OFL) version
2.00.052.0000.1599259237
  9     | eml         | Install SAP HANA EML AFL version
2.00.052.0000.1599259237
  10    | epmmds      | Install SAP HANA EPM-MDS version
2.00.052.0000.1599259237

Enter comma-separated list of the selected indices [3]: 2,3
Enter Installation Path [/hana/shared]:
```

2. Verify that the installation tool installed all selected components at all worker and standby hosts.

Adding additional data volume partitions

Starting with SAP HANA 2.0 SPS4, you can configure additional data volume partitions, which allows you to configure two or more volumes for the data volume of an SAP HANA tenant database. You can also scale beyond the size and performance limits of a single volume.

Using two or more individual volumes for the data volume is available for SAP HANA single-host and multiple-host systems. You can add additional data volume partitions at any time, but doing so might require a restart of the SAP HANA database.

Enabling additional data volume partitions

1. To enable additional data volume partitions, add the following entry within `global.ini` using SAP HANA Studio or Cockpit in the SYSTEMDB configuration.

```
[customizable_functionalities]
persistence_datavolume_partition_multipath = true
```

Adding the parameter manually to the `global.ini` file requires the restart of the database.

Volume configuration for a single-host SAP HANA system

The layout of volumes for a single-host SAP HANA system with multiple partitions is like the layout for a system with one data volume partition, but with an additional data volume stored on a different aggregate as the log volume and the other data volume. The following table shows an example configuration of an SAP HANA single-host system with two data volume partitions.

Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller b
Data volume: SID_data_mnt00001	Shared volume: SID_shared	Data volume: SID_data2_mnt00001	Log volume: SID_log_mnt00001

The following table shows an example of the mount point configuration for a single-host system with two data volume partitions.

Junction path	Directory	Mount point at HANA host
SID_data_mnt00001	–	/hana/data/SID/mnt00001
SID_data2_mnt00001	–	/hana/data2/SID/mnt00001
SID_log_mnt00001	–	/hana/log/SID/mnt00001
SID_shared	usr-sap shared	/usr/sap/SID /hana/shared

Create the new data volume and mount it to the namespace using either ONTAP System Manager or the ONTAP cluster command line interface.

Volume configuration for multiple-host SAP HANA system

The layout of volumes for a multiple-host SAP HANA system with multiple partitions is like the layout for a system with one data volume partition, but with an additional data volume stored on a different aggregate as the log volume and the other data volume. The following table shows an example configuration of an SAP HANA multiple-host system with two data volume partitions.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	–	Log volume: SID_log_mnt00001	Data2 volume: SID_data2_mnt00001
Data and log volumes for node 2	Log volume: SID_log_mnt00002	Data2 volume: SID_data2_mnt00002	Data volume: SID_data_mnt00002	–
Data and log volumes for node 3	–	Data volume: SID_data_mnt00003	Data2 volume: SID_data2_mnt00003	Log volume: SID_log_mnt00003
Data and log volumes for node 4	Data2 volume: SID_data2_mnt00004	Log volume: SID_log_mnt00004	–	Data volume: SID_data_mnt00004
Shared volume for all hosts	Shared volume: SID_shared	–	–	–

The following table shows an example of the mount point configuration for a single-host system with two data volume partitions.

Junction path	Directory	Mount point at SAP HANA host	Note
SID_data_mnt00001	–	/hana/data/SID/mnt00001	Mounted at all hosts
SID_data2_mnt00001	–	/hana/data2/SID/mnt00001	Mounted at all hosts
SID_log_mnt00001	–	/hana/log/SID/mnt00001	Mounted at all hosts
SID_data_mnt00002	–	/hana/data/SID/mnt00002	Mounted at all hosts

Junction path	Directory	Mount point at SAP HANA host	Note
SID_data2_mnt00002	–	/hana/data2/SID/mnt00002	Mounted at all hosts
SID_log_mnt00002	–	/hana/log/SID/mnt00002	Mounted at all hosts
SID_data_mnt00003	–	/hana/data/SID/mnt00003	Mounted at all hosts
SID_data2_mnt00003	–	/hana/data2/SID/mnt00003	Mounted at all hosts
SID_log_mnt00003	–	/hana/log/SID/mnt00003	Mounted at all hosts
SID_data_mnt00004	–	/hana/data/SID/mnt00004	Mounted at all hosts
SID_data2_mnt00004	–	/hana/data2/SID/mnt00004	Mounted at all hosts
SID_log_mnt00004	–	/hana/log/SID/mnt00004	Mounted at all hosts
SID_shared	shared	/hana/shared/SID	Mounted at all hosts
SID_shared	usr-sap-host1	/usr/sap/SID	Mounted at host 1
SID_shared	usr-sap-host2	/usr/sap/SID	Mounted at host 2
SID_shared	usr-sap-host3	/usr/sap/SID	Mounted at host 3
SID_shared	usr-sap-host4	/usr/sap/SID	Mounted at host 4
SID_shared	usr-sap-host5	/usr/sap/SID	Mounted at host 5

Create the new data volume and mount it to the namespace using either ONTAP System Manager or the ONTAP cluster command line interface.

Host configuration

In addition to the tasks described in the section "Host setup," you must create the additional mount points and fstab entries for the new additional data volume(s), and you must mount the new volumes.

1. Create additional mount points:
   - For a single-host system, create mount points and set the permissions on the database host.

     ```
     sapcc-hana-tst-06:/ # mkdir -p /hana/data2/SID/mnt00001
     sapcc-hana-tst-06:/ # chmod –R 777 /hana/data2/SID
     ```

   - For a multiple-host system, create mount points and set the permissions on all worker and standby hosts. The following example commands are for a 2+1 multiple-host HANA system.
     - First worker host:

       ```
       sapcc-hana-tst-06:~ # mkdir -p /hana/data2/SID/mnt00001
       sapcc-hana-tst-06:~ # mkdir -p /hana/data2/SID/mnt00002
       sapcc-hana-tst-06:~ # chmod -R 777 /hana/data2/SID
       ```

- Second worker host:

```
sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00001
sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00002
sapcc-hana-tst-07:~ # chmod -R 777 /hana/data2/SID
```

- Standby host:

```
sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00001
sapcc-hana-tst-07:~ # mkdir -p /hana/data2/SID/mnt00002
sapcc-hana-tst-07:~ # chmod -R 777 /hana/data2/SID
```

2. Add the additional file systems to the `/etc/fstab` configuration file on all hosts. An example for a single-host system using NFSv4.1 is as follows:

```
<storage-vif-data02>:/SID_data2_mnt00001 /hana/data2/SID/mnt00001 nfs
rw,vers=4,
minorversion=1,hard,timeo=600,rsize=1048576,wsize=266144,bg,noatime,lock
0 0
```

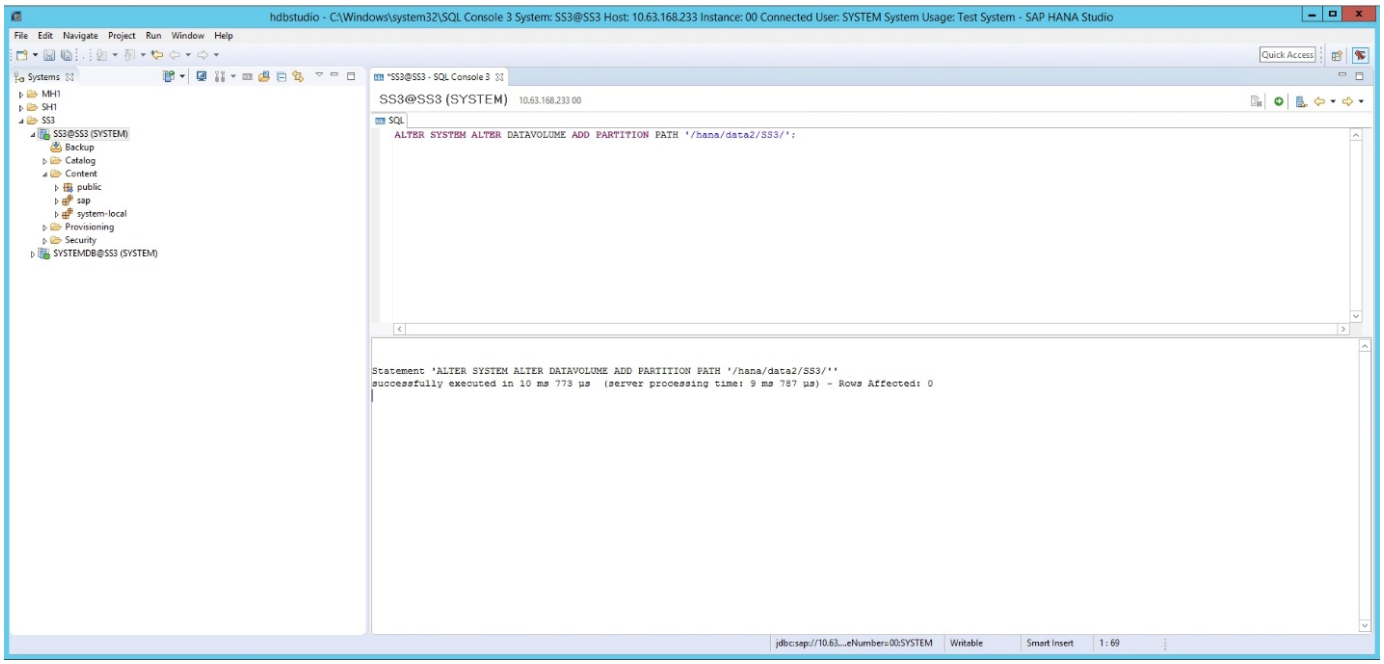
Use a different storage virtual interface for connecting to each data volume to make sure that different TCP sessions are used for each volume. You can also use the nconnect mount option if it is available for your OS.

3. To mount the file systems, run the `mount -a` command.

Adding an additional data volume partition

Execute the following SQL statement against the tenant database to add an additional data volume partition to your tenant database. Use the path to additional volume(s):

```
ALTER SYSTEM ALTER DATAVOLUME ADD PARTITION PATH '/hana/data2/SID/';
```



Where to find additional information

To learn more about the information described in this document, refer to the following documents and/or websites:

- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere www.vmware.com/files/pdf/SAP_HANA_on_vmware_vSphere_best_practices_guide.pdf
- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere www.vmware.com/files/pdf/sap-hana-scale-out-deployments-on-vsphere.pdf
- SAP Certified Enterprise Storage Hardware for SAP HANA https://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/enterprise-storage.html
- SAP HANA Storage Requirements http://go.sap.com/documents/2015/03/74cdb554-5a7c-0010-82c7-eda71af511fa.html
- SAP HANA Tailored Data Center Integration Frequently Asked Questions www.sap.com/documents/2016/05/e8705aae-717c-0010-82c7-eda71af511fa.html
- TR-4646: SAP HANA Disaster Recovery with Storage Replication www.netapp.com/us/media/tr-4646.pdf
- TR-4614: SAP HANA Backup and Recovery with SnapCenter www.netapp.com/us/media/tr-4614.pdf
- TR-4338: SAP HANA on VMware vSphere with NetApp FAS and AFF Systems www.netapp.com/us/media/tr-4338.pdf
- TR-4667: Automating SAP System Copies Using the SnapCenter 4.0 SAP HANA Plug-In www.netapp.com/us/media/tr-4667.pdf
- NetApp Documentation Centers https://www.netapp.com/us/documentation/index.aspx
- NetApp FAS Storage System Resources https://mysupport.netapp.com/info/web/ECMLP2676498.html
- SAP HANA Software Solutions www.netapp.com/us/solutions/applications/sap/index.aspx#sap-hana

SAP HANA on FAS Systems with FCP Configuration Guide

TR-4384: SAP HANA on NetApp FAS Systems with Fibre Channel Protocol Configuration Guide

Nils Bauer and Marco Schoen, NetApp

The NetApp FAS product family has been certified for use with SAP HANA in TDI projects. The certified enterprise storage platform is characterized by the NetApp ONTAP operating system.

The certification is valid for the following models:

- FAS2720, FAS2750, FAS8200, FAS8300, FAS8700, FAS9000, FAS9500

For a complete list of NetApp's certified storage solutions for SAP HANA, see the certified and supported SAP HANA hardware directory.

This document describes FAS configurations that use the Fibre Channel Protocol (FCP).

> The configuration described in this paper is necessary to achieve the required SAP HANA KPIs and the best performance for SAP HANA. Changing any settings or using features not listed herein might result in performance degradation or unexpected behavior and should only be done if advised by NetApp support.

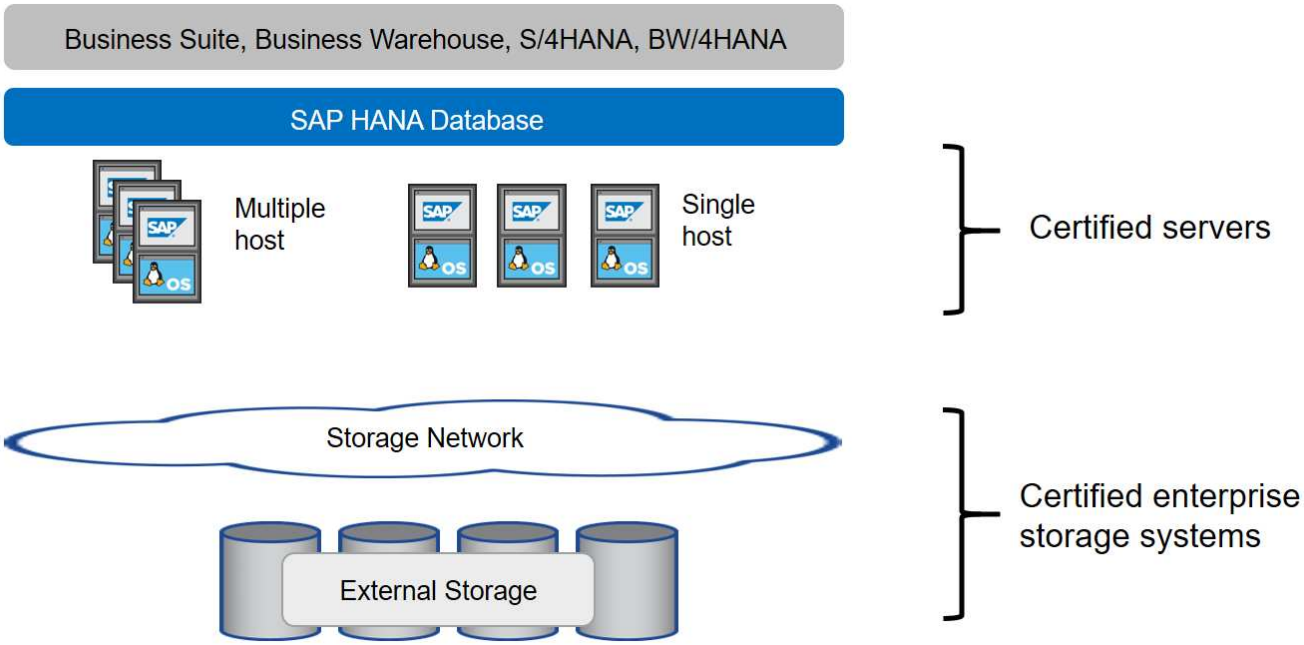
The configuration guides for FAS systems using NFS and NetApp AFF systems can be found using the following links:

- SAP HANA on NetApp AFF Systems with Fibre Channel Protocol
- SAP HANA on NetApp FAS Systems with NFS
- SAP HANA on NetApp AFF Systems with NFS

In an SAP HANA multiple-host environment, the standard SAP HANA storage connector is used to provide fencing in the event of an SAP HANA host failover. Refer to the relevant SAP notes for operating system configuration guidelines and HANA-specific Linux kernel dependencies. For more information, see SAP Note 2235581 – SAP HANA Supported Operating Systems.

SAP HANA tailored data center integration

NetApp FAS storage controllers are certified in the SAP HANA Tailored Data Center Integration (TDI) program using NFS (NAS) and Fibre Channel (SAN) protocols. They can be deployed in any SAP HANA scenario, such as, SAP Business Suite on HANA, S/4HANA, BW/4HANA or SAP Business Warehouse on HANA in single-host or multiple-host configurations. Any server that is certified for use with SAP HANA can be combined with the certified storage solution. See the following figure for an architecture overview.



For more information regarding the prerequisites and recommendations for productive SAP HANA systems, see the following resource:

- SAP HANA Tailored Data Center Integration Frequently Asked Questions

SAP HANA using VMware vSphere

There are several options for connecting storage to virtual machines (VMs). The preferred one is to connect the storage volumes with NFS directly out of the guest operating system. This option is described in SAP HANA on NetApp AFF Systems with NFS.

Raw device mappings (RDM), FCP datastores, or VVOL datastores with FCP are supported as well. For both datastore options, only one SAP HANA data or log volume must be stored within the datastore for productive use cases. In addition, Snapshot- based backup and recovery orchestrated by SnapCenter and solutions based on this, such as SAP System cloning, cannot be implemented.

For more information about using vSphere with SAP HANA, see the following links:

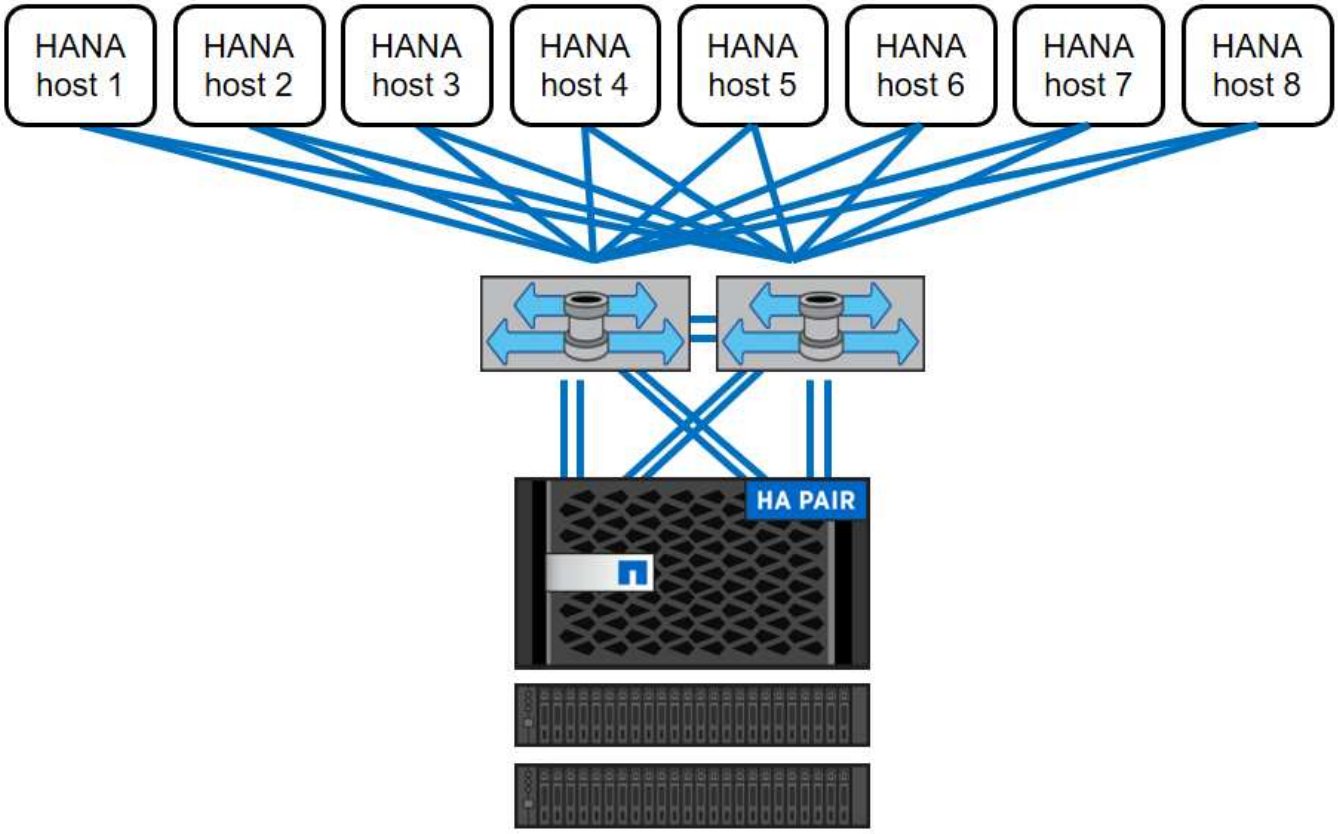
- SAP HANA on VMware vSphere - Virtualization - Community Wiki
- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere
- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere
- 2161991 - VMware vSphere configuration guidelines - SAP ONE Support Launchpad (Login required)

Architecture

SAP HANA hosts are connected to the storage controllers using a redundant FCP infrastructure and multipath software. A redundant FCP switch infrastructure is required to provide fault-tolerant SAP HANA host-to-storage connectivity in case of switch or host bus adapter (HBA) failure. Appropriate zoning must be configured at the switch to allow all HANA hosts to reach the required LUNs on the storage controllers.

Different models of the FAS product family can be used at the storage layer. The maximum number of SAP HANA hosts attached to the storage is defined by the SAP HANA performance requirements. The number of disk shelves required is determined by the capacity and performance requirements of the SAP HANA systems.

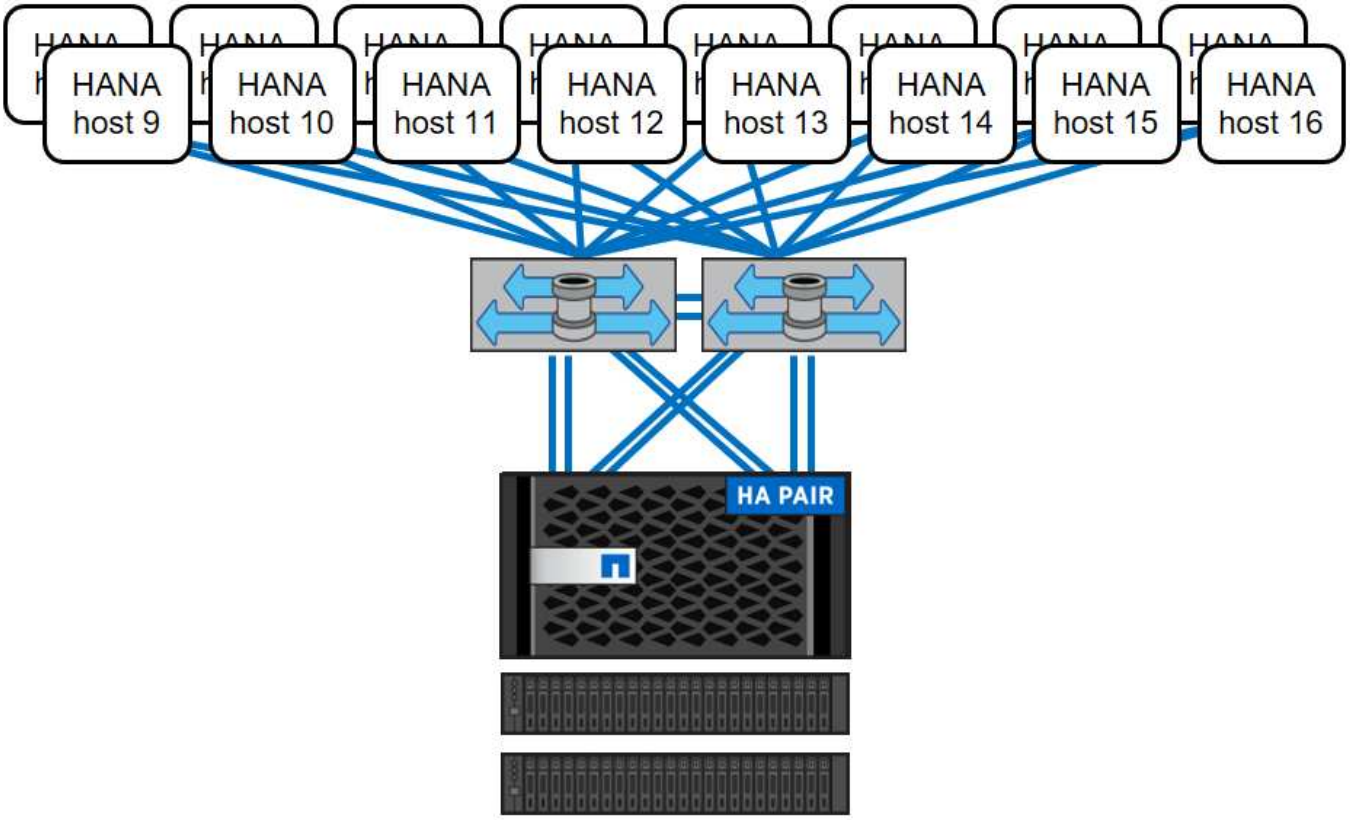
The following figure shows an example configuration with eight SAP HANA hosts attached to a storage HA pair.



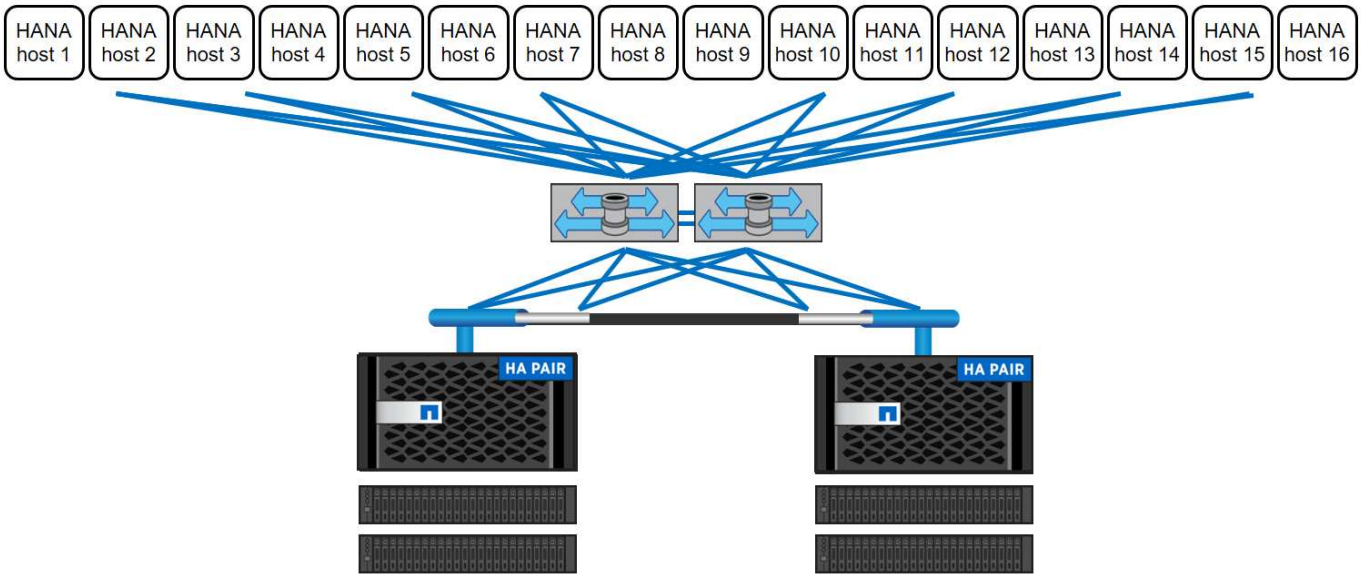
This architecture can be scaled in two dimensions:

- By attaching additional SAP HANA hosts and disk capacity to the storage, assuming that the storage controllers can provide enough performance under the new load to meet key performance indicators (KPIs)
- By adding more storage systems and disk capacity for the additional SAP HANA hosts

The following figure shows a configuration example in which more SAP HANA hosts are attached to the storage controllers. In this example, more disk shelves are necessary to meet the capacity and performance requirements of the 16 SAP HANA hosts. Depending on the total throughput requirements, you must add additional FC connections to the storage controllers.



Independent of the deployed FAS system storage model, the SAP HANA landscape can also be scaled by adding more storage controllers, as shown in the following figure.



SAP HANA backup

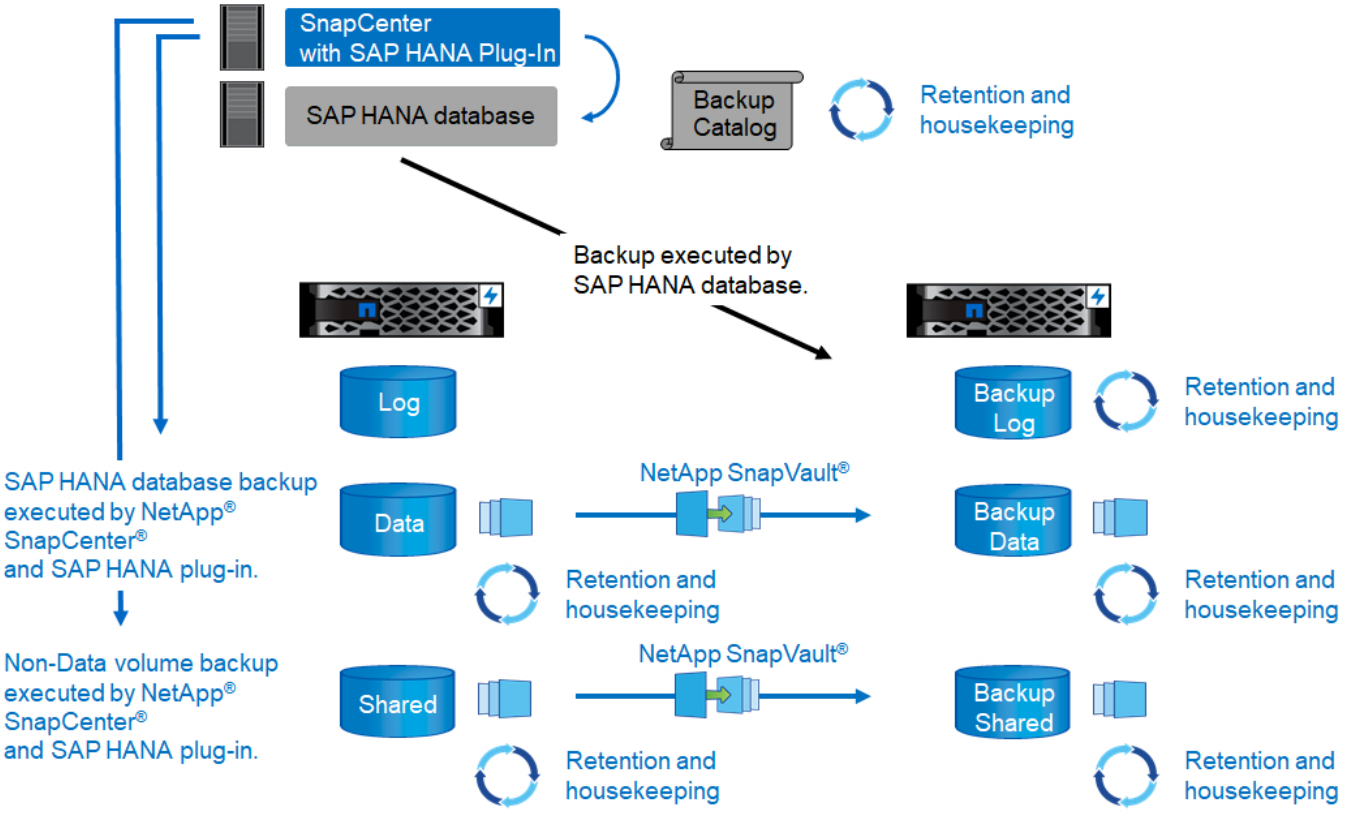
NetApp ONTAP software provides a built-in mechanism to back up SAP HANA databases. Storage-based Snapshot backup is a fully supported and integrated backup solution available for SAP HANA single-container systems and for SAP HANA MDC single- tenant systems.

Storage-based Snapshot backups are implemented by using the NetApp SnapCenter plug-in for SAP HANA,

which enables consistent storage-based Snapshot backups by using the interfaces provided by the SAP HANA database. SnapCenter registers the Snapshot backups in the SAP HANA backup catalog so that the backups are visible within the SAP HANA studio and can be selected for restore and recovery operations.

By using NetApp SnapVault software, the Snapshot copies that were created on the primary storage can be replicated to the secondary backup storage controlled by SnapCenter. Different backup retention policies can be defined for backups on the primary storage and for backups on the secondary storage. The SnapCenter Plug-in for SAP HANA Database manages the retention of Snapshot copy-based data backups and log backups including the housekeeping of the backup catalog. The SnapCenter Plug-in for SAP HANA Database also enables the execution of a block-integrity check of the SAP HANA database by performing a file-based backup.

The database logs can be backed up directly to the secondary storage by using an NFS mount, as shown in the following figure.



Storage-based Snapshot backups provide significant advantages compared to file-based backups. Those advantages include the following:

- Faster backup (few minutes)
- Faster restore on the storage layer (a few minutes)
- No effect on the performance of the SAP HANA database host, network, or storage during backup
- Space-efficient and bandwidth-efficient replication to secondary storage based on block changes

For detailed information about the SAP HANA backup and recovery solution using SnapCenter, see TR-4614: SAP HANA Backup and Recovery with SnapCenter.

SAP HANA disaster recovery

SAP HANA disaster recovery can be performed on the database layer by using SAP system replication or on the storage layer by using storage-replication technologies. The following section provides an overview of disaster recovery solutions based on storage replication.

For detailed information about the SAP HANA disaster recovery solution using SnapCenter, see TR-4646: SAP HANA Disaster Recovery with Storage Replication.

Storage replication based on SnapMirror

The following figure shows a three-site disaster recovery solution, using synchronous SnapMirror replication to the local DR datacenter and asynchronous SnapMirror to replicate data to the remote DR datacenter.

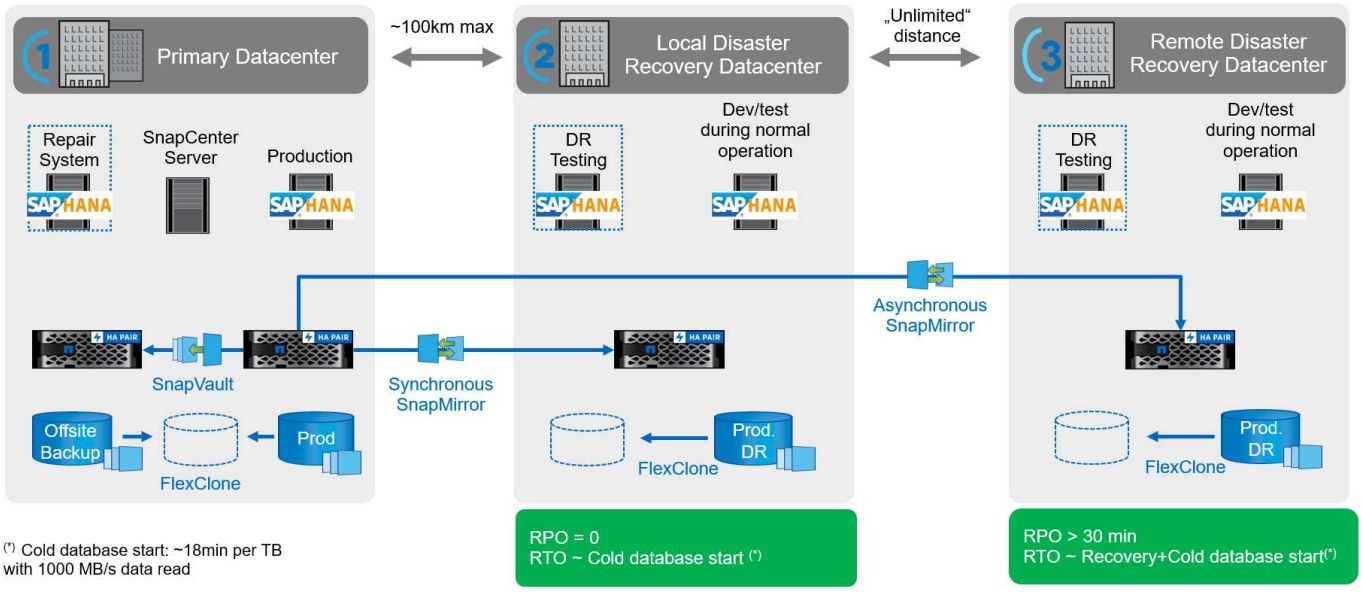
Data replication using synchronous SnapMirror provides an RPO of zero. The distance between the primary and the local DR datacenter is limited to around 100km.

Protection against failures of both the primary and the local DR site is performed by replicating the data to a third remote DR datacenter using asynchronous SnapMirror. The RPO depends on the frequency of replication updates and how fast they can be transferred. In theory, the distance is unlimited, but the limit depends on the amount of data that must be transferred and the connection that is available between the data centers. Typical RPO values are in the range of 30 minutes to multiple hours.

The RTO for both replication methods primarily depends on the time needed to start the HANA database at the DR site and load the data into memory. With the assumption that the data is read with a throughput of 1000MBps, loading 1TB of data would take approximately 18 minutes.

The servers at the DR sites can be used as dev/test systems during normal operation. In the case of a disaster, the dev/test systems would need to be shut down and started as DR production servers.

Both replication methods allow to you execute DR workflow testing without influencing the RPO and RTO. FlexClone volumes are created on the storage and are attached to the DR testing servers.

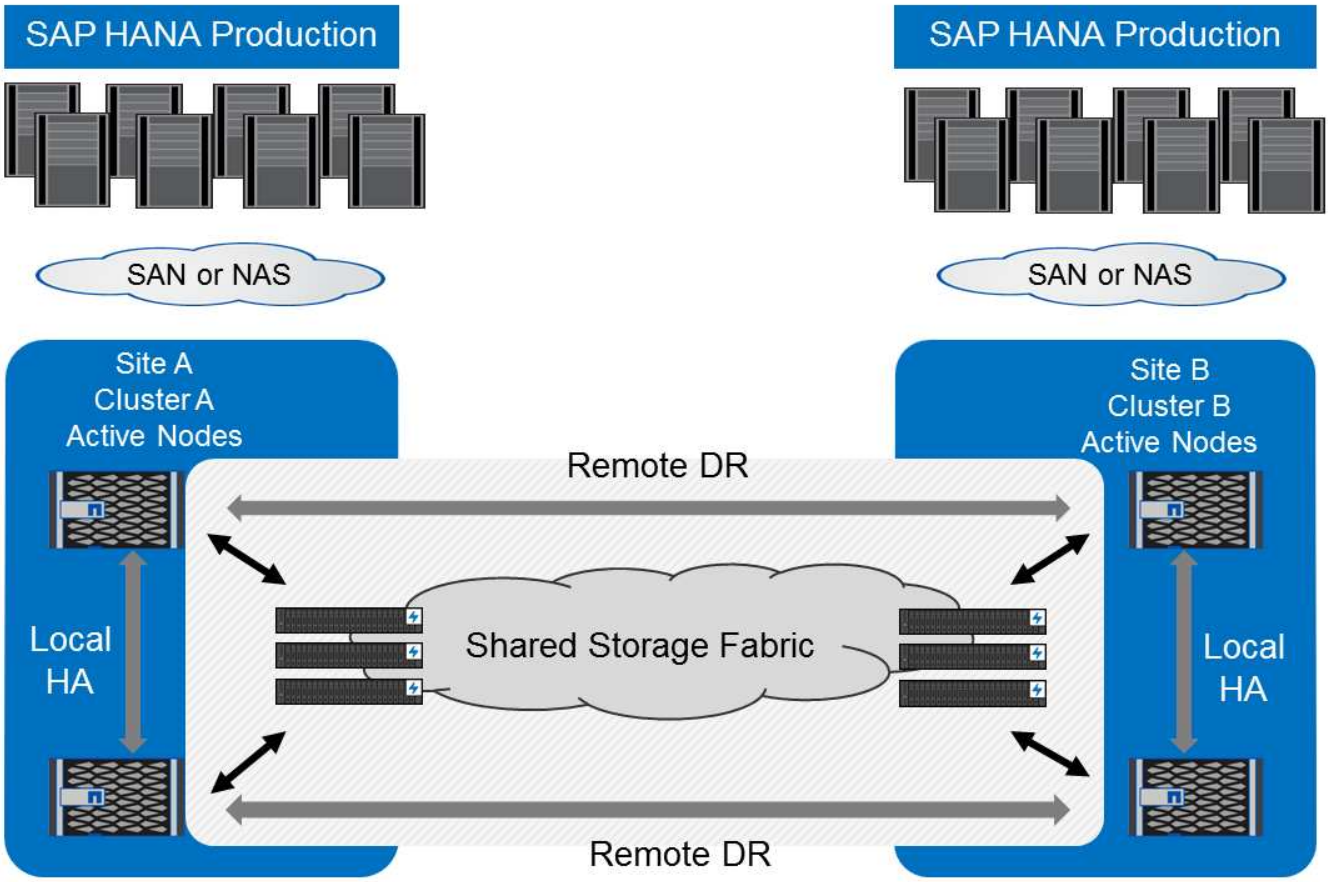


Synchronous replication offers StrictSync mode. If the write to secondary storage is not completed for any reason, the application I/O fails, thereby ensuring that the primary and secondary storage systems are identical. Application I/O to the primary resumes only after the SnapMirror relationship returns to the InSync status. If the primary storage fails, application I/O can be resumed on the secondary storage after failover with

no loss of data. In StrictSync mode, the RPO is always zero.

Storage replication based on NetApp MetroCluster

The following figure shows a high-level overview of the solution. The storage cluster at each site provides local high availability and is used for production workloads. The data at each site is synchronously replicated to the other location and is available in case of disaster failover.



Storage sizing

The following section provides an overview of performance and capacity considerations for sizing a storage system for SAP HANA.

Contact your NetApp or NetApp partner sales representative to support the storage sizing process and to create a properly sized storage environment.

Performance considerations

SAP has defined a static set of storage KPIs. These KPIs are valid for all production SAP HANA environments independent of the memory size of the database hosts and the applications that use the SAP HANA database. These KPIs are valid for single-host, multiple-host, Business Suite on HANA, Business Warehouse on HANA, S/4HANA, and BW/4HANA environments. Therefore, the current performance sizing approach depends on only the number of active SAP HANA hosts that are attached to the storage system.

Storage performance KPIs are required only for production SAP HANA systems.

SAP delivers a performance test tool, which must be used to validate the storage performance for active SAP HANA hosts attached to the storage.

NetApp tested and predefined the maximum number of SAP HANA hosts that can be attached to a specific storage model, while still fulfilling the required storage KPIs from SAP for production-based SAP HANA systems.

> The storage controllers of the certified FAS product family can also be used for SAP HANA with other disk types or disk back-end solutions, as long as they are supported by NetApp and fulfill SAP HANA TDI performance KPIs. Examples include NetApp Storage Encryption (NSE) and NetApp FlexArray technology.

This document describes disk sizing for SAS hard disk drives and solid-state drives.

Hard disk drives

A minimum of 10 data disks (10k RPM SAS) per SAP HANA node is required to fulfill the storage performance KPIs from SAP.

> This calculation is independent of the storage controller and disk shelf used.

Solid-state drives

With solid-state drives (SSDs), the number of data disks is determined by the SAS connection throughput from the storage controllers to the SSD shelf.

The maximum number of SAP HANA hosts that can be run on a disk shelf and the minimum number of SSDs required per SAP HANA host were determined by running the SAP performance test tool.

- The 12Gb SAS disk shelf (DS224C) with 24 SSDs supports up to 14 SAP HANA hosts, when the disk shelf is connected with 12Gb.
- The 6Gb SAS disk shelf (DS2246) with 24 SSDs supports up to 4 SAP HANA hosts.

The SSDs and the SAP HANA hosts must be equally distributed between both storage controllers.

The following table summarizes the supported number of SAP HANA hosts per disk shelf.

	6Gb SAS shelves (DS2246) fully loaded with 24 SSDs	12Gb SAS shelves (DS224C) fully loaded with 24 SSDs
Maximum number of SAP HANA hosts per disk shelf	4	14

> This calculation is independent of the storage controller used. Adding more disk shelves does not increase the maximum number of SAP HANA hosts that a storage controller can support.

Mixed workloads

SAP HANA and other application workloads running on the same storage controller or in the same storage aggregate are supported. However, it is a NetApp best practice to separate SAP HANA workloads from all other application workloads.

You might decide to deploy SAP HANA workloads and other application workloads on either the same storage

controller or the same aggregate. If so, you must make sure that enough performance is always available for SAP HANA within the mixed workload environment. NetApp also recommends that you use quality of service (QoS) parameters to regulate the impact these other applications could have on SAP HANA applications.

The SAP HCMT test tool must be used to check if additional SAP HANA hosts can be run on a storage controller that is already used for other workloads. However, SAP application servers can be safely placed on the same storage controller and aggregate as the SAP HANA databases.

Capacity considerations

A detailed description of the capacity requirements for SAP HANA is in the SAP Note 1900823 white paper.

> The capacity sizing of the overall SAP landscape with multiple SAP HANA systems must be determined by using SAP HANA storage sizing tools from NetApp. Contact NetApp or your NetApp partner sales representative to validate the storage sizing process for a properly sized storage environment.

Configuration of performance test tool

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage system used. These parameters must also be set for the performance test tool from SAP (fsperf) when the storage performance is tested by using the SAP test tool.

Performance tests were conducted by NetApp to define the optimal values. The following table lists the parameters that must be set within the configuration file of the SAP test tool.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For more information about the configuration of SAP test tool, see SAP note 1943937 for HWCCT (SAP HANA 1.0) and SAP note 2493172 for HCMT/HCOT (SAP HANA 2.0).

The following example shows how variables can be set for the HCMT/HCOT execution plan.

```
…{
          "Comment": "Log Volume: Controls whether read requests are
submitted asynchronously, default is 'on'",
          "Name": "LogAsyncReadSubmit",
          "Value": "on",
          "Request": "false"
       },
       {
          "Comment": "Data Volume: Controls whether read requests are
submitted asynchronously, default is 'on'",
          "Name": "DataAsyncReadSubmit",
```

```
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "LogAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls whether write requests can be
submitted asynchronously",
         "Name": "DataAsyncWriteSubmitActive",
         "Value": "on",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "LogAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Controls which blocks are written
asynchronously. Only relevant if AsyncWriteSubmitActive is 'on' or 'auto'
and file system is flagged as requiring asynchronous write submits",
         "Name": "DataAsyncWriteSubmitBlocks",
         "Value": "all",
         "Request": "false"
      },
      {
         "Comment": "Log Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "LogExtMaxParallelIoRequests",
         "Value": "128",
         "Request": "false"
      },
      {
         "Comment": "Data Volume: Maximum number of parallel I/O requests
per completion queue",
         "Name": "DataExtMaxParallelIoRequests",
         "Value": "128",
         "Request": "false"
```

```
        }, …
```

These variables must be used for the test configuration. This is usually the case with the predefined execution plans SAP delivers with the HCMT/HCOT tool. The following example for a 4k log write test is from an execution plan.

```
…
      {
         "ID": "D664D001-933D-41DE-A904F304AEB67906",
         "Note": "File System Write Test",
         "ExecutionVariants": [
            {
               "ScaleOut": {
                  "Port": "${RemotePort}",
                  "Hosts": "${Hosts}",
                  "ConcurrentExecution": "${FSConcurrentExecution}"
               },
               "RepeatCount": "${TestRepeatCount}",
               "Description": "4K Block, Log Volume 5GB, Overwrite",
               "Hint": "Log",
               "InputVector": {
                  "BlockSize": 4096,
                  "DirectoryName": "${LogVolume}",
                  "FileOverwrite": true,
                  "FileSize": 5368709120,
                  "RandomAccess": false,
                  "RandomData": true,
                  "AsyncReadSubmit": "${LogAsyncReadSubmit}",
                  "AsyncWriteSubmitActive":
"${LogAsyncWriteSubmitActive}",
                  "AsyncWriteSubmitBlocks":
"${LogAsyncWriteSubmitBlocks}",
                  "ExtMaxParallelIoRequests":
"${LogExtMaxParallelIoRequests}",
                  "ExtMaxSubmitBatchSize": "${LogExtMaxSubmitBatchSize}",
                  "ExtMinSubmitBatchSize": "${LogExtMinSubmitBatchSize}",
                  "ExtNumCompletionQueues":
"${LogExtNumCompletionQueues}",
                  "ExtNumSubmitQueues": "${LogExtNumSubmitQueues}",
                  "ExtSizeKernelIoQueue": "${ExtSizeKernelIoQueue}"
               }
            }, …
```

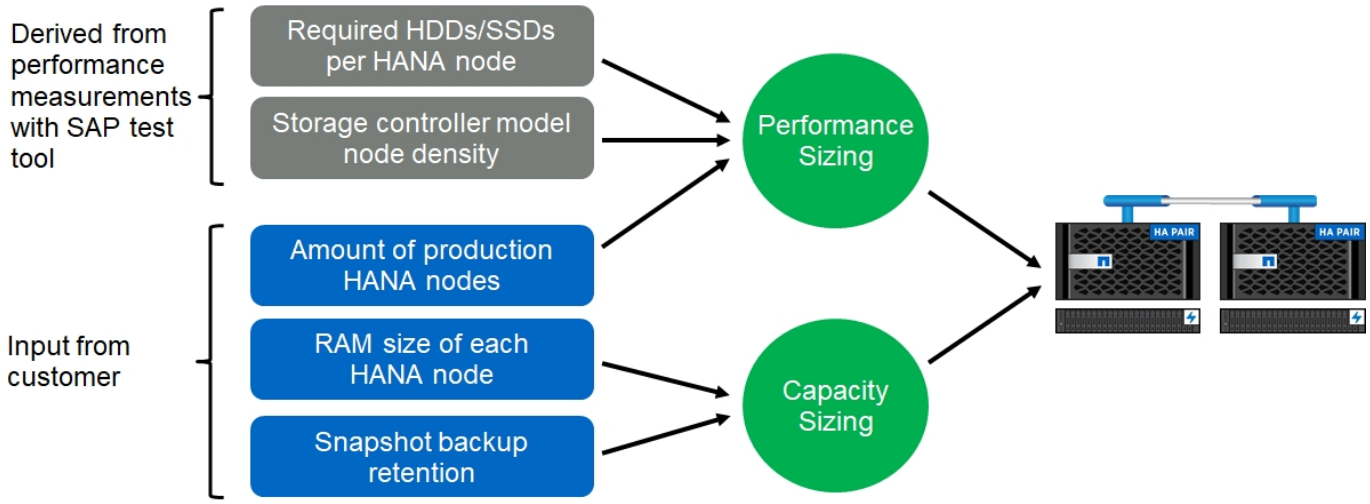
Storage sizing process overview

The number of disks per HANA host and the SAP HANA host density for each storage model were determined with the SAP HANA test tool.

The sizing process requires details such as the number of production and nonproduction SAP HANA hosts, the RAM size of each host, and the backup retention period of the storage-based Snapshot copies. The number of SAP HANA hosts determines the storage controller and the number of disks required.

The size of the RAM, the net data size on the disk of each SAP HANA host, and the Snapshot copy backup retention period are used as inputs during capacity sizing.

The following figure summarizes the sizing process.



Infrastructure setup and configuration

Overview

The following sections provide SAP HANA infrastructure setup and configuration guidelines. All the steps needed to set up SAP HANA are included. An SVM is created to host the data. Within these sections, the following example configurations are used:

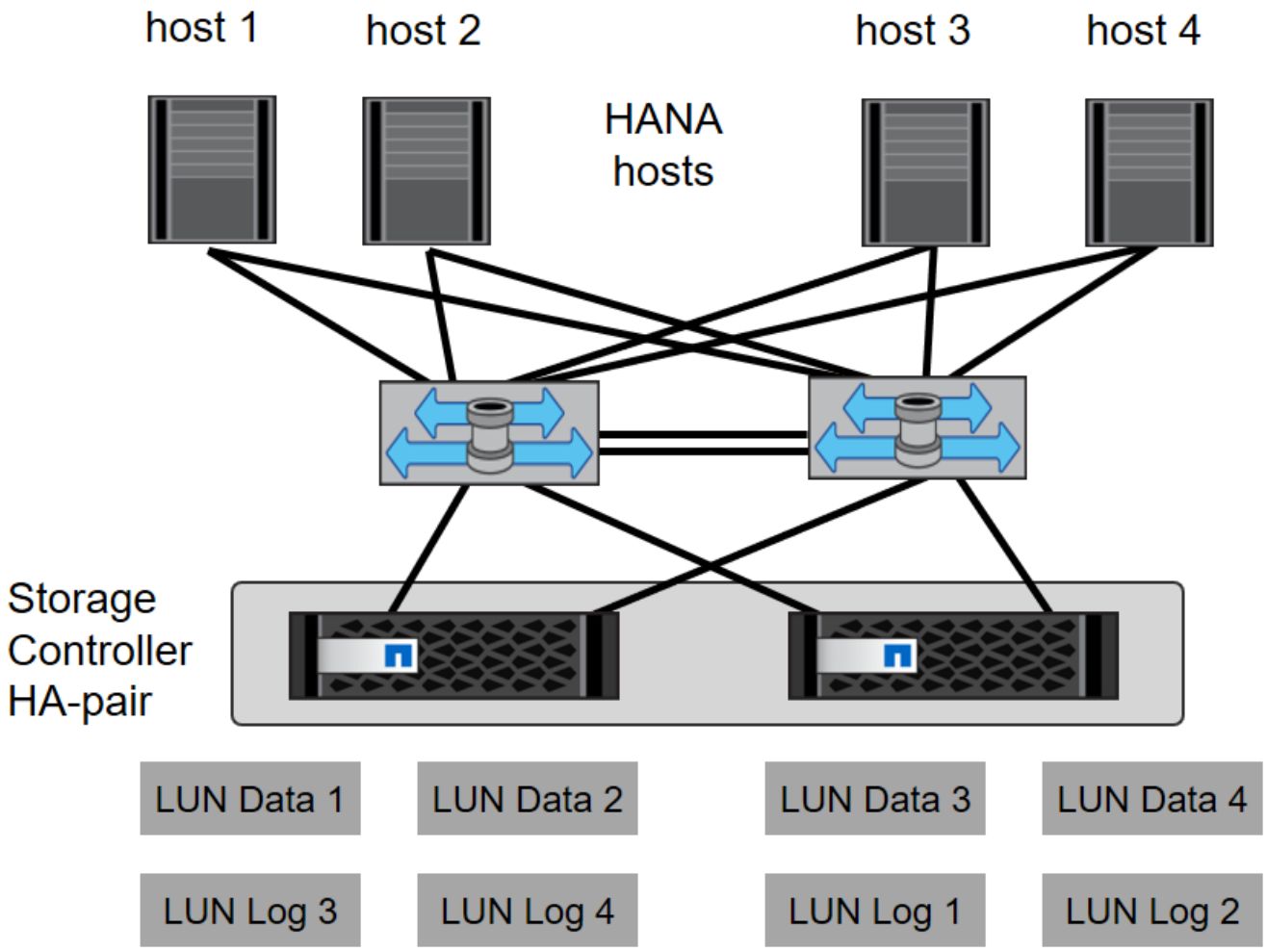
- HANA system with SID=SS3 and ONTAP 9.7 or earlier
  - SAP HANA single and multiple host
  - SAP HANA single host using SAP HANA multiple partitions
- HANA system with SID=FC5 and ONTAP 9.8 using Linux logical volume manager (LVM)
  - SAP HANA single and multiple host

SAN fabric setup

Each SAP HANA server must have a redundant FCP SAN connection with a minimum of 8Gbps bandwidth. For each SAP HANA host attached to a storage controller, at least 8Gbps of bandwidth must be configured at the storage controller.

The following figure shows an example with four SAP HANA hosts attached to two storage controllers. Each SAP HANA host has two FCP ports connected to the redundant fabric. At the storage layer, four FCP ports are

configured to provide the required throughput for each SAP HANA host.



In addition to the zoning on the switch layer, you must map each LUN on the storage system to the hosts that connect to this LUN. Keep the zoning on the switch simple; that is, define one zone set in which all host HBAs can see all controller HBAs.

Time synchronization

You must synchronize the time between the storage controllers and the SAP HANA database hosts. The same time server must be set for all storage controllers and all SAP HANA hosts.

Storage controller setup

This section describes the configuration of the NetApp storage system. You must complete the primary installation and setup according to the corresponding ONTAP setup and configuration guides.

Storage efficiency

Inline deduplication, cross- volume inline deduplication, inline compression, and inline compaction are supported with SAP HANA in an SSD configuration.

Enabling the storage efficiency features in an HDD configuration is not supported.

NetApp Volume and Aggregate Encryption

The use of NetApp Volume Encryption (NVE) and NetApp Aggregate Encryption (NAE) are supported with SAP HANA.

Quality of service

QoS can be used to limit the storage throughput for specific SAP HANA systems. One use case would be to limit the throughput of development and test systems so that they cannot influence production systems in a mixed setup.

During the sizing process, the performance requirements of a nonproduction system must be determined. Development and test systems can be sized with lower performance values, typically in the range of 20% to 50% of a production system.

Starting with ONTAP 9, QoS is configured on the storage volume level and uses maximum values for throughput (MBps) and number of I/O (IOPS).

Large write I/O has the biggest performance effect on the storage system. Therefore, the QoS throughput limit should be set to a percentage of the corresponding write SAP HANA storage performance KPI values in the data and log volumes.

NetApp FabricPool

NetApp FabricPool technology must not be used for active primary file systems in SAP HANA systems. This includes the file systems for the data and log area as well as the `/hana/shared` file system. Doing so results in unpredictable performance, especially during the startup of an SAP HANA system.

Using the “snapshot-only” tiering policy is possible as well as using FabricPool in general at a backup target such as SnapVault or SnapMirror destination.

Using FabricPool for tiering Snapshot copies at primary storage or using FabricPool at a backup target changes the required time for the restore and recovery of a database or other tasks such as creating system clones or repair systems. Take this into consideration for planning your overall lifecycle- management strategy, and check to make sure that your SLAs are still being met while using this function.

FabricPool is a good option for moving log backups to another storage tier. Moving backups affects the time needed to recover an SAP HANA database. Therefore, the option “tiering-minimum-cooling-days” should be set to a value that places log backups, which are routinely needed for recovery, on the local fast storage tier.

Configure storage

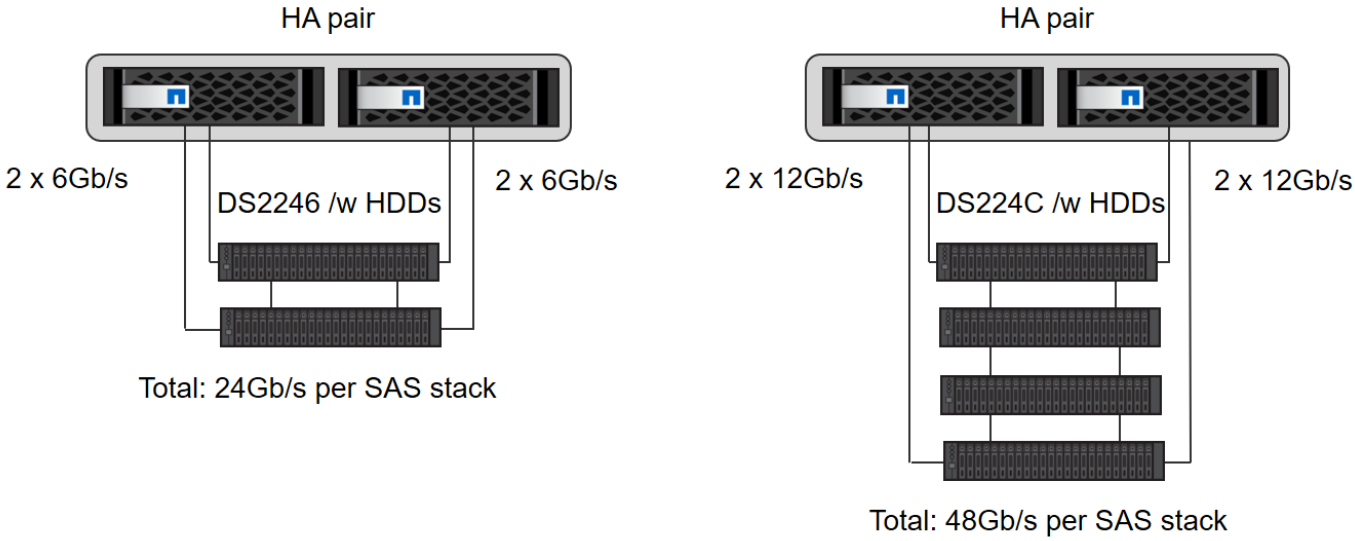
The following overview summarizes the required storage configuration steps. Each step is covered in more detail in the subsequent sections. Before initiating these steps, complete the storage hardware setup, the ONTAP software installation, and the connection of the storage FCP ports to the SAN fabric.

1. Check the correct SAS stack configuration, as described in the section Disk shelf connection.
2. Create and configure the required aggregates, as described in the section Aggregate configuration.
3. Create a storage virtual machine (SVM) as described in the section Storage virtual machine configuration.
4. Create logical interfaces (LIFs) as described in the section Logical interface configuration.

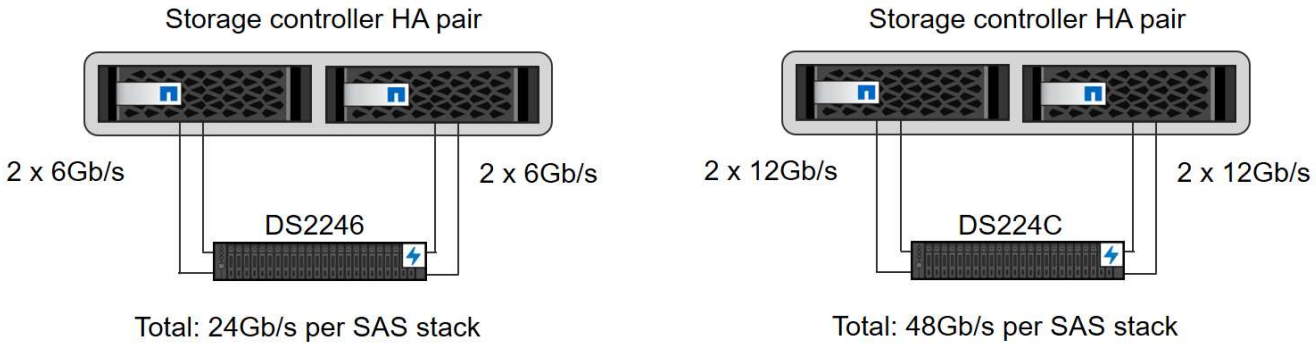
5. Create FCP port sets as described in the section FCP port sets.
6. Create initiator groups (igroups) with worldwide names (WWNs) of HANA servers as described in the section Initiator groups.
7. Create volumes and LUNs within the aggregates as described in the section Volume and LUN configuration for SAP HANA single-host systems and Volume and LUN configuration for SAP HANA multiple-host systems.

Disk shelf connection

With HDDs, a maximum of two DS2246 disk shelves or four DS224C disk shelves can be connected to one SAS stack to provide the required performance for the SAP HANA hosts, as shown in the following figure. The disks within each shelf must be distributed equally to both controllers of the HA pair.



With SSDs, a maximum of one disk shelf can be connected to one SAS stack to provide the required performance for the SAP HANA hosts, as shown in the following figure. The disks within each shelf must be distributed equally to both controllers of the HA pair. With the DS224C disk shelf, quad-path SAS cabling can also be used but is not required.

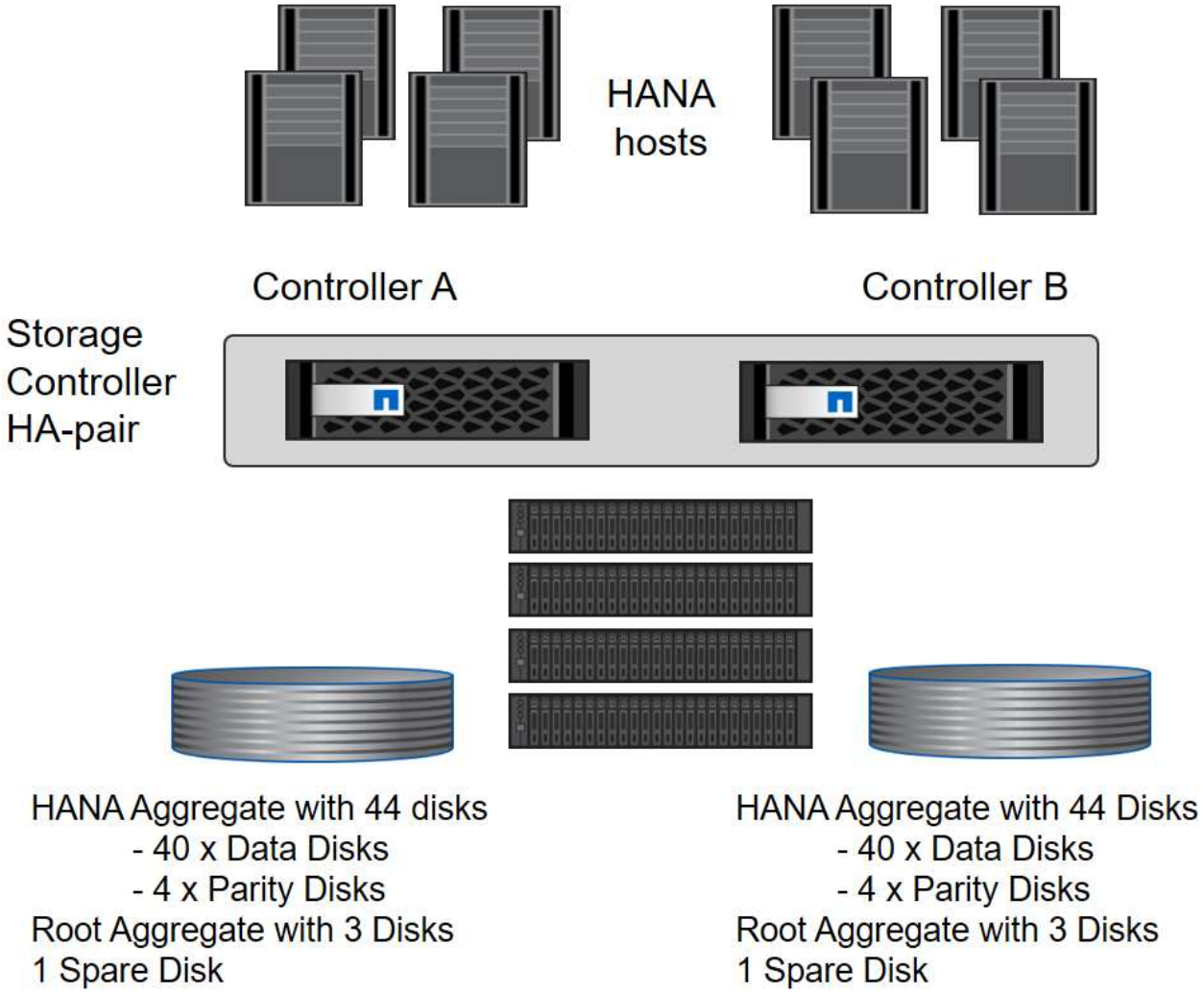


Aggregate configuration

In general, you must configure two aggregates per controller, independent of which disk shelf or disk technology (SSD or HDD) is used. This step is necessary so that you can use all available controller resources. For FAS 2000 series systems, one data aggregate is sufficient.

Aggregate configuration with HDDs

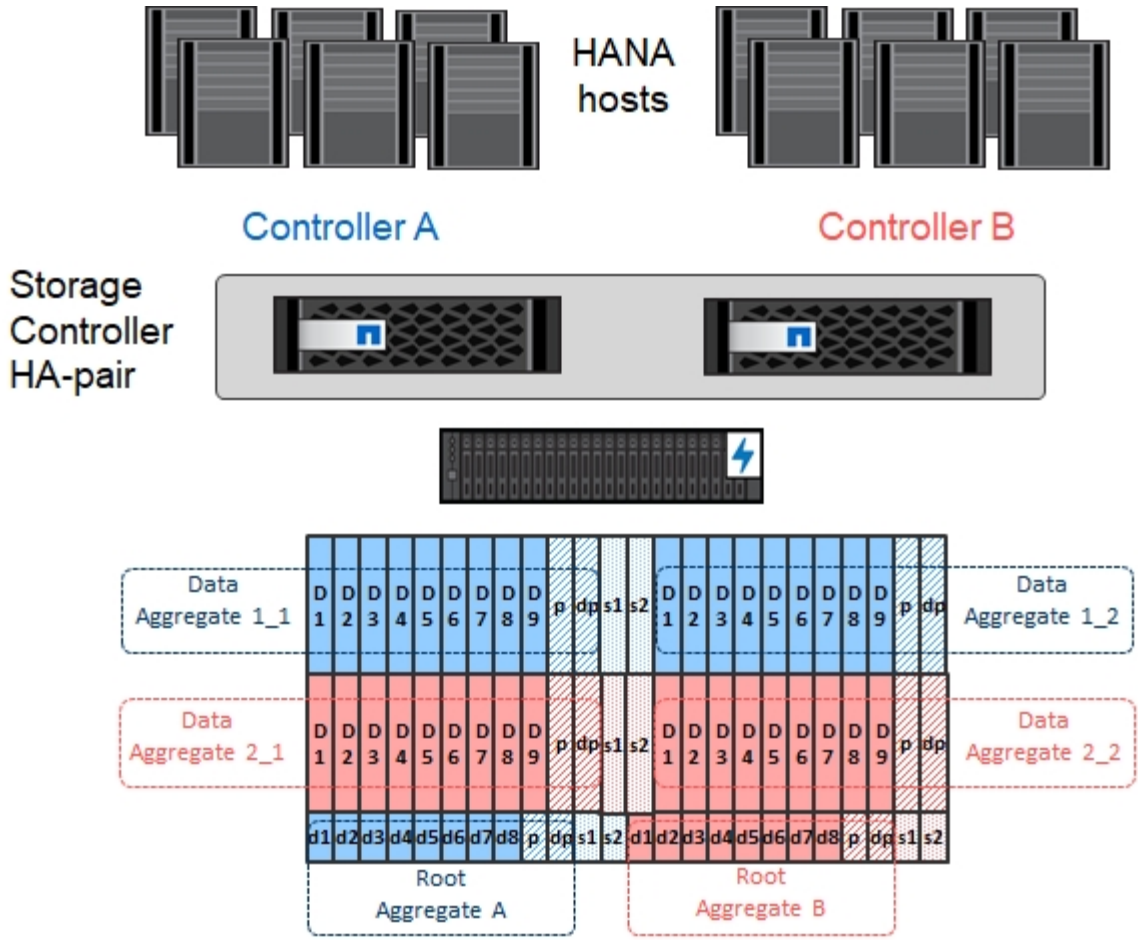
The following figure shows a configuration for eight SAP HANA hosts. Four SAP HANA hosts are attached to each storage controller. Two separate aggregates, one at each storage controller, are configured. Each aggregate is configured with 4 × 10 = 40 data disks (HDDs).



Aggregate configuration with SDD-only systems

In general, two aggregates per controller must be configured, independently of which disk shelf or disk technology (SSDs or HDDs) is used. For FAS2000 series systems, one data aggregate is sufficient.

The following figure shows a configuration of 12 SAP HANA hosts running on a 12Gb SAS shelf configured with ADPv2. Six SAP HANA hosts are attached to each storage controller. Four separate aggregates, two at each storage controller, are configured. Each aggregate is configured with 11 disks with nine data and two parity disk partitions. For each controller, two spare partitions are available.

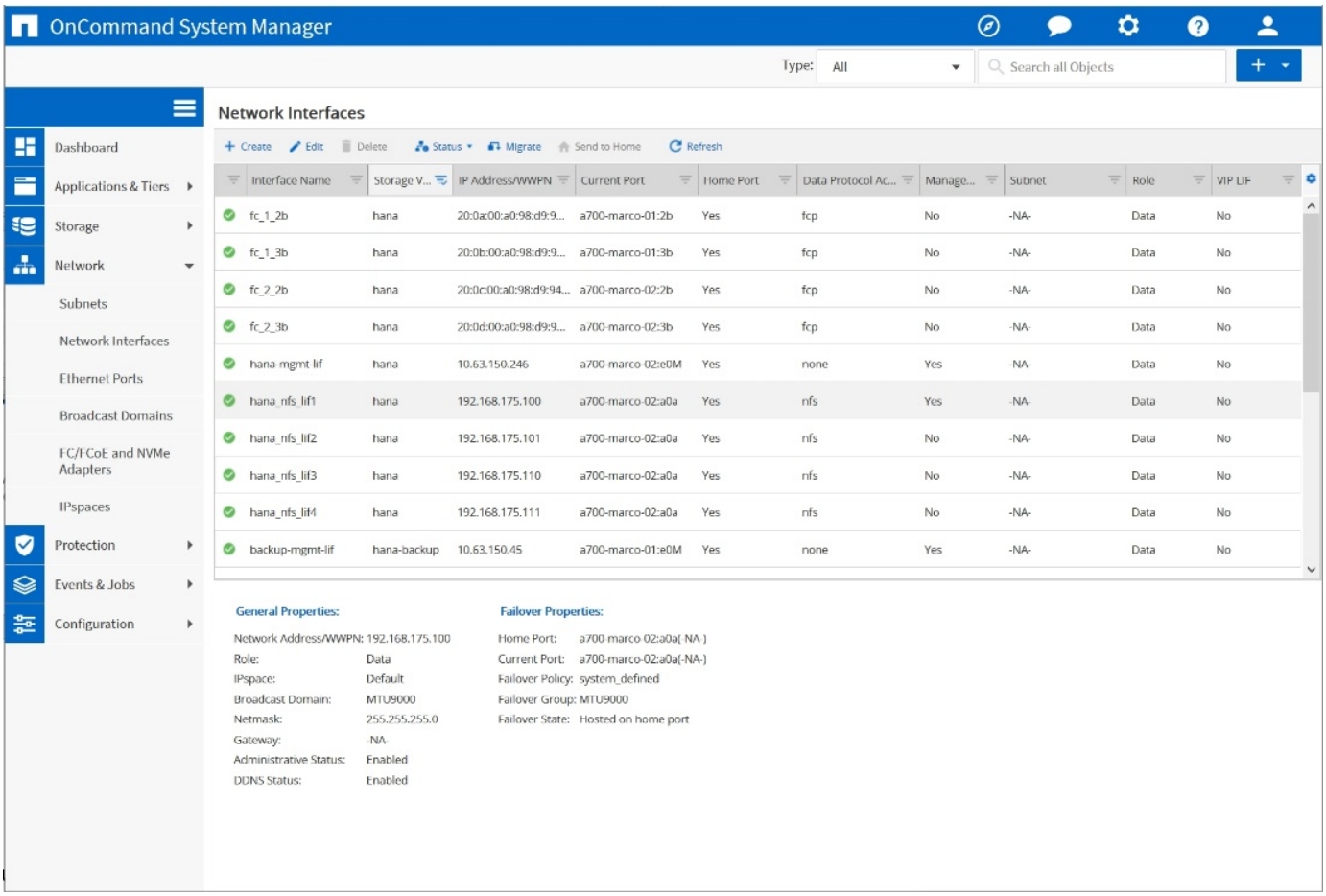


Storage virtual machine configuration

Multiple-host SAP landscapes with SAP HANA databases can use a single SVM. An SVM can also be assigned to each SAP landscape if necessary in case they are managed by different teams within a company. The screenshots and command outputs in this document use an SVM named `hana`.

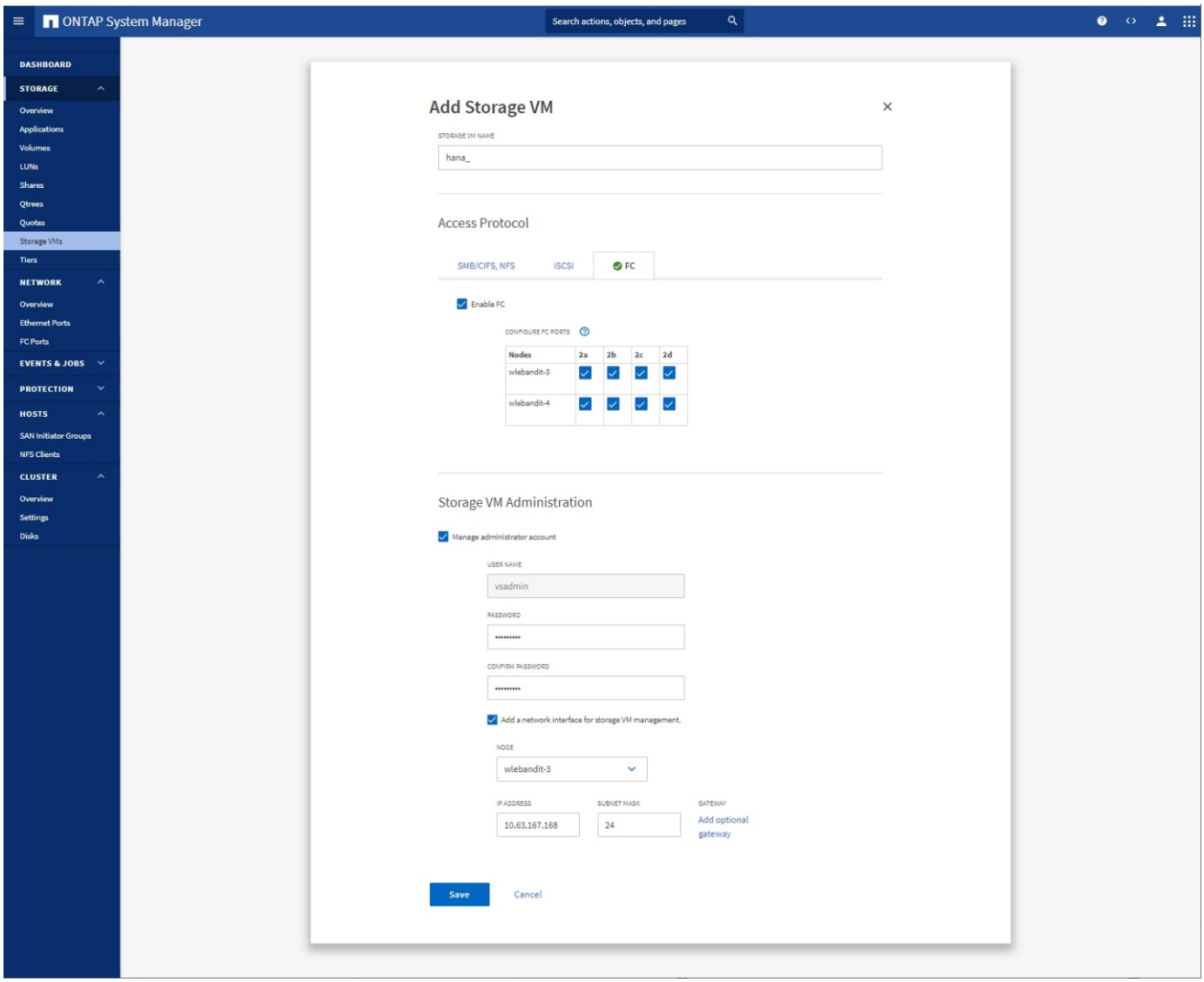
Logical interface configuration

Within the storage cluster configuration, one network interface (LIF) must be created and assigned to a dedicated FCP port. If, for example, four FCP ports are required for performance reasons, four LIFs must be created. The following figure shows a screenshot of the four LIFs (named `fc_*_*)` that were configured on the `hana` SVM.



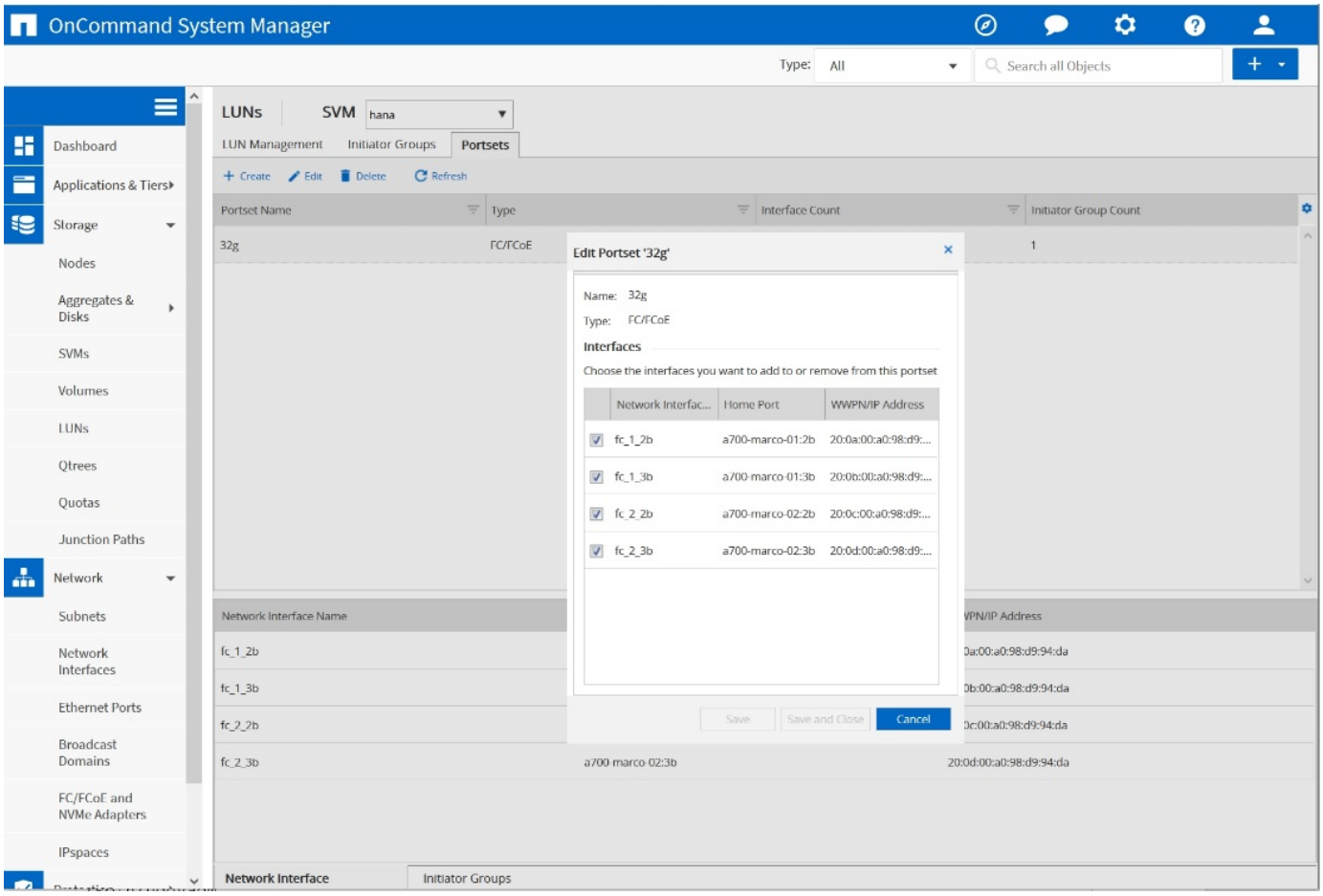
During SVM creation with ONTAP 9.8 System Manager, all the required physical FCP ports can be selected, and one LIF per physical port is created automatically.

The following figure depicts the creation of SVM and LIFs with ONTAP 9.8 System Manager.



FCP port sets

An FCP port set is used to define which LIFs are to be used by a specific igroup. Typically, all LIFs created for the HANA systems are placed in the same port set. The following figure shows the configuration of a port set named 32g, which includes the four LIFs that were already created.



With ONTAP 9.8, a port set is not required, but it can be created and used through the command line.

Initiator groups

An igroup can be configured for each server or for a group of servers that require access to a LUN. The igroup configuration requires the worldwide port names (WWPNs) of the servers.

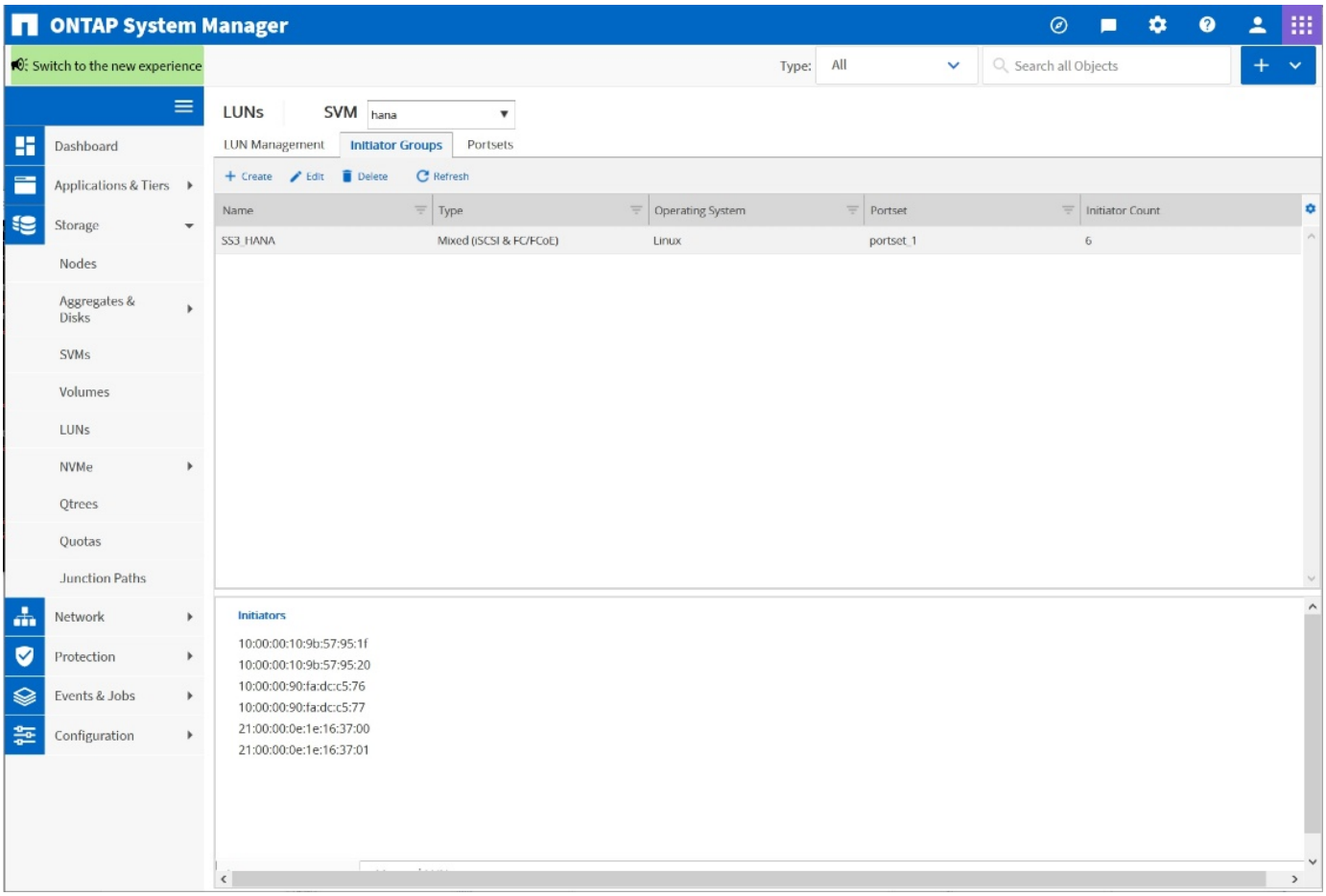
Using the `sanlun` tool, run the following command to obtain the WWPNs of each SAP HANA host:

```
stlrx300s8-6:~ # sanlun fcp show adapter
/sbin/udevadm
/sbin/udevadm

host0 ..... WWPN:2100000e1e163700
host1 ..... WWPN:2100000e1e163701
```

The `sanlun` tool is part of the NetApp Host Utilities and must be installed on each SAP HANA host. More details can be found in section Host setup.

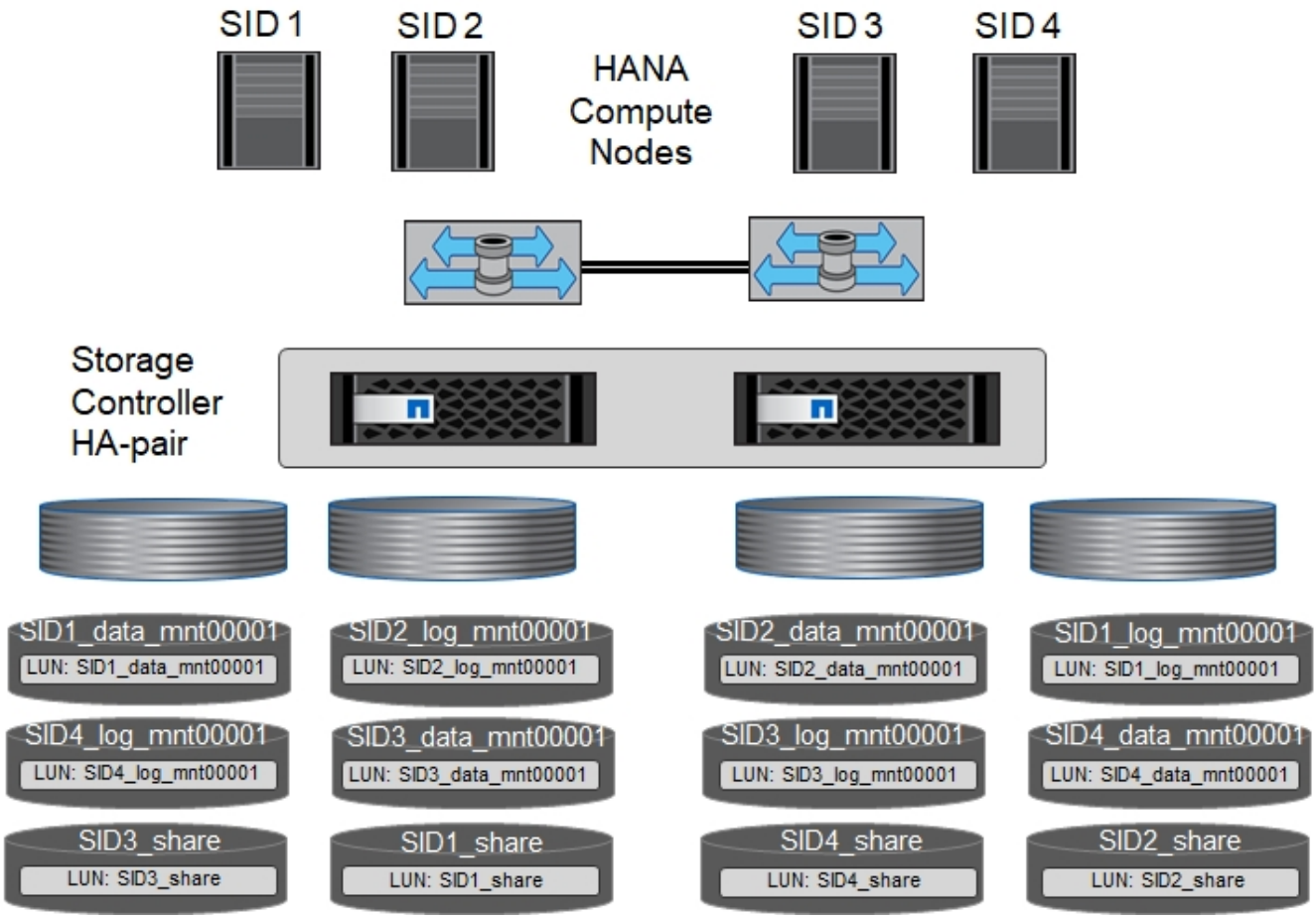
The following figure shows the list of initiators for SS3_HANA. The igroup contains all WWPNs of the servers and is assigned to the port set of the storage controller.



Volume and LUN configuration for SAP HANA single-host systems

The following figure shows the volume configuration of four single-host SAP HANA systems. The data and log volumes of each SAP HANA system are distributed to different storage controllers. For example, volume `SID1``data``mnt00001 `is configured on controller A and volume `SID1` `log``mnt00001` is configured on controller B. Within each volume, a single LUN is configured.

If only one storage controller of a high-availability (HA) pair is used for the SAP HANA systems, data volumes and log volumes can also be stored on the same storage controller.



For each SAP HANA host, a data volume, a log volume, and a volume for `/hana/shared` are configured. The following table shows an example configuration with four SAP HANA single-host systems.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data, log, and shared volumes for system SID1	Data volume: SID1_data_mnt00001	Shared volume: SID1_shared	–	Log volume: SID1_log_mnt00001
Data, log, and shared volumes for system SID2	–	Log volume: SID2_log_mnt00001	Data volume: SID2_data_mnt00001	Shared volume: SID2_shared
Data, log, and shared volumes for system SID3	Shared volume: SID3_shared	Data volume: SID3_data_mnt00001	Log volume: SID3_log_mnt00001	–
Data, log, and shared volumes for system SID4	Log volume: SID4_log_mnt00001	–	Shared volume: SID4_shared	Data volume: SID4_data_mnt00001

The next table shows an example of the mount point configuration for a single-host system.

LUN	Mount point at HANA host	Note
SID1_data_mnt00001	/hana/data/SID1/mnt00001	Mounted using /etc/fstab entry

LUN	Mount point at HANA host	Note
SID1_log_mnt00001	/hana/log/SID1/mnt00001	Mounted using /etc/fstab entry
SID1_shared	/hana/shared/SID1	Mounted using /etc/fstab entry

With the described configuration, the `/usr/sap/SID1` directory in which the default home directory of user SID1adm is stored, is on the local disk. In a disaster recovery setup with disk-based replication, NetApp recommends creating an additional LUN within the `SID1`_`shared `volume for the `/usr/sap/SID1` directory so that all file systems are on the central storage.

Volume and LUN configuration for SAP HANA single-host systems using Linux LVM

The Linux LVM can be used to increase performance and to address LUN size limitations. The different LUNs of an LVM volume group should be stored within a different aggregate and at a different controller. The following table shows an example for two LUNs per volume group.

It is not necessary to use LVM with multiple LUNs to fulfil the SAP HANA KPIs. A single LUN setup fulfils the required KPIs.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data, log, and shared volumes for LVM based system	Data volume: SID1_data_mnt00001	Shared volume: SID1_shared Log2 volume: SID1_log2_mnt00001	Data2 volume: SID1_data2_mnt00001	Log volume: SID1_log_mnt00001

At the SAP HANA host, volume groups and logical volumes must be created and mounted. The next table lists the mount points for single-host systems using LVM.

Logical volume/LUN	Mount point at SAP HANA host	Note
LV: SID1_data_mnt0000-vol	/hana/data/SID1/mnt00001	Mounted using /etc/fstab entry
LV: SID1_log_mnt00001-vol	/hana/log/SID1/mnt00001	Mounted using /etc/fstab entry
LUN: SID1_shared	/hana/shared/SID1	Mounted using /etc/fstab entry

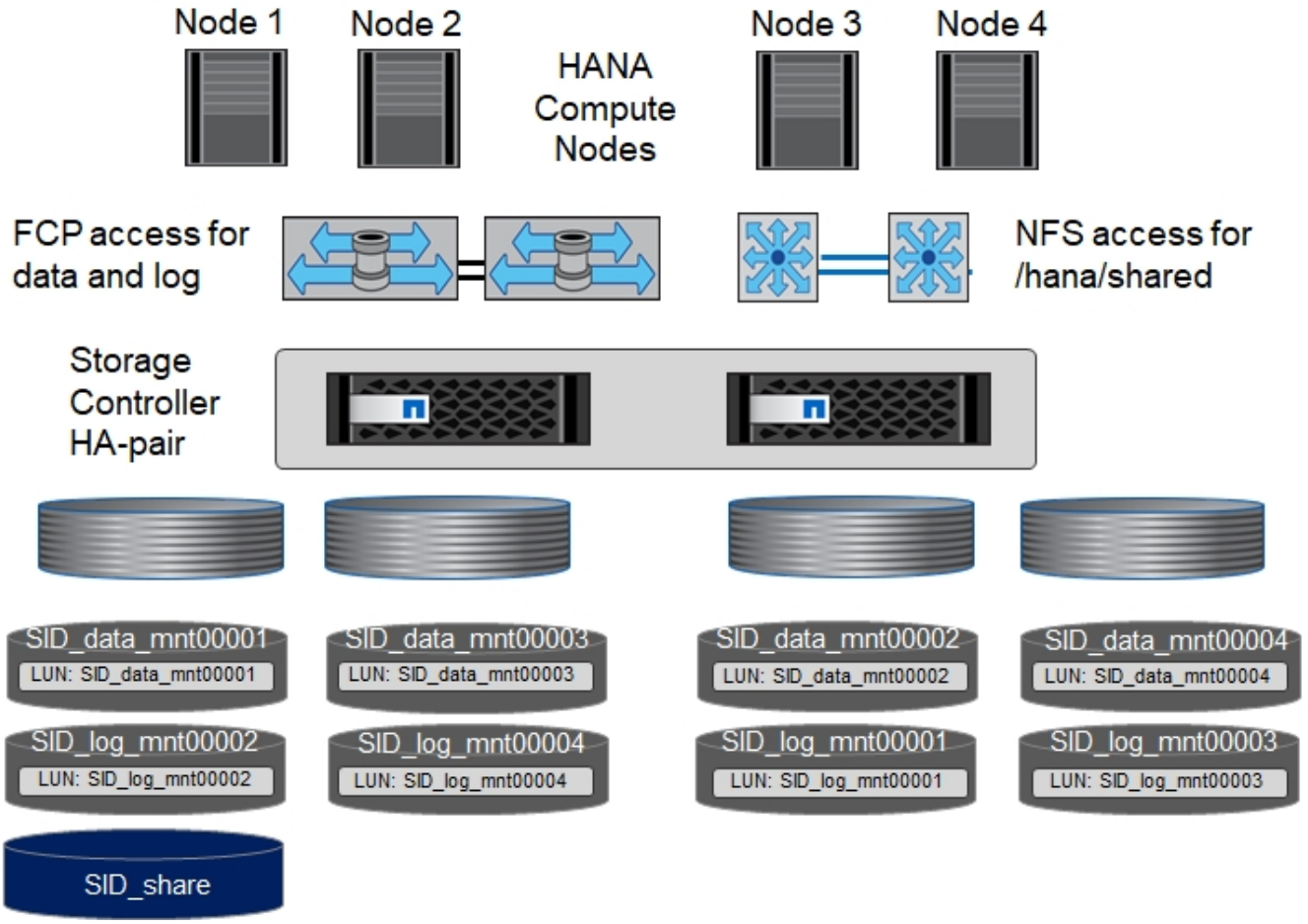
With the described configuration, the `/usr/sap/SID1` directory in which the default home directory of user SID1adm is stored, is on the local disk. In a disaster recovery setup with disk-based replication, NetApp recommends creating an additional LUN within the `SID1`_`shared `volume for the `/usr/sap/SID1` directory so that all file systems are on the central storage.

Volume and LUN configuration for SAP HANA multiple-host systems

The following figure shows the volume configuration of a 4+1 multiple-host SAP HANA system. The data volumes and log volumes of each SAP HANA host are distributed to different storage controllers. For example, the volume `SID``*data*``mnt00001` is configured on controller A and the volume `SID``*log*``mnt00001` is configured on controller B. One LUN is configured within each volume.

The `/hana/shared` volume must be accessible by all HANA hosts and is therefore exported by using NFS. Even though there are no specific performance KPIs for the `/hana/shared` file system, NetApp recommends using a 10Gb Ethernet connection.

If only one storage controller of an HA pair is used for the SAP HANA system, data and log volumes can also be stored on the same storage controller.



For each SAP HANA host, a data volume and a log volume are created. The `/hana/shared` volume is used by all hosts of the SAP HANA system. The following figure shows an example configuration for a 4+1 multiple-host SAP HANA system.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	–	Log volume: SID_log_mnt00001	–
Data and log volumes for node 2	Log volume: SID_log_mnt00002	–	Data volume: SID_data_mnt00002	–
Data and log volumes for node 3	–	Data volume: SID_data_mnt00003	–	Log volume: SID_log_mnt00003
Data and log volumes for node 4	–	Log volume: SID_log_mnt00004	–	Data volume: SID_data_mnt00004

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Shared volume for all hosts	Shared volume: SID_shared	–	–	–

The next table shows the configuration and the mount points of a multiple-host system with four active SAP HANA hosts.

LUN or Volume	Mount point at SAP HANA host	Note
LUN: SID_data_mnt00001	/hana/data/SID/mnt00001	Mounted using storage connector
LUN: SID_log_mnt00001	/hana/log/SID/mnt00001	Mounted using storage connector
LUN: SID_data_mnt00002	/hana/data/SID/mnt00002	Mounted using storage connector
LUN: SID_log_mnt00002	/hana/log/SID/mnt00002	Mounted using storage connector
LUN: SID_data_mnt00003	/hana/data/SID/mnt00003	Mounted using storage connector
LUN: SID_log_mnt00003	/hana/log/SID/mnt00003	Mounted using storage connector
LUN: SID_data_mnt00004	/hana/data/SID/mnt00004	Mounted using storage connector
LUN: SID_log_mnt00004	/hana/log/SID/mnt00004	Mounted using storage connector
Volume: SID_shared	/hana/shared/SID	Mounted at all hosts using NFS and /etc/fstab entry

With the described configuration, the `/usr/sap/SID` directory in which the default home directory of user SIDadm is stored is on the local disk for each HANA host. In a disaster recovery setup with disk-based replication, NetApp recommends creating four additional subdirectories in the `SID`_`shared` volume for the `/usr/sap/SID` file system so that each database host has all its file systems on the central storage.

Volume and LUN configuration for SAP HANA multiple-host systems using Linux LVM

The Linux LVM can be used to increase performance and to address LUN size limitations. The different LUNs of an LVM volume group should be stored within a different aggregate and at a different controller. The following table shows an example for two LUNs per volume group for a 2+1 SAP HANA multiple host system.

It is not necessary to use LVM to combine several LUN to fulfil the SAP HANA KPIs. A single LUN setup fulfils the required KPIs.

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data and log volumes for node 1	Data volume: SID_data_mnt00001	Log2 volume: SID_log2_mnt00001	Log volume: SID_log_mnt00001	Data2 volume: SID_data2_mnt00001
Data and log volumes for node 2	Log2 volume: SID_log2_mnt00002	Data volume: SID_data_mnt00002	Data2 volume: SID_data2_mnt00002	Log volume: SID_log_mnt00002

Purpose	Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Shared volume for all hosts	Shared volume: SID_shared	–	–	–

At the SAP HANA host, volume groups and logical volumes need to be created and mounted:

Logical volume (LV) or volume	Mount point at SAP HANA host	Note
LV: SID_data_mnt00001-vol	/hana/data/SID/mnt00001	Mounted using storage connector
LV: SID_log_mnt00001-vol	/hana/log/SID/mnt00001	Mounted using storage connector
LV: SID_data_mnt00002-vol	/hana/data/SID/mnt00002	Mounted using storage connector
LV: SID_log_mnt00002-vol	/hana/log/SID/mnt00002	Mounted using storage connector
Volume: SID_shared	/hana/shared	Mounted at all hosts using NFS and /etc/fstab entry

With the described configuration, the `/usr/sap/SID` directory in which the default home directory of user SIDadm is stored, is on the local disk for each HANA host. In a disaster recovery setup with disk-based replication, NetApp recommends creating four additional subdirectories in the `SID`_`shared` volume for the `/usr/sap/SID` file system so that each database host has all its file systems on the central storage.

Volume options

The volume options listed in the following table must be verified and set on all SVMs.

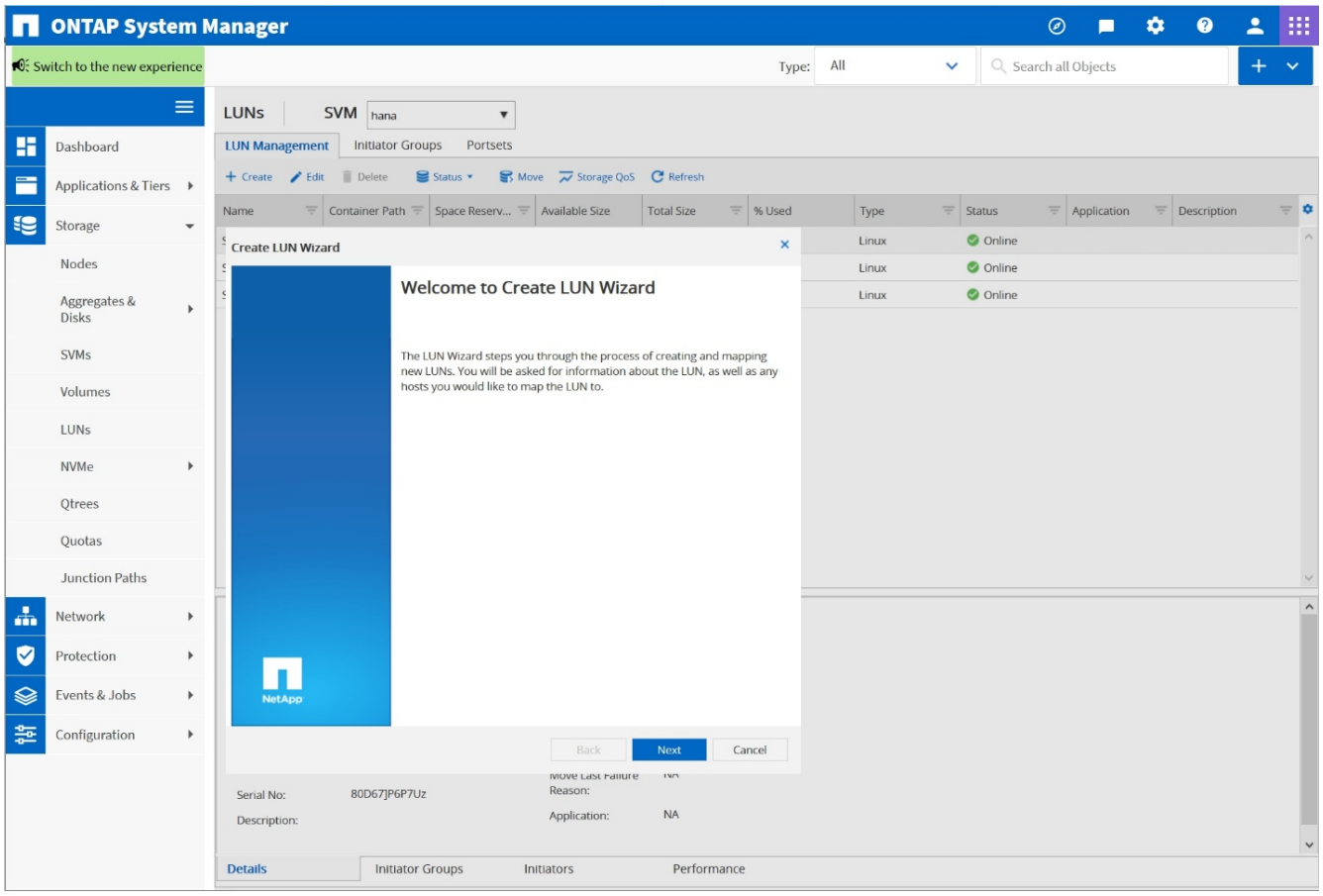
Action	ONTAP 9
Disable automatic Snapshot copies	vol modify –vserver <vserver-name> -volume <volname> -snapshot-policy none
Disable visibility of Snapshot directory	vol modify -vserver <vserver-name> -volume <volname> -snapdir-access false

Creating LUNs, volumes, and mapping LUNs to initiator groups

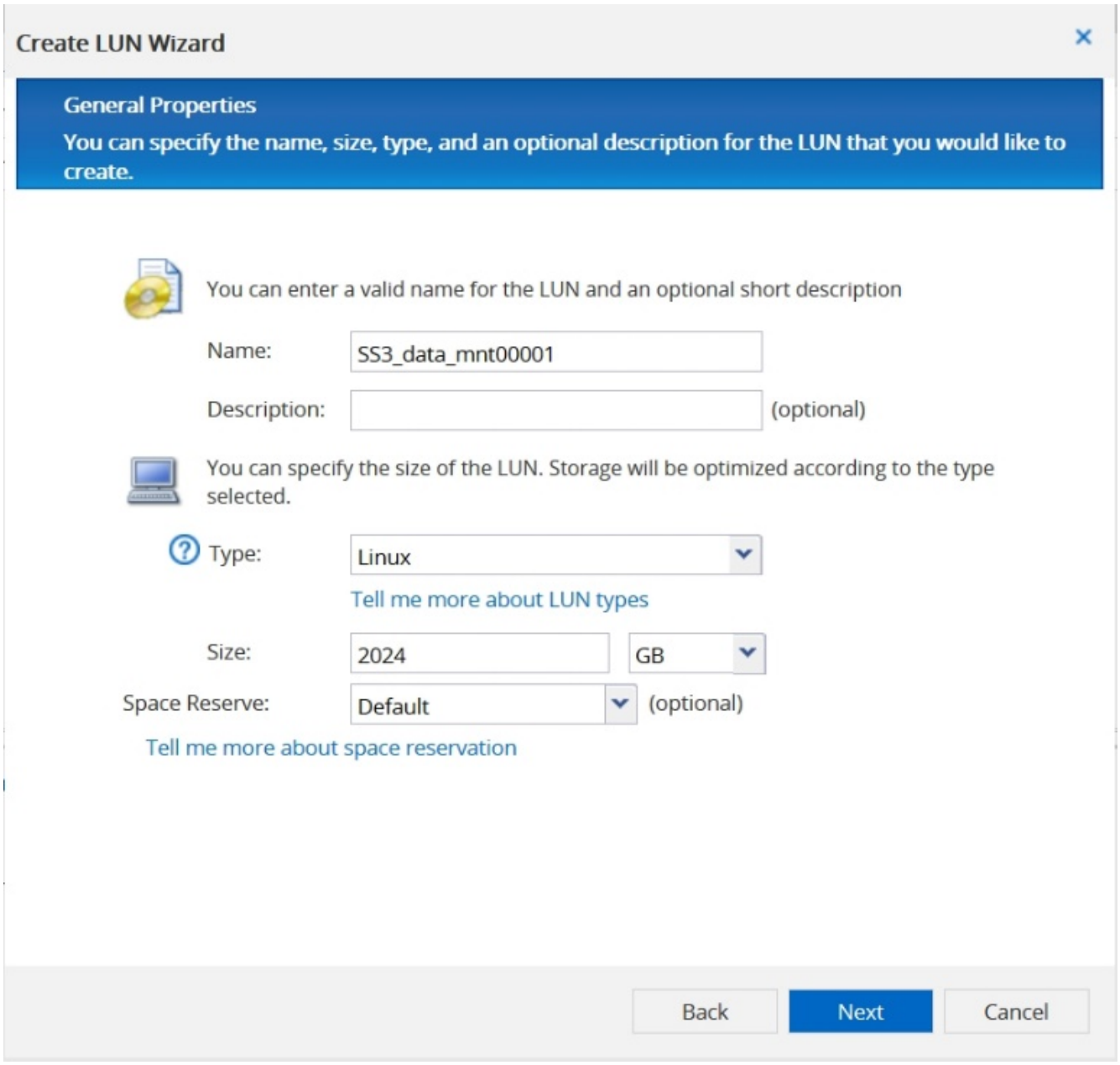
You can use NetApp OnCommand System Manager to create storage volumes and LUNs and the map them to the igroups of the servers.

The following steps show the configuration of a 2+1 multiple-host HANA system with the SID SS3.

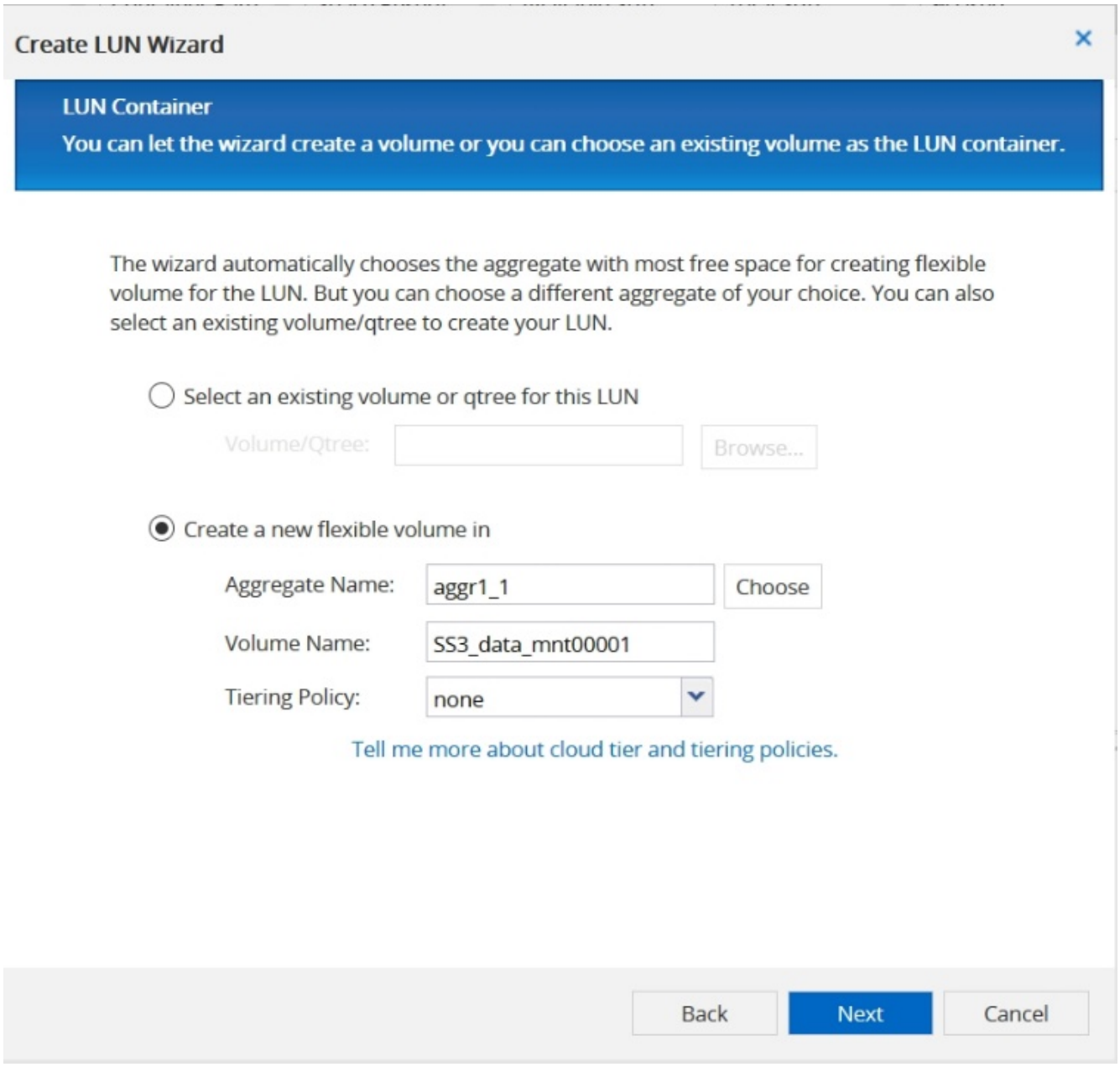
1. Start the Create LUN Wizard in NetApp ONTAP System Manager.



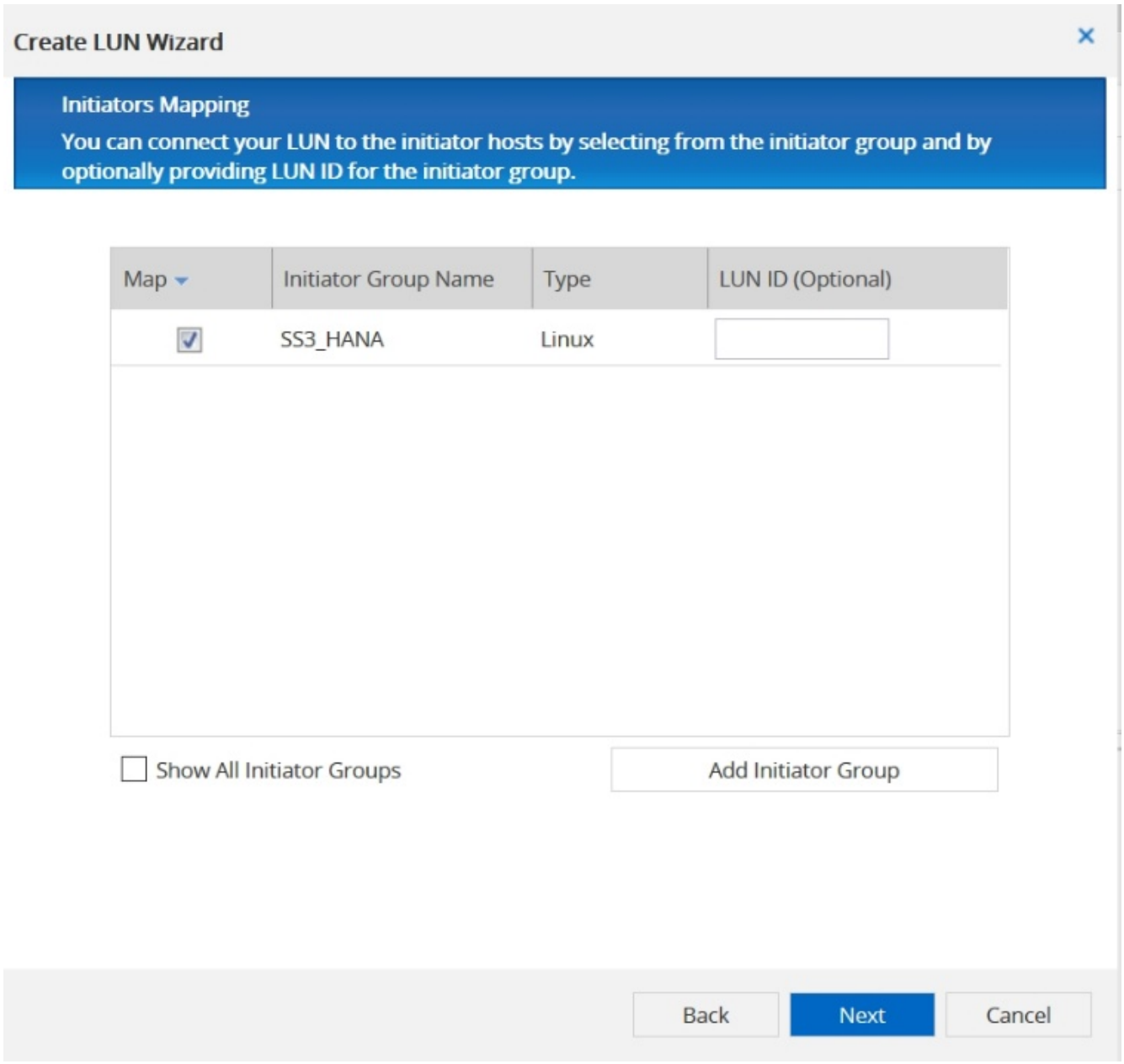
2. Enter the LUN name, select the LUN type, and enter the size of the LUN.



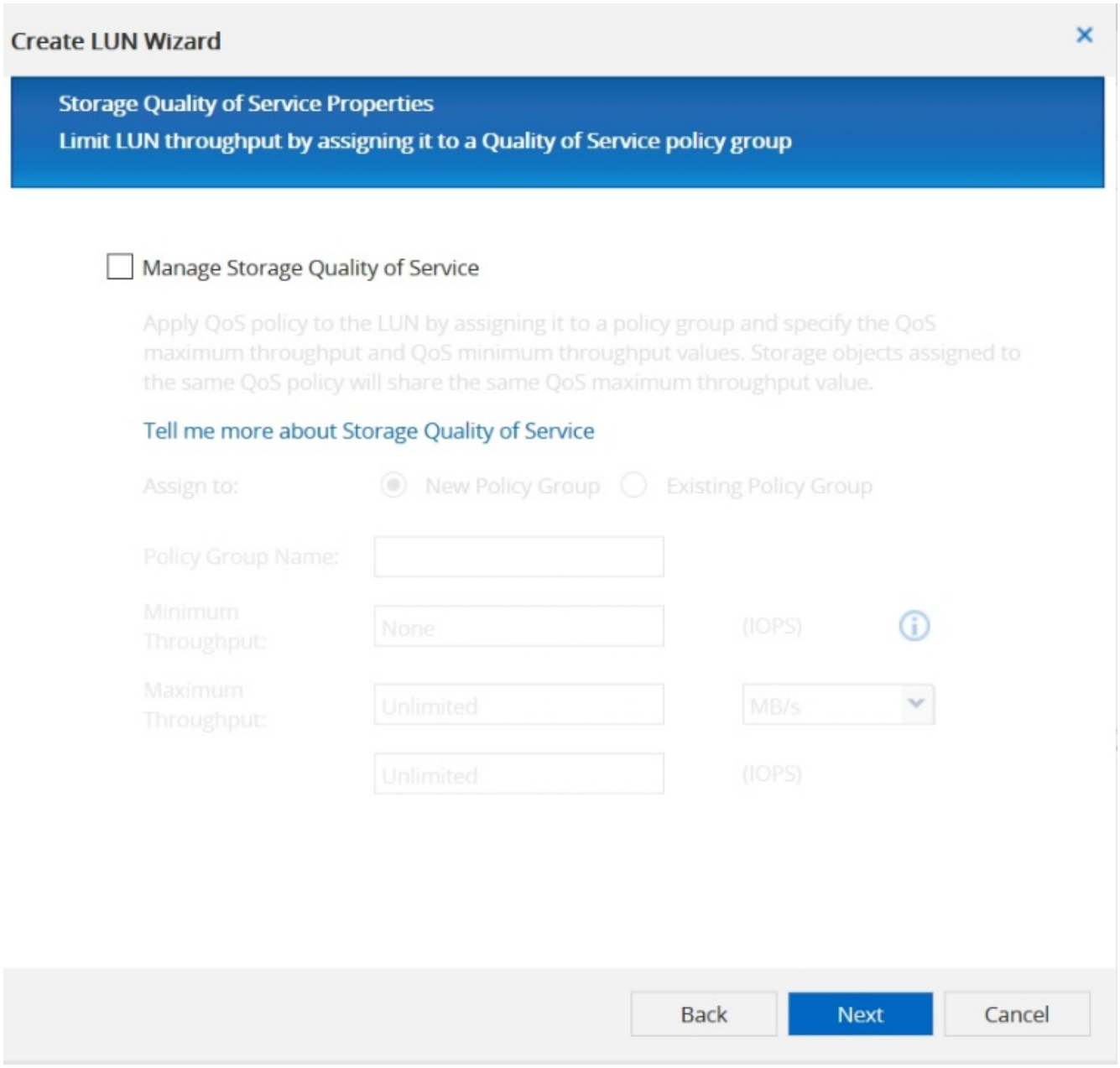
3. Enter the volume name and the hosting aggregate.



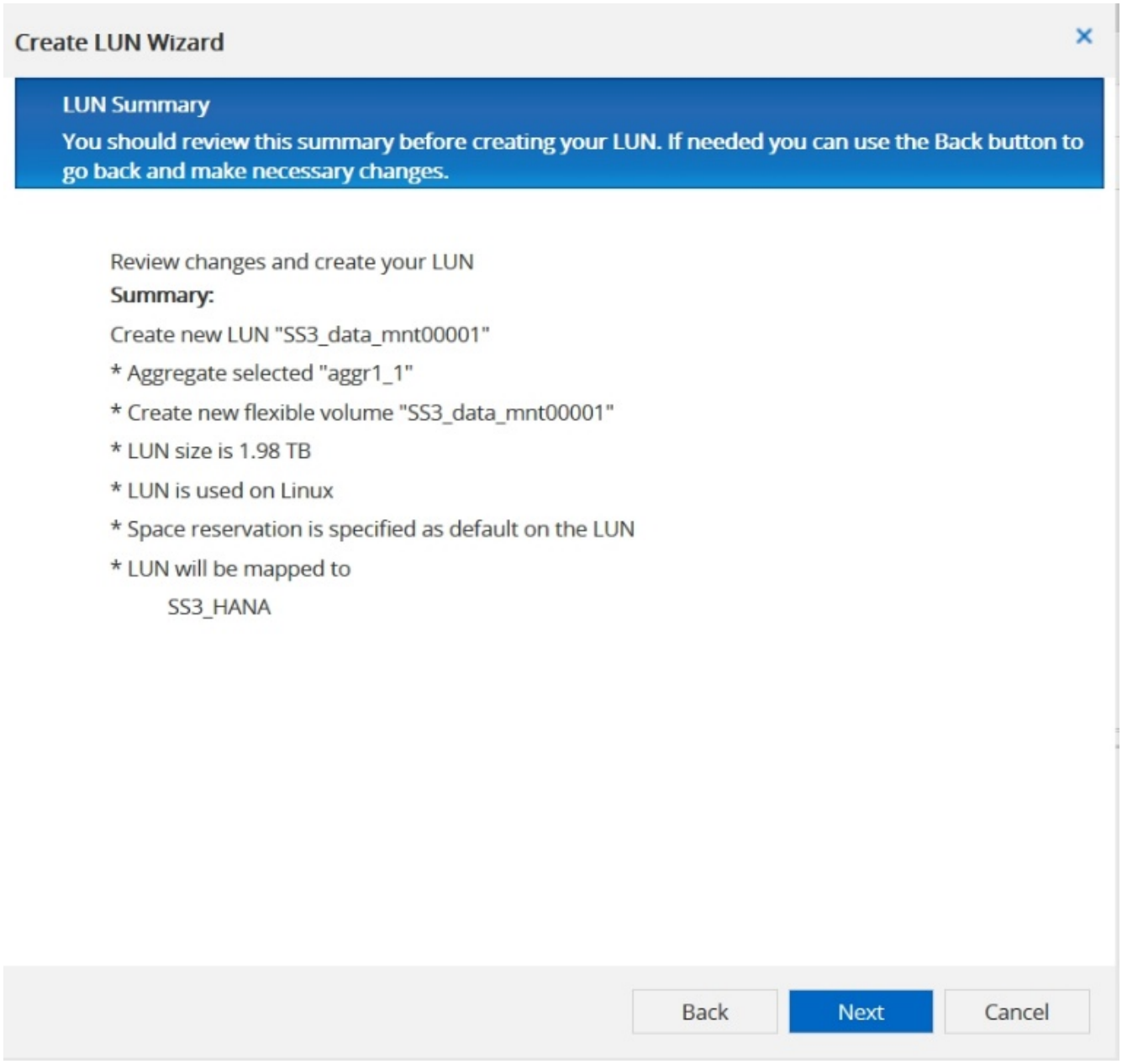
4. Select the igroups to which the LUNs should be mapped.



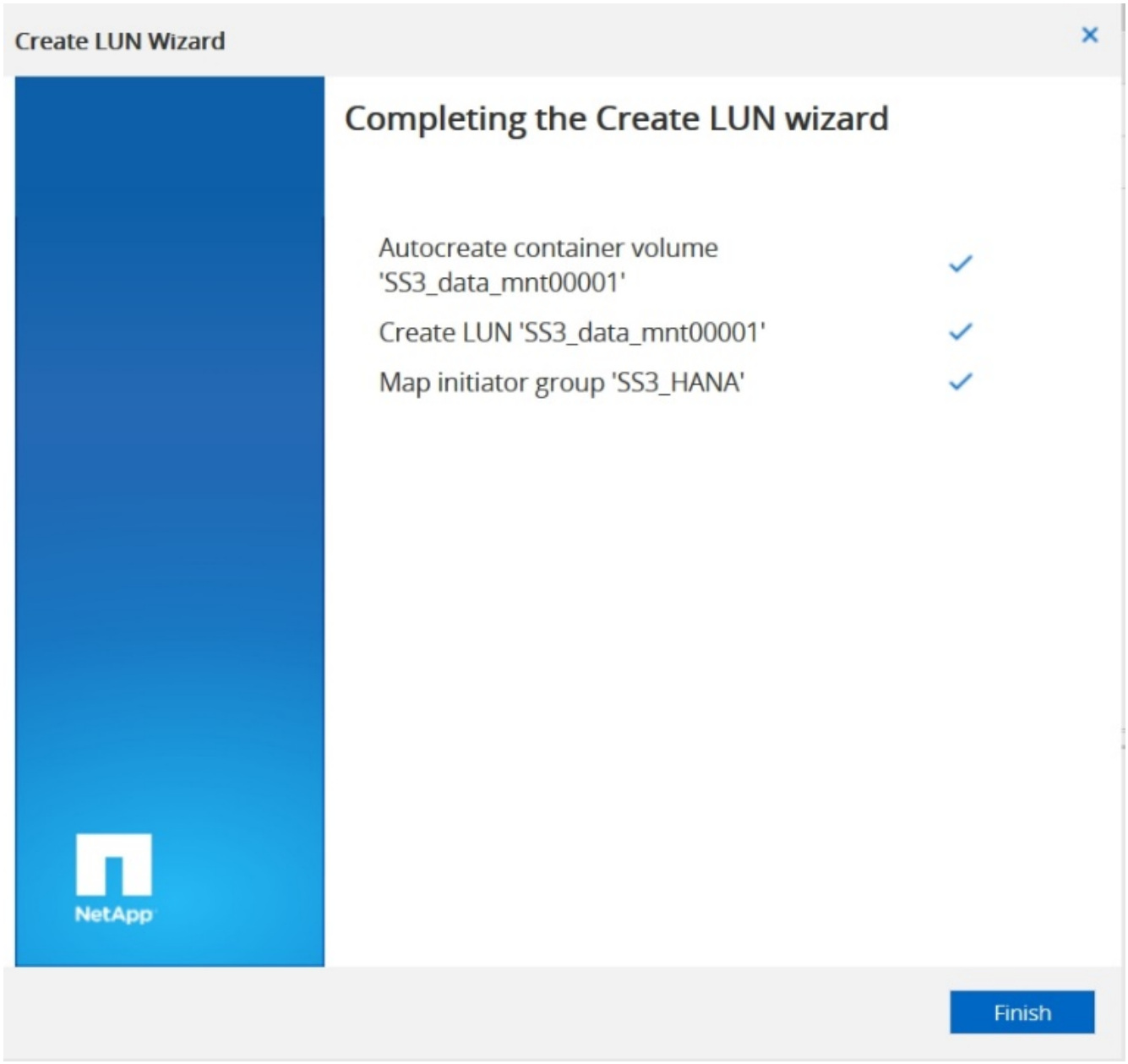
5. Provide the QoS settings.



6. Click Next on the Summary page.

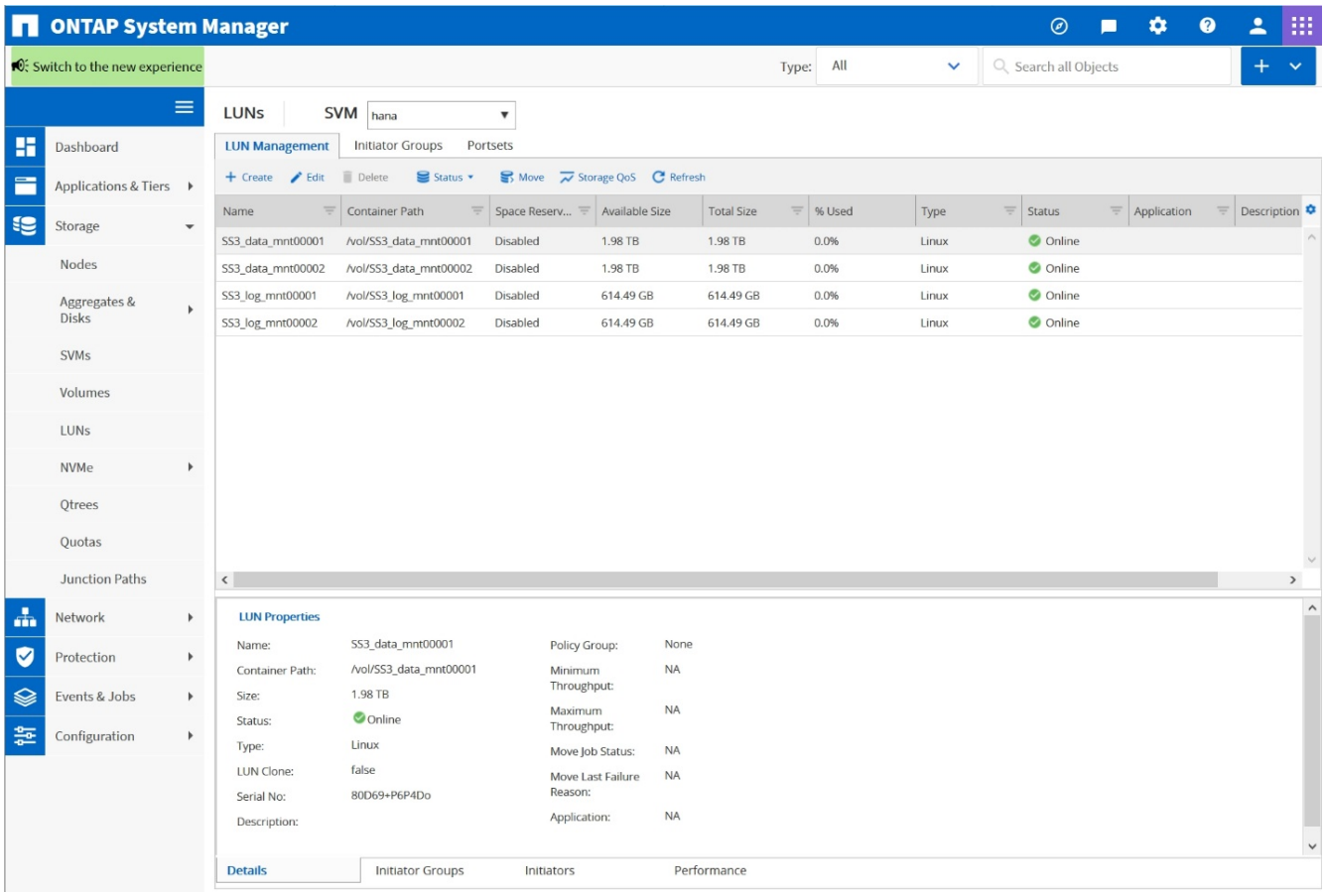


7. Click Finish on the Completion page.



8. Repeat steps 2 to 7 for each LUN.

   The following figure shows a summary of all LUNs that need to be created for 2+1 multiple-host setup.



Creating LUNs, volumes, and mapping LUNs to igroups using the CLI

This section shows an example configuration using the command line with ONTAP 9.8 for a 2+1 SAP HANA multiple host system with SID FC5 using LVM and two LUNs per LVM volume group.

1. Create all necessary volumes.

```
vol create -volume FC5_data_mnt00001 -aggregate aggr1_1 -size 1200g
-snapshot-policy none -foreground true -encrypt false  -space-guarantee
none
vol create -volume FC5_log_mnt00002  -aggregate aggr2_1 -size 280g
-snapshot-policy none -foreground true -encrypt false  -space-guarantee
none
vol create -volume FC5_log_mnt00001  -aggregate aggr1_2 -size 280g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_data_mnt00002  -aggregate aggr2_2 -size 1200g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_data2_mnt00001 -aggregate aggr1_2 -size 1200g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_log2_mnt00002  -aggregate aggr2_2 -size 280g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_log2_mnt00001  -aggregate aggr1_1 -size 280g
-snapshot-policy none -foreground true -encrypt false  -space-guarantee
none
vol create -volume FC5_data2_mnt00002  -aggregate aggr2_1 -size 1200g
-snapshot-policy none -foreground true -encrypt false -space-guarantee
none
vol create -volume FC5_shared -aggregate aggr1_1 -size 512g -state
online -policy default -snapshot-policy none -junction-path /FC5_shared
-encrypt false  -space-guarantee none
```

2. Create all LUNs.

```
lun create -path  /vol/FC5_data_mnt00001/FC5_data_mnt00001   -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_data2_mnt00001/FC5_data2_mnt00001 -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_data_mnt00002/FC5_data_mnt00002 -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_data2_mnt00002/FC5_data2_mnt00002 -size 1t
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log_mnt00001/FC5_log_mnt00001 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log2_mnt00001/FC5_log2_mnt00001 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log_mnt00002/FC5_log_mnt00002 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
lun create -path /vol/FC5_log2_mnt00002/FC5_log2_mnt00002 -size 260g
-ostype linux -space-reserve disabled -space-allocation disabled -class
regular
```

3. Create the igroup for all servers belonging to system FC5.

```
lun igroup create -igroup HANA-FC5 -protocol fcp -ostype linux
-initiator 10000090fadcc5fa,10000090fadcc5fb,
10000090fadcc5c1,10000090fadcc5c2,  10000090fadcc5c3,10000090fadcc5c4
-vserver hana
```

4. Map all LUNs to the created igroup.

```
lun map -path  /vol/FC5_data_mnt00001/FC5_data_mnt00001    -igroup HANA-
FC5
lun map -path /vol/FC5_data2_mnt00001/FC5_data2_mnt00001  -igroup HANA-
FC5
lun map -path /vol/FC5_data_mnt00002/FC5_data_mnt00002  -igroup HANA-FC5
lun map -path /vol/FC5_data2_mnt00002/FC5_data2_mnt00002  -igroup HANA-
FC5
lun map -path /vol/FC5_log_mnt00001/FC5_log_mnt00001  -igroup HANA-FC5
lun map -path /vol/FC5_log2_mnt00001/FC5_log2_mnt00001  -igroup HANA-FC5
lun map -path /vol/FC5_log_mnt00002/FC5_log_mnt00002  -igroup HANA-FC5
lun map -path /vol/FC5_log2_mnt00002/FC5_log2_mnt00002  -igroup HANA-FC5
```

SAP HANA storage connector API

A storage connector is required only in multiple-host environments that have failover capabilities. In multiple-host setups, SAP HANA provides high-availability functionality so that an SAP HANA database host can fail over to a standby host. In this case, the LUNs of the failed host are accessed and used by the standby host. The storage connector is used to make sure that a storage partition can be actively accessed by only one database host at a time.

In SAP HANA multiple-host configurations with NetApp storage, the standard storage connector delivered by SAP is used. The “SAP HANA FC Storage Connector Admin Guide” can be found as an attachment to SAP note 1900823.

Host setup

Before setting up the host, NetApp SAN Host Utilities must be downloaded from the NetApp Support site and installed on the HANA servers. The Host Utility documentation includes information about additional software that must be installed depending on the FCP HBA used.

The documentation also contains information about multipath configurations that are specific to the Linux version used. This document covers the required configuration steps for SLES 15 and Red Hat Enterprise Linux 7.6 or higher, as described in the Linux Host Utilities 7.1 Installation and Setup Guide.

Configure multipathing

Steps 1 to 6 must be performed on all worker and standby hosts in the SAP HANA multiple-host configuration.

To configure multipathing, complete the following steps:

1. Run the Linux `rescan-scsi-bus.sh -a` command on each server to discover new LUNs.
2. Run the `sanlun lun show` command and verify that all required LUNs are visible. The following example shows the `sanlun lun show` command output for a 2+1 multiple-host HANA system with two data LUNs and two log LUNs. The output shows the LUNs and the corresponding device files, such as LUN

`SS3_data_mnt00001` and the device file `/dev/sdag`. Each LUN has eight FC paths from the host to the storage controllers.

```
stlrx300s8-6:~ # sanlun lun show
controller(7mode/E-Series)/
device          host       lun
vserver(cDOT/FlashRay)        lun-pathname
filename        adapter    protocol   size    product
------------------------------------------------------------------------
-------------------------------------------------
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdah       host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdag       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdaf       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdae       host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdad       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdac       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdab       host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdaa       host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdz        host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdy        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdx        host11     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdw        host11     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdv        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdu        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdt        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sds        host11     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdr        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdq        host10     FCP        1.2t    cDOT
```

```
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdp        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdo        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdn        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdm        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdl        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdk        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdj        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00002/SS3_log_mnt00002
/dev/sdi        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_data_mnt00001/SS3_data_mnt00001
/dev/sdh        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_data_mnt00002/SS3_data_mnt00002
/dev/sdg        host10     FCP        1.2t    cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdf        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sde        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdd        host10     FCP        512.0g  cDOT
hana                          /vol/SS3_log_mnt00001/SS3_log_mnt00001
/dev/sdc        host10     FCP        512.0g  cDOT
```

3. Run the `multipath -r` command to get the worldwide identifiers (WWIDs) for the device file names:

   In this example, there are four LUNs.

```
stlrx300s8-6:~ # multipath -r
create: 3600a098038304436375d4d442d753878 undef NETAPP,LUN C-Mode
size=512G features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:1:0 sdd  8:48   undef ready running
| |- 10:0:3:0 sdf  8:80   undef ready running
| |- 11:0:0:0 sds  65:32  undef ready running
| `- 11:0:2:0 sdu  65:64  undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:0:0 sdc  8:32   undef ready running
  |- 10:0:2:0 sde  8:64   undef ready running
```

```
  |- 11:0:1:0 sdt  65:48  undef ready running
  `- 11:0:3:0 sdv  65:80  undef ready running
create: 3600a098038304436375d4d442d753879 undef NETAPP,LUN C-Mode
size=1.2T features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:1:1 sdj  8:144  undef ready running
| |- 10:0:3:1 sdp  8:240  undef ready running
| |- 11:0:0:1 sdw  65:96  undef ready running
| `- 11:0:2:1 sdac 65:192 undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:0:1 sdg  8:96   undef ready running
  |- 10:0:2:1 sdm  8:192  undef ready running
  |- 11:0:1:1 sdz  65:144 undef ready running
  `- 11:0:3:1 sdaf 65:240 undef ready running
create: 3600a098038304436392b4d442d6f534f undef NETAPP,LUN C-Mode
size=1.2T features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:0:2 sdh  8:112  undef ready running
| |- 10:0:2:2 sdn  8:208  undef ready running
| |- 11:0:1:2 sdaa 65:160 undef ready running
| `- 11:0:3:2 sdag 66:0   undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:1:2 sdk  8:160  undef ready running
  |- 10:0:3:2 sdq  65:0   undef ready running
  |- 11:0:0:2 sdx  65:112 undef ready running
  `- 11:0:2:2 sdad 65:208 undef ready running
create: 3600a098038304436392b4d442d6f5350 undef NETAPP,LUN C-Mode
size=512G features='3 pg_init_retries 50 queue_if_no_path' hwhandler='0'
wp=undef
|-+- policy='service-time 0' prio=50 status=undef
| |- 10:0:0:3 sdi  8:128  undef ready running
| |- 10:0:2:3 sdo  8:224  undef ready running
| |- 11:0:1:3 sdab 65:176 undef ready running
| `- 11:0:3:3 sdah 66:16  undef ready running
`-+- policy='service-time 0' prio=10 status=undef
  |- 10:0:1:3 sdl  8:176  undef ready running
  |- 10:0:3:3 sdr  65:16  undef ready running
  |- 11:0:0:3 sdy  65:128 undef ready running
  `- 11:0:2:3 sdae 65:224 undef ready running
```

4. Edit the `/etc/multipath.conf` file and add the WWIDs and alias names.

The example output shows the content of the `/etc/multipath.conf` file, which includes alias names for the four LUNs of a 2+1 multiple-host system. If there is no `multipath.conf` file available, you can create one by running the following command: `multipath -T > /etc/multipath.conf`.

```
stlrx300s8-6:/ # cat /etc/multipath.conf
multipaths {
        multipath {
                wwid    3600a098038304436392b4d442d6f534f
                alias   hana-SS3_data_mnt00001
        }
        multipath {
                wwid    3600a098038304436375d4d442d753879
                alias   hana-SS3_data_mnt00002
        }
        multipath {
                wwid    3600a098038304436375d4d442d753878
                alias   hana-SS3_log_mnt00001
        }
        multipath {
                wwid    3600a098038304436392b4d442d6f5350
                alias   hana-SS3_log_mnt00002
        }
}
```

5. Run the `multipath -r` command to reload the device map.
6. Verify the configuration by running the `multipath -ll` command to list all the LUNs, alias names, and active and standby paths.

The following example output shows the output of a 2+1 multiple-host HANA system with two data and two log LUNs.

```
stlrx300s8-6:~ # multipath -ll
hana- SS3_data_mnt00002 (3600a098038304436375d4d442d753879) dm-1
NETAPP,LUN C-Mode
size=1.2T features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:1:1 sdj  8:144  active ready running
| |- 10:0:3:1 sdp  8:240  active ready running
| |- 11:0:0:1 sdw  65:96  active ready running
| `- 11:0:2:1 sdac 65:192 active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:0:1 sdg  8:96   active ready running
```

```
  |- 10:0:2:1 sdm  8:192  active ready running
  |- 11:0:1:1 sdz  65:144 active ready running
  `- 11:0:3:1 sdaf 65:240 active ready running
hana- SS3_data_mnt00001 (3600a098038304436392b4d442d6f534f) dm-2
NETAPP,LUN C-Mode
size=1.2T features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:0:2 sdh  8:112  active ready running
| |- 10:0:2:2 sdn  8:208  active ready running
| |- 11:0:1:2 sdaa 65:160 active ready running
| `- 11:0:3:2 sdag 66:0   active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:2 sdk  8:160  active ready running
  |- 10:0:3:2 sdq  65:0   active ready running
  |- 11:0:0:2 sdx  65:112 active ready running
  `- 11:0:2:2 sdad 65:208 active ready running
hana- SS3_log_mnt00002 (3600a098038304436392b4d442d6f5350) dm-3
NETAPP,LUN C-Mode
size=512G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:0:3 sdi  8:128  active ready running
| |- 10:0:2:3 sdo  8:224  active ready running
| |- 11:0:1:3 sdab 65:176 active ready running
| `- 11:0:3:3 sdah 66:16  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:1:3 sdl  8:176  active ready running
  |- 10:0:3:3 sdr  65:16  active ready running
  |- 11:0:0:3 sdy  65:128 active ready running
  `- 11:0:2:3 sdae 65:224 active ready running
hana- SS3_log_mnt00001 (3600a098038304436375d4d442d753878) dm-0
NETAPP,LUN C-Mode
size=512G features='4 queue_if_no_path pg_init_retries 50
retain_attached_hw_handler' hwhandler='1 alua' wp=rw
|-+- policy='service-time 0' prio=50 status=enabled
| |- 10:0:1:0 sdd  8:48   active ready running
| |- 10:0:3:0 sdf  8:80   active ready running
| |- 11:0:0:0 sds  65:32  active ready running
| `- 11:0:2:0 sdu  65:64  active ready running
`-+- policy='service-time 0' prio=10 status=enabled
  |- 10:0:0:0 sdc  8:32   active ready running
  |- 10:0:2:0 sde  8:64   active ready running
  |- 11:0:1:0 sdt  65:48  active ready running
  `- 11:0:3:0 sdv  65:80  active ready running
```

Create LVM volume groups and logical volumes

This step is only needed if LVM will be used. The following example is for a 2+1 host setup using SID FC5.

> For an LVM-based setup, the multipath configuration described in the previous section must be completed as well. In this example, eight LUNs must be configured for multipathing.

1. Initialize all LUNs as a physical volume.

```
pvcreate /dev/mapper/hana-FC5_data_mnt00001
pvcreate /dev/mapper/hana-FC5_data2_mnt00001pvcreate /dev/mapper/hana-
FC5_data_mnt00002
pvcreate /dev/mapper/hana-FC5_data2_mnt00002
pvcreate /dev/mapper/hana-FC5_log_mnt00001
pvcreate /dev/mapper/hana-FC5_log2_mnt00001pvcreate /dev/mapper/hana-
FC5_log_mnt00002
pvcreate /dev/mapper/hana-FC5_log2_mnt00002
```

2. Create the volume groups for each data and log partition.

```
vgcreate FC5_data_mnt00001 /dev/mapper/hana-FC5_data_mnt00001
/dev/mapper/hana-FC5_data2_mnt00001
vgcreate FC5_data_mnt00002 /dev/mapper/hana-FC5_data_mnt00002
/dev/mapper/hana-FC5_data2_mnt00002
vgcreate FC5_log_mnt00001 /dev/mapper/hana-FC5_log_mnt00001
/dev/mapper/hana-FC5_log2_mnt00001
vgcreate FC5_log_mnt00002 /dev/mapper/hana-FC5_log_mnt00002
/dev/mapper/hana-FC5_log2_mnt00002
```

3. Create a logical volume for each data and log partition. Use a stripe size that is equal to the number of LUNs used per volume group (in example two) and a stripe size of 256k for data and 64k for log. SAP only supports one logical volume per volume group.

```
lvcreate --extents 100%FREE -i 2 -I 256k --name vol FC5_data_mnt00001
lvcreate --extents 100%FREE -i 2 -I 256k --name vol FC5_data_mnt00002
lvcreate --extents 100%FREE -i 2 -I 64k --name vol FC5_log_mnt00002
lvcreate --extents 100%FREE -i 2 -I 64k --name vol FC5_log_mnt00001
```

4. Scan the physical volumes, volume groups, and vol groups at all other hosts.

```
modprobe dm_mod
pvscan
vgscan
lvscan
```

If the above commands do not find the volumes, a restart is required.

5. To mount the logical volumes, the logical volumes must be activated. To activate the volumes, run the following command:

```
vgchange -a y
```

Create file systems

To create the XFS file system on each LUN belonging to the HANA system, take one of the following actions:

- For a single-host system, create the XFS file system on the data, log, and `/hana/shared` LUNs.

```
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_data_mnt00001
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_log_mnt00001
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_shared
```

- For a multiple-host system, create the XFS file system on all data and log LUNs.

```
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_log_mnt00001
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_log_mnt00002
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_data_mnt00001
stlrx300s8-6:~ # mkfs.xfs /dev/mapper/hana-SS3_data_mnt00002
```

- If LVM is used, create the XFS file system on all data and log logical volumes.

```
mkfs.xfs FC5_data_mnt00001-vol
mkfs.xfs FC5_data_mnt00002-vol
mkfs.xfs FC5_log_mnt00001-vol
mkfs.xfs FC5_log_mnt00002-vol
```

The multiple host example commands show a 2+1 multiple-host HANA system.

Create mount points

To create the required mount point directories, take one of the following actions:

- For a single-host system, set permissions and create mount points on the database host.

```
stlrx300s8-6:/ # mkdir -p /hana/data/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/log/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/shared

stlrx300s8-6:/ # chmod -R 777 /hana/log/SS3
stlrx300s8-6:/ # chmod -R 777 /hana/data/SS3
stlrx300s8-6:/ # chmod 777 /hana/shared
```

- For a multiple-host system, set permissions and create mount points on all worker and standby hosts.

The example commands show a 2+1 multiple-host HANA system.

```
stlrx300s8-6:/ # mkdir -p /hana/data/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/log/SS3/mnt00001
stlrx300s8-6:/ # mkdir -p /hana/data/SS3/mnt00002
stlrx300s8-6:/ # mkdir -p /hana/log/SS3/mnt00002
stlrx300s8-6:/ # mkdir -p /hana/shared

stlrx300s8-6:/ # chmod -R 777 /hana/log/SS3
stlrx300s8-6:/ # chmod -R 777 /hana/data/SS3
stlrx300s8-6:/ # chmod 777 /hana/shared
```

The same steps must be executed for a system configuration with Linux LVM.

Mount file systems

To mount file systems during system boot using the `/etc/fstab` configuration file, complete the following steps:

1. Take one of the following actions:
   - For a single-host system, add the required file systems to the `/etc/fstab` configuration file.

     The XFS file systems for the data and log LUN must be mounted with the `relatime` and `inode64` mount options.

     ```
     stlrx300s8-6:/ # cat /etc/fstab
     /dev/mapper/hana-SS3_shared /hana/shared xfs defaults 0 0
     /dev/mapper/hana-SS3_log_mnt00001 /hana/log/SS3/mnt00001 xfs
     relatime,inode64 0 0
     /dev/mapper/hana-SS3_data_mnt00001 /hana/data/SS3/mnt00001 xfs
     relatime,inode64 0 0
     ```

     If LVM is used, use the logical volume names for data and log.

```
# cat /etc/fstab
/dev/mapper/hana-FC5_shared /hana/shared xfs defaults 0 0
/dev/mapper/FC5_log_mnt00001-vol /hana/log/FC5/mnt00001 xfs
relatime,inode64 0 0
/dev/mapper/FC5_data_mnt00001-vol /hana/data/FC5/mnt00001 xfs
relatime,inode64 0 0
```

- For a multiple-host system, add the `/hana/shared` file system to the `/etc/fstab` configuration file of each host.

  All the data and log file systems are mounted through the SAP HANA storage connector.

```
stlrx300s8-6:/ # cat /etc/fstab
<storage-ip>:/hana_shared /hana/shared nfs
rw,vers=3,hard,timeo=600,intr,noatime,nolock 0 0
```

2. To mount the file systems, run the `mount -a` command at each host.

I/O stack configuration for SAP HANA

Starting with SAP HANA 1.0 SPS10, SAP introduced parameters to adjust the I/O behavior and optimize the database for the file and storage system used.

NetApp conducted performance tests to define the ideal values. The following table lists the optimal values as inferred from the performance tests.

Parameter	Value
max_parallel_io_requests	128
async_read_submit	on
async_write_submit_active	on
async_write_submit_blocks	all

For SAP HANA 1.0 up to SPS12, these parameters can be set during the installation of the SAP HANA database as described in SAP Note 2267798 – Configuration of the SAP HANA Database during Installation Using hdbparam.

Alternatively, the parameters can be set after the SAP HANA database installation using the `hdbparam` framework.

```
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.max_parallel_io_requests=128
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.async_write_submit_active=on
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.async_read_submit=on
SS3adm@stlrx300s8-6:/usr/sap/SS3/HDB00> hdbparam --paramset
fileio.async_write_submit_blocks=all
```

Starting with SAP HANA 2.0, `hdbparam` is deprecated and the parameters have been moved to the `global.ini` file. The parameters can be set by using SQL commands or SAP HANA Studio. For more information, see SAP Note 2399079 - Elimination of hdbparam in HANA 2. The parameters can be also set within the `global.ini` file.

```
SS3adm@stlrx300s8-6:/usr/sap/SS3/SYS/global/hdb/custom/config> cat
global.ini
…
[fileio]
async_read_submit = on
async_write_submit_active = on
max_parallel_io_requests = 128
async_write_submit_blocks = all
…
```

With SAP HANA 2.0 SPS5 and later, you can use the `setParameter.py `script to set the parameters mentioned above.

```
fc5adm@sapcc-hana-tst-03:/usr/sap/FC5/HDB00/exe/python_support>
python setParameter.py
-set=SYSTEM/global.ini/fileio/max_parallel_io_requests=128
python setParameter.py -set=SYSTEM/global.ini/fileio/async_read_submit=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_active=on
python setParameter.py
-set=SYSTEM/global.ini/fileio/async_write_submit_blocks=all
```

SAP HANA software installation

Below are the requirements for SAP HANA software installation.

Install on single-host system

SAP HANA software installation does not require any additional preparation for a single-host system.

Install on multiple-host system

The following installation procedure is based on SAP HANA 1.0 SPS12 or later.

Before beginning the installation, create a `global.ini` file to enable use of the SAP storage connector during the installation process. The SAP storage connector mounts the required file systems at the worker hosts during the installation process. The `global.ini` file must be available in a file system that is accessible from all hosts, such as the `/hana/shared/SID` file system.

Before installing SAP HANA software on a multiple-host system, the following steps must be completed:

1. Add the following mount options for the data LUNs and the log LUNs to the `global.ini` file:
   - `relatime` and `inode64` for the data and log file system
2. Add the WWIDs of the data and log partitions. The WWIDs must match the alias names configured in the `/etc/multipath.conf` file.

   The following output shows an example of a 2+1 multiple-host setup in which the system identifier (SID) is SS3.

```
stlrx300s8-6:~ # cat /hana/shared/global.ini
[communication]
listeninterface = .global
[persistence]
basepath_datavolumes = /hana/data/SS3
basepath_logvolumes = /hana/log/SS3
[storage]
ha_provider = hdb_ha.fcClient
partition_*_*__prtype = 5
partition_*_data__mountoptions = -o relatime,inode64
partition_*_log__mountoptions = -o relatime,inode64,nobarrier
partition_1_data__wwid = hana-SS3_data_mnt00001
partition_1_log__wwid = hana-SS3_log_mnt00001
partition_2_data__wwid = hana-SS3_data_mnt00002
partition_2_log__wwid = hana-SS3_log_mnt00002
[system_information]
usage = custom
[trace]
ha_fcclient = info
stlrx300s8-6:~ #
```

   If LVM is used, the needed configuration is different. The example below shows a 2+1 multiple-host setup with SID=FC5.

```
sapcc-hana-tst-03:/hana/shared # cat global.ini
[communication]
listeninterface = .global
[persistence]
basepath_datavolumes = /hana/data/FC5
basepath_logvolumes = /hana/log/FC5
[storage]
ha_provider = hdb_ha.fcClientLVM
partition_*_*__prtype = 5
partition_*_data__mountOptions = -o relatime,inode64
partition_*_log__mountOptions = -o relatime,inode64
partition_1_data__lvmname = FC5_data_mnt00001-vol
partition_1_log__lvmname = FC5_log_mnt00001-vol
partition_2_data__lvmname = FC5_data_mnt00002-vol
partition_2_log__lvmname = FC5_log_mnt00002-vol
sapcc-hana-tst-03:/hana/shared #
```

Using the SAP `hdblcm` installation tool, start the installation by running the following command at one of the worker hosts. Use the `addhosts` option to add the second worker (sapcc-hana-tst-04) and the standby host (sapcc-hana-tst-05).
The directory where the prepared the `global.ini` file has been stored is included with the `storage_cfg` CLI option (`--storage_cfg=/hana/shared`).
Depending on the OS version being used, it might be necessary to install phyton 2.7 before installing the SAP HANA database.

```
sapcc-hana-tst-03:/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_LCM_LINUX_X86_64 # ./hdblcm --action=install
--addhosts=sapcc-hana-tst-04:role=worker:storage_partion=2,sapcc-hana-tst
-05:role:=standby --storage_cfg=/hana(shared/shared


SAP HANA Lifecycle Management - SAP HANA Database 2.00.052.00.1599235305
************************************************************************


Scanning software locations...
Detected components:
    SAP HANA AFL (incl.PAL,BFL,OFL) (2.00.052.0000.1599259237) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_AFL_LINUX_X86_64/packages
    SAP HANA Database (2.00.052.00.1599235305) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_SERVER_LINUX_X86_64/server
    SAP HANA Database Client (2.5.109.1598303414) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_CLIENT_LINUX_X86_64/client
    SAP HANA Smart Data Access (2.00.5.000.0) in /mnt/sapcc-
```

```
share/software/SAP/HANA2SP5-
52/DATA_UNITS/SAP_HANA_SDA_20_LINUX_X86_64/packages
    SAP HANA Studio (2.3.54.000000) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/HDB_STUDIO_LINUX_X86_64/studio
    SAP HANA Local Secure Store (2.4.24.0) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HANA_LSS_24_LINUX_X86_64/packages
    SAP HANA XS Advanced Runtime (1.0.130.519) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/XSA_RT_10_LINUX_X86_64/packages
    SAP HANA EML AFL (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/HDB_EML_AFL_10_LINUX_X86_64/packages
    SAP HANA EPM-MDS (2.00.052.0000.1599259237) in /mnt/sapcc-
share/software/SAP/HANA2SP5-52/DATA_UNITS/SAP_HANA_EPM-MDS_10/packages
    GUI for HALM for XSA (including product installer) Version 1 (1.014.1)
in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACALMPIUI14_1.zip
    XSAC FILEPROCESSOR 1.0 (1.000.85) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACFILEPROC00_85.zip
    SAP HANA tools for accessing catalog content, data preview, SQL
console, etc. (2.012.20341) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_HRTT_20/XSACHRTT12_20341.zip
    XS Messaging Service 1 (1.004.10) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACMESSSRV04_10.zip
    Develop and run portal services for customer apps on XSA (1.005.1) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACPORTALSERV05_1.zip
    SAP Web IDE Web Client (4.005.1) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSAC_SAP_WEB_IDE_20/XSACSAPWEBIDE05_1.zip
    XS JOB SCHEDULER 1.0 (1.007.12) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACSERVICES07_12.zip
    SAPUI5 FESV6 XSA 1 - SAPUI5 1.71 (1.071.25) in /mnt/sapcc-
share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5FESV671_25.zip
    SAPUI5 SERVICE BROKER XSA 1 - SAPUI5 Service Broker 1.0 (1.000.3) in
/mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACUI5SB00_3.zip
    XSA Cockpit 1 (1.001.17) in /mnt/sapcc-share/software/SAP/HANA2SP5-
52/DATA_UNITS/XSA_CONTENT_10/XSACXSACOCKPIT01_17.zip


SAP HANA Database version '2.00.052.00.1599235305' will be installed.
```

```
Select additional components for installation:
  Index | Components | Description

-------------------------------------------------------------------------------
-------------------
  1     | all        | All components
  2     | server     | No additional components
  3     | client     | Install SAP HANA Database Client version
2.5.109.1598303414
  4     | lss        | Install SAP HANA Local Secure Store version
2.4.24.0
  5     | studio     | Install SAP HANA Studio version 2.3.54.000000
  6     | smartda    | Install SAP HANA Smart Data Access version
2.00.5.000.0
  7     | xs         | Install SAP HANA XS Advanced Runtime version
1.0.130.519
  8     | afl        | Install SAP HANA AFL (incl.PAL,BFL,OFL) version
2.00.052.0000.1599259237
  9     | eml        | Install SAP HANA EML AFL version
2.00.052.0000.1599259237
  10    | epmmds     | Install SAP HANA EPM-MDS version
2.00.052.0000.1599259237

Enter comma-separated list of the selected indices [3]: 2,3
Enter Installation Path [/hana/shared]:
Enter Local Host Name [sapcc-hana-tst-03]:
```

Verify that the installation tool installed all selected components at all worker and standby hosts.

Adding additional data volume partitions for SAP HANA single-host systems

Starting with SAP HANA 2.0 SPS4, additional data volume partitions can be configured. This feature allows you to configure two or more LUNs for the data volume of an SAP HANA tenant database and to scale beyond the size and performance limits of a single LUN.

> It is not necessary to use multiple partitions to fulfil the SAP HANA KPIs. A single LUN with a single partition fulfils the required KPIs.

> Using two or more individual LUNs for the data volume is only available for SAP HANA single-host systems. The SAP storage connector required for SAP HANA multiple-host systems does only support one device for the data volume.

You can add more data volume partitions at any time but it might require a restart of the SAP HANA database.

Enabling additional data volume partitions

To enable additional data volume partitions, complete the following steps:

1. Add the following entry within the `global.ini` file:

```
[customizable_functionalities]
persistence_datavolume_partition_multipath = true
```

2. Restart the database to enable the feature. Adding the parameter through the SAP HANA Studio to the `global.ini` file by using the Systemdb configuration prevents the restart of the database.

Volume and LUN configuration

The layout of volumes and LUNs is similar to the layout of a single host with one data volume partition, but with an additional data volume and LUN stored on a different aggregate as log volume and the other data volume. The following table shows an example configuration of an SAP HANA single-host systems with two data volume partitions.

Aggregate 1 at Controller A	Aggregate 2 at Controller A	Aggregate 1 at Controller B	Aggregate 2 at Controller B
Data volume: SID_data_mnt00001	Shared volume: SID_shared	Data volume: SID_data2_mnt00001	Log volume: SID_log_mnt00001

The next table shows an example of the mount point configuration for a single-host system with two data volume partitions.

LUN	Mount point at HANA host	Note
SID_data_mnt00001	/hana/data/SID/mnt00001	Mounted using /etc/fstab entry
SID_data2_mnt00001	/hana/data2/SID/mnt00001	Mounted using /etc/fstab entry
SID_log_mnt00001	/hana/log/SID/mnt00001	Mounted using /etc/fstab entry
SID_shared	/hana/shared/SID	Mounted using /etc/fstab entry

Create the new data LUNs by using either ONTAP System Manager or the ONTAP CLI.

Host configuration

To configure a host, complete the following steps:

1. Configure multipathing for the additional LUNs, as described in section 0.
2. Create the XFS file system on each additional LUN belonging to the HANA system.

```
stlrx300s8-6:/ # mkfs.xfs /dev/mapper/hana-SS3_data2_mnt00001
```

3. Add the additional file system/s to the `/etc/fstab` configuration file.

The XFS file systems for the data LUN must be mounted with the `relatime` and `inode64` mount options. The XFS file systems for the log LUN must be mounted with the `relatime`, `inode64`, and `nobarrier` mount options.

```
stlrx300s8-6:/ # cat /etc/fstab
/dev/mapper/hana-SS3_shared /hana/shared xfs defaults 0 0
/dev/mapper/hana-SS3_log_mnt00001 /hana/log/SS3/mnt00001 xfs
relatime,inode64 0 0
/dev/mapper/hana-SS3_data_mnt00001 /hana/data/SS3/mnt00001 xfs
relatime,inode64 0 0
/dev/mapper/hana-SS3_data2_mnt00001 /hana/data2/SS3/mnt00001 xfs
relatime,inode64 0 0
```

4. Create the mount points and set the permissions on the database host.

```
stlrx300s8-6:/ # mkdir -p /hana/data2/SS3/mnt00001
stlrx300s8-6:/ # chmod -R 777 /hana/data2/SS3
```

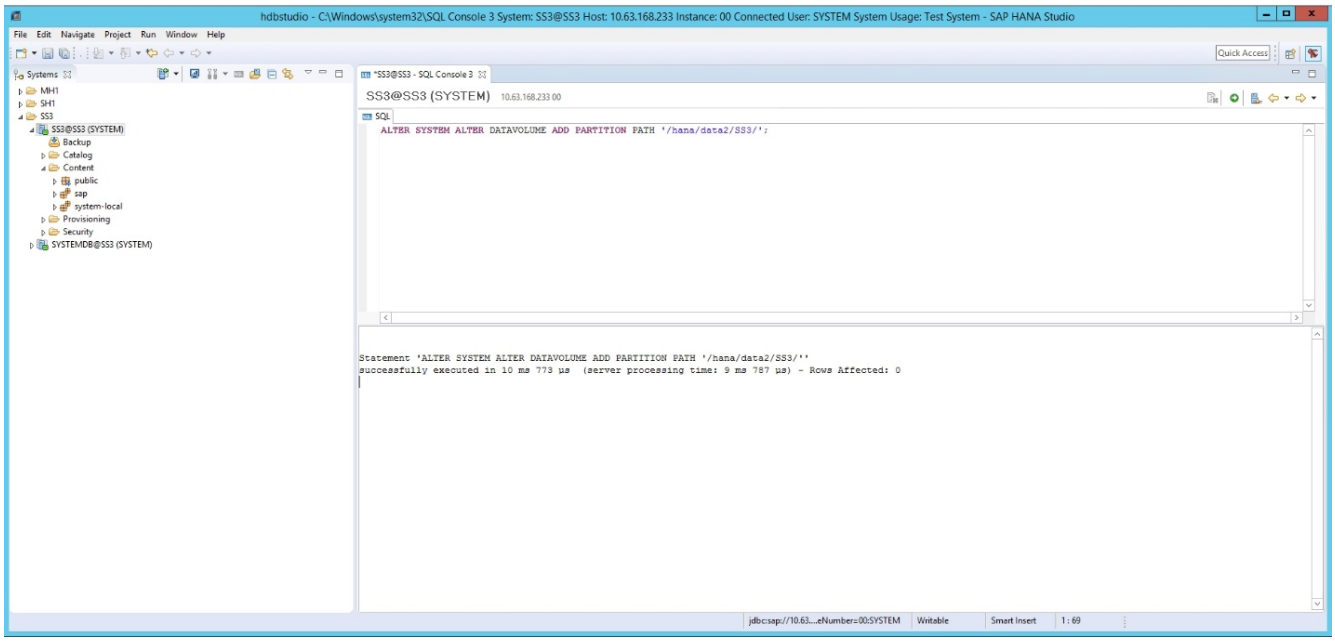
5. To mount the file systems, run the `mount -a` command.

Adding an additional datavolume partition

To add an additional datavolume partition to your tenant database, complete the following step:

1. Execute the following SQL statement against the tenant database. Each additional LUN can have a different path.

```
ALTER SYSTEM ALTER DATAVOLUME ADD PARTITION PATH '/hana/data2/SID/';
```



Where to find additional information

To learn more about the information described in this document, refer to the following documents and/or websites:

- Best Practices and Recommendations for Scale-Up Deployments of SAP HANA on VMware vSphere

  www.vmware.com/files/pdf/SAP_HANA_on_vmware_vSphere_best_practices_guide.pdf

- Best Practices and Recommendations for Scale-Out Deployments of SAP HANA on VMware vSphere

  http://www.vmware.com/files/pdf/sap-hana-scale-out-deployments-on-vsphere.pdf

- SAP Certified Enterprise Storage Hardware for SAP HANA

  https://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/enterprise-storage.html

- SAP HANA Storage Requirements

  http://go.sap.com/documents/2015/03/74cdb554-5a7c-0010-82c7-eda71af511fa.html

- SAP HANA Tailored Data Center Integration Frequently Asked Questions

  https://www.sap.com/documents/2016/05/e8705aae-717c-0010-82c7-eda71af511fa.html

- TR-4646: SAP HANA Disaster Recovery with Asynchronous Storage Replication Using SnapCenter 4.0 SAP HANA Plug-In

  https://www.netapp.com/us/media/tr-4646.pdf

- TR-4614: SAP HANA Backup and Recovery with SnapCenter

  https://www.netapp.com/us/media/tr-4614.pdf

- TR-4338: SAP HANA on VMware vSphere with NetApp FAS and AFF Systems

www.netapp.com/us/media/tr-4338.pdf

- TR-4667: Automating SAP System Copies Using the SnapCenter 4.0 SAP HANA Plug-in

  https://docs.netapp.com/us-en/netapp-solutions-sap/lifecycle/sc-copy-clone-introduction.html

- NetApp Documentation Centers

  https://www.netapp.com/us/documentation/index.aspx

- NetApp FAS Storage System Resources
- https://mysupport.netapp.com/info/web/ECMLP2676498.html
- SAP HANA Software Solutions

  www.netapp.com/us/solutions/applications/sap/index.aspx#sap-hana

TR-4821: SAP HANA on IBM Power Systems and NetApp AFF Systems with NFS

: hardbreaks:
:icons: font
:linkattrs:
:relative_path: ./bp/
:imagesdir: /tmp/d20231203-6435-uf6p21/source/./bp/./../media/

Tobias Brandl, NetApp

Carsten Dieterle, IBM

IBM Power Systems are designed for data-intensive and mission-critical workloads like SAP HANA. IBM Power Systems simplify and accelerate SAP HANA deployments by providing four key capabilities: superior virtualization and flexibility, faster provisioning, affordable scalability, and maximized uptime. The NetApp AFF product family is certified for use with SAP HANA in tailored data center integration (TDI) projects and perfectly complements IBM Power Systems. This document describes best practices for a NAS (NFS) storage setup using NetApp ONTAP with the AFF product family and IBM Power Systems.

https://www.netapp.com/pdf.html?item=/media/19887-TR-4821.pdf

TR-4250: SAP with Oracle on UNIX and NFS with NetApp ONTAP and SnapManager for SAP 3.4

: hardbreaks:
:icons: font
:linkattrs:
:relative_path: ./bp/
:imagesdir: /tmp/d20231203-6435-uf6p21/source/./bp/./../media/

Nils Bauer, NetApp

This document addresses the challenges of designing storage solutions to support SAP business suite products using an Oracle database. The primary focus of this document is the common storage infrastructure

design, deployment, operation, and management challenges faced by business and IT leaders who use the latest generation of SAP solutions. The recommendations in this document are generic; they are not specific to an SAP application or to the size and scope of the SAP implementation. This document assumes that the reader has a basic understanding of the technology and operation of NetApp and SAP products. The document was developed based on the interaction of technical staff from NetApp, SAP, Oracle, and our customers.

https://www.netapp.com/pdf.html?item=/media/19525-tr-4250.pdf

TR-4467: SAP with Microsoft SQL Server on Windows - Best Practices Using NetApp ONTAP and SnapCenter

Marco Schoen, NetApp

This document provides customers and partners with best practices for deploying NetApp ONTAP in support of SAP Business Suite solutions running in a Microsoft SQL Server in a Windows environment.

https://www.netapp.com/media/16865-tr-4467.pdf

Copyright information

Trademark information