

Virtualized SAP HANA on FlashStack: Design Considerations and Best Practices



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Introduction

Support for running SAP HANA virtualized and Tailored Datacenter Integration (TDI) option enable customers to align established data center processes and reuse existing infrastructure while implementing SAP HANA.

SAP supports VMware vSphere 6.5 and 6.7 for virtual deployments in production scenarios of SAP HANA on certified appliances and TDI verified hardware configurations. Customers thus can gain the benefits of virtualization for their SAP HANA environments and optimize costs through more efficient resource utilization. With Intel® Broadwell (running SAP HANA 1.0 SPS 12) and Intel Skylake processors (with SAP HANA 1.0 SPS 12 Revision 122.19, or with SAP HANA 2.0, recommended), virtual machines with up to 128 virtual CPUs (vCPUs) and 4 to 6 terabytes (TB) of main memory are possible.

The main use case for SAP HANA on VMware is within the TDI framework. Virtualized SAP HANA systems implemented by the customer using existing hardware listed in the Certified and Supported SAP HANA Hardware Directory should be verified with the SAP HANA Hardware Configuration Check Tool (HWCCT) to be sure that they qualify for SAP support. Increasing numbers of customers are taking advantage of the enhanced flexibility achieved by running SAP HANA TDI.

IDC confirmed in a recent survey (IDC US42198216) that Cisco is the leading vendor for SAP HANA infrastructure. In line with the current trend toward converged infrastructure to further simplify and support multitenant workload deployments, Cisco and Pure Storage have partnered to deliver FlashStack as a platform for a variety of SAP workloads, including fully virtualized workloads. FlashStack uses best-in-class server and network components integrated with Cisco Unified Computing System™ (Cisco UCS®) programmability features and backed by high-performance all-flash Non-Volatile Memory Express (NVMe)-based storage from Pure Storage. Using the Cisco UCS servers and FlashArray //X series arrays listed in the SAP HANA Hardware Directory's Certified Appliances and Certified Enterprise Storage sections, respectively, FlashStack provides an optimized platform for SAP HANA TDI.

Purpose of this document

This document provides configuration guidelines for implementing a virtualized SAP HANA on FlashStack converged infrastructure. It describes the best practices to be followed while configuring the storage, server, network, virtualization, and operating system layers for optimal operation.

Audience

This document is intended for IT architects, engineers, and administrators who are responsible for configuring and deploying the SAP HANA platform in a VMware virtualization environment. It assumes that the reader has a basic knowledge of FlashStack, Cisco UCS, Pure Storage FlashArray, VMware vSphere, Linux, and SAP HANA TDI scenarios.

Document reference

The Cisco® Validated Design document [FlashStack Virtual Server Infrastructure with Fibre Channel Storage for VMware vSphere 6.5 U1](#) provides the foundation design for this solution. This document builds on that foundation, focusing on preparation of the infrastructure to support a virtualized SAP HANA system. It describes the steps that need to be performed for the various layers of the architecture.

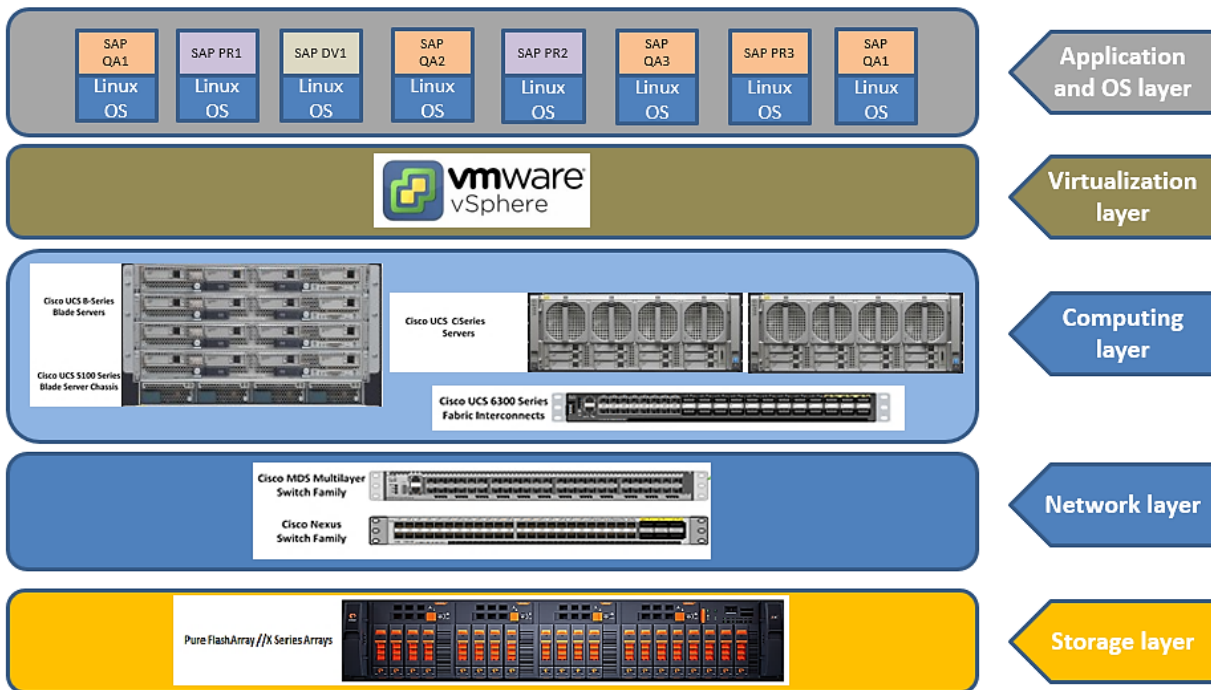
The best practices documented here are consistent with [VMware's best practices guide for SAP HANA](#). This document serves as a reference for implementing a virtualized SAP HANA solution on FlashStack converged infrastructure.

Reference architecture

Figure 1 shows the various layers of architecture, from the storage layer to the application layer. It shows the possible constituents of each layer for FlashStack converged infrastructure.

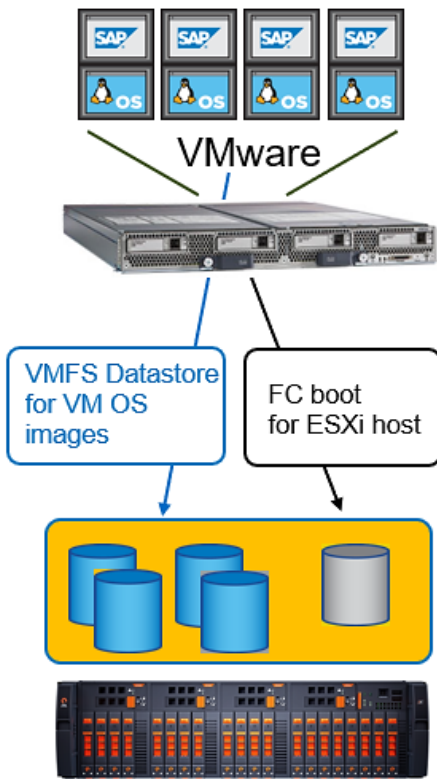
FlashArray //X series arrays make up the storage layer. Cisco MDS 9100 Series Multilayer Fabric Switches and Cisco Nexus® 9000 Series Switches at the network layer service, respectively, Fibre Channel and Ethernet traffic. Cisco UCS C-Series Rack Servers and B-Series Blade Servers provide the computing layer. SAP HANA is installed in virtual machines running either the SUSE Linux Enterprise Server (SLES) or Red Hat Enterprise Linux (RHEL) OS hosted on the VMware ESXi virtualization platform.

Figure 1. Architecture overview: Layered representation



Virtualized SAP HANA implementations use Fibre Channel and Network File System (NFS) protocols. The ESXi hosts are configured to boot from SAN, and the SAP HANA virtual machines have their OS installed in the VMware Virtual Machine File System (VMFS) data store. The Small Computer System Interface over IP (iSCSI) storage protocol may also be used to boot ESXi hosts (Figure 2).

Figure 2. OS boot mechanism



For each SAP HANA node in a virtual machine, a data volume; a log volume; and a volume for executable files, configurations, and application logs are configured. The persistence volumes for the SAP HANA system are carved out of the dedicated VMFS data store. The NFS-based SAP HANA binary file system is mounted directly on the provisioned SAP HANA virtual machine using the dedicated network connection to the storage.

The storage configuration and sizing for a virtualized SAP HANA system is identical to that for bare-metal servers. The existing SAP HANA storage requirements for the partitioning, configuration, and sizing of data, log, and binary volumes remain valid for virtualization scenarios.

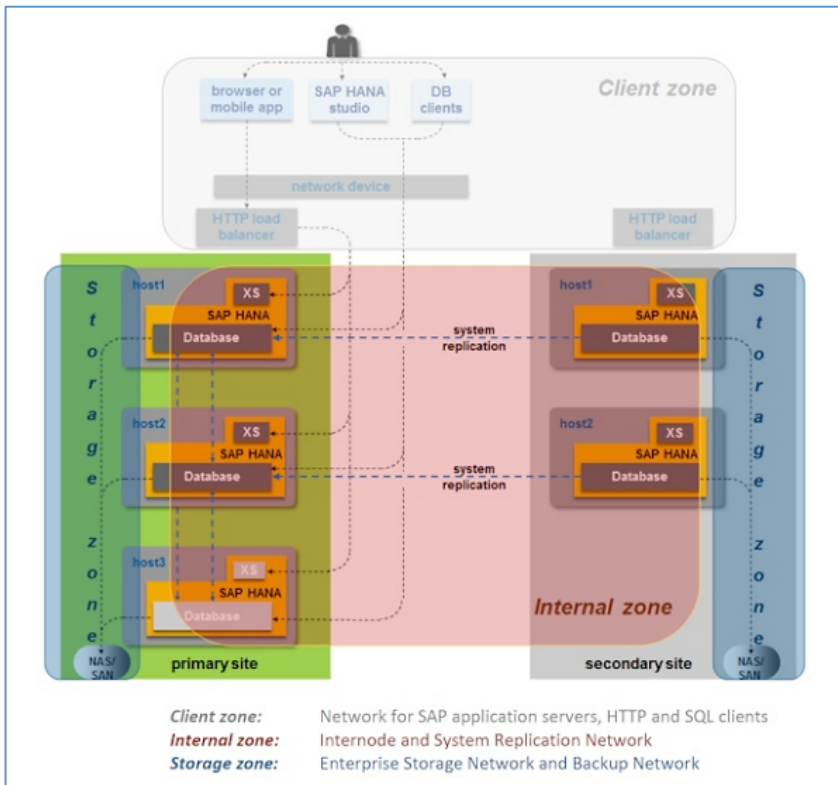
The configuration flow starts with the definition of VLANs specific to SAP HANA that correspond to the various networks required by the system.

Network layer

SAP categorizes the SAP HANA system networks into three logical communication zones (Figure 3):

- Client zone: External communication networks consisting of application server and client connectivity networks
- Internal zone: Internal communication networks consisting of the internode communication network in a scale-out system and the replication network for traffic in a distributed configuration
- Storage zone: All storage-related networks consisting of the NFS-based /hana/shared file system access network along with the dedicated backup network

Figure 3. SAP HANA TDI network requirements (source: SAP SE)



The system also includes a management zone consisting of the ESXi host management network and a SAP HANA virtual machine vMotion network, at a minimum. The configuration steps are presented in the Cisco Validated Design.

1. Create the SAP HANA system-specific VLANs on the Cisco Nexus switch pair.

```

vlan <<var_admin_vlan_id>>
name HANA-Mgmt

vlan <<var_vmotion_vlan_id>>
name HANA-vMotion

vlan <<var_internal_vlan_id>>
name HANA-Internal

vlan <<var_backup_vlan_id>>
name HANA-Backup

vlan <<var_client_vlan_id>>
name HANA-Client
    
```

```
vlan <<var_appserver_vlan_id>>
name HANA-AppServer
```

```
vlan <<var_datasource_vlan_id>>
name HANA-DataSource
```

```
vlan <<var_replication_vlan_id>>
name HANA-Replication
```

```
vlan <<var_hanashared_vlan_id>>
name HANA-NFSshared
```

Note: The configuration variables in double angle brackets are placeholders for customer-specific VLAN values. The naming conventions used in this document are only suggestions and can be altered according to customer requirements.

2. Verify that the defined VLANs are allowed on the Cisco UCS port channels and the virtual port channel (vPC) peer link of the uplink Cisco Nexus switch pair.

Computing layer

In Cisco UCS, one approach to setting up a tenant’s virtualized SAP HANA system is to dedicate a VMware ESXi cluster with a set of Cisco UCS servers for each tenant.

1. Create the SAP HANA VLANs in Cisco UCS within the LAN cloud.

LAN / LAN Cloud / VLANs						
VLANs						
Advanced Filter Export Print						
Name	ID	Type	Transport	Native	VLAN Sharing	
VLAN HANA-AppServer (223)	223	Lan	Ether	No	None	
VLAN HANA-Backup (221)	221	Lan	Ether	No	None	
VLAN HANA-Client (222)	222	Lan	Ether	No	None	
VLAN HANA-DataSource (224)	224	Lan	Ether	No	None	
VLAN HANA-Internal (220)	220	Lan	Ether	No	None	
VLAN HANA-Mgmt (76)	76	Lan	Ether	No	None	
VLAN HANA-NFSshared (111)	111	Lan	Ether	No	None	
VLAN HANA-Replication (225)	225	Lan	Ether	No	None	
VLAN vMotion (200)	200	Lan	Ether	No	None	

2. Create virtual network interface card (vNIC) templates for the SAP HANA traffic: one each for Fabric A and Fabric B. These templates are in addition to the vNIC templates for management and vMotion traffic on Fabrics A and B. For a scale-out system requiring access to SAP application servers, SAP DataSource, the NFS share for /hana/shared, and internode networks, create the vNIC templates as shown here:

Create vNIC Template ? X

Name :

Description :

Fabric ID : Fabric A Fabric B Enable Failover

Redundancy

Redundancy Type : No Redundancy Primary Template Secondary Template

Peer Redundancy Template :

Target

Adapter VM

Warning

If VM is selected, a port profile by the same name will be created.
If a port profile of the same name exists, and updating template is selected, it will be overwritten

Template Type : Initial Template Updating Template

VLANs | VLAN Groups

Advanced Filter | Export | Print

Select	Name	Native VLAN
<input checked="" type="checkbox"/>	HANA-AppServer	<input type="radio"/>
<input type="checkbox"/>	HANA-Backup	<input type="radio"/>
<input type="checkbox"/>	HANA-Client	<input type="radio"/>
<input checked="" type="checkbox"/>	HANA-DataSource	<input type="radio"/>
<input checked="" type="checkbox"/>	HANA-Internal	<input type="radio"/>
<input type="checkbox"/>	HANA-Mgmt	<input type="radio"/>
<input checked="" type="checkbox"/>	HANA-NFSshared	<input type="radio"/>
<input type="checkbox"/>	HANA-Replication	<input type="radio"/>

Create VLAN

CDN Source : vNIC Name User Defined

MTU :

MAC Pool :

QoS Policy :

Network Control Policy :

Pin Group :

Stats Threshold Policy :

Connection Policies

Dynamic vNIC usNIC VMQ

Dynamic vNIC Connection Policy :

Create vNIC Template ?

Name : vNIC_vHANA_B

Description : For virtualized HANA system networks via Fabric B

Fabric ID : Fabric A Fabric B Enable Failover

Redundancy

Redundancy Type : No Redundancy Primary Template Secondary Template

Peer Redundancy Template : vNIC_vHANA_A

Target

Adapter VM

Warning

If **VM** is selected, a port profile by the same name will be created.
If a port profile of the same name exists, and updating template is selected, it will be overwritten

Template Type : Initial Template Updating Template

VLANs | VLAN Groups

Advanced Filter | Export | Print

Select	Name	Native VLAN
<input checked="" type="checkbox"/>	HANA-AppServer	<input type="radio"/>
<input type="checkbox"/>	HANA-Backup	<input type="radio"/>
<input type="checkbox"/>	HANA-Client	<input type="radio"/>
<input checked="" type="checkbox"/>	HANA-DataSource	<input type="radio"/>
<input checked="" type="checkbox"/>	HANA-Internal	<input type="radio"/>
<input type="checkbox"/>	HANA-Mgmt	<input type="radio"/>
<input checked="" type="checkbox"/>	HANA-NFSshared	<input type="radio"/>
<input type="checkbox"/>	HANA-Replication	<input type="radio"/>

Create VLAN

CDN Source : vNIC Name User Defined

MTU : 9000

MAC Pool : FI-B(100/128)

QoS Policy : <not set>

Network Control Policy : Enable_CDP

Pin Group : <not set>

Stats Threshold Policy : default

Connection Policies

Dynamic vNIC usNIC VMQ

Dynamic vNIC Connection Policy : <not set>

Note: Creation of VLAN groups based on the different network zones as mandated by SAP mapped to different uplink port channels requires creation of separate vNIC templates for corresponding groups of networks. One vNIC each for Fabric A and Fabric B encompassing all networks related to SAP HANA is sufficient if the VLAN groups were assigned to the same uplink port channels.

3. Create the LAN connectivity policy for the vNICs based on the two additional vNIC templates created for the virtualized SAP HANA use case, to be used with the service profile template.

Create vNIC

Name :

Use vNIC Template :

Redundancy Pair :

vNIC Template :

Adapter Performance Profile

Adapter Policy :

Create vNIC

Name :

Use vNIC Template :

Redundancy Pair :

vNIC Template :

Adapter Performance Profile

Adapter Policy :

The LAN connectivity policy is shown here:

LAN / Policies / root / Sub-Organizations / HANA / LAN Connectivity Policies / vHANA-LAN-Policy

General | Events

Actions

Delete

Show Policy Usage

Use Global

Name : **vHANA-LAN-Policy**

Description :

Owner : **Local**

Click **Add** to specify one or more vNICs that the server should use to connect to the LAN.

Name	MAC Address
▶ vNIC 00-Mgmt-A	Derived
▶ vNIC 01-Mgmt-B	Derived
▶ vNIC 02-vMotion-A	Derived
▶ vNIC 03-vMotion-B	Derived
▶ vNIC 04-vHANA-A	Derived
▶ vNIC 05-vHANA-B	Derived

The corresponding vNICs in the service profile template are shown here:

Servers / Service Profiles / root / Sub-Organizations / HANA / Service Profile vHANA-host1

General Storage **Network** iSCSI vNICs vMedia Policy Boot Order Virtual Machines FC Zones Policies Server Details

LAN Connectivity Policy : vHANA-LAN-Policy

LAN Connectivity Policy Instance : org-root/org-HANA/lan-conn-pol-vHANA-LAN-Policy

Create LAN Connectivity Policy

No Configuration Change of vNICs/vHBAs/iSCSI vNICs is allowed due to connectivity policy.

vNICs

Advanced Filter Export Print

Name	MAC Address	Desired Order	Actual Order	Fabric ID	Desired Placement	Actual Placement
vNIC 00-Mgmt-A	00:25:B5:00:0A:09	2	1	A	1	1
vNIC 01-Mgmt-B	00:25:B5:00:0B:09	2	1	B	3	3
vNIC 02-vMotion-A	00:25:B5:00:0A:0A	3	2	A	1	1
vNIC 03-vMotion-B	00:25:B5:00:0B:0A	3	2	B	3	3
vNIC 04-vHANA-A	00:25:B5:00:0A:0B	4	4	A	1	1
vNIC 05-vHANA-B	00:25:B5:00:0B:0B	4	4	B	3	3

- In addition to the existing Infra-DSwitch that services the management and vMotion networks, create a vSphere distributed switch (vDS) exclusively for SAP HANA system-specific networks.

New Distributed Switch

1 Name and location

2 Select version

3 Edit settings

4 Ready to complete

Ready to complete

Review your settings selections before finishing the wizard.

Name: vHANA-DSwitch

Version: 6.6.0

Number of uplinks: 2

Network I/O Control: Enabled

Default port group: AppServer

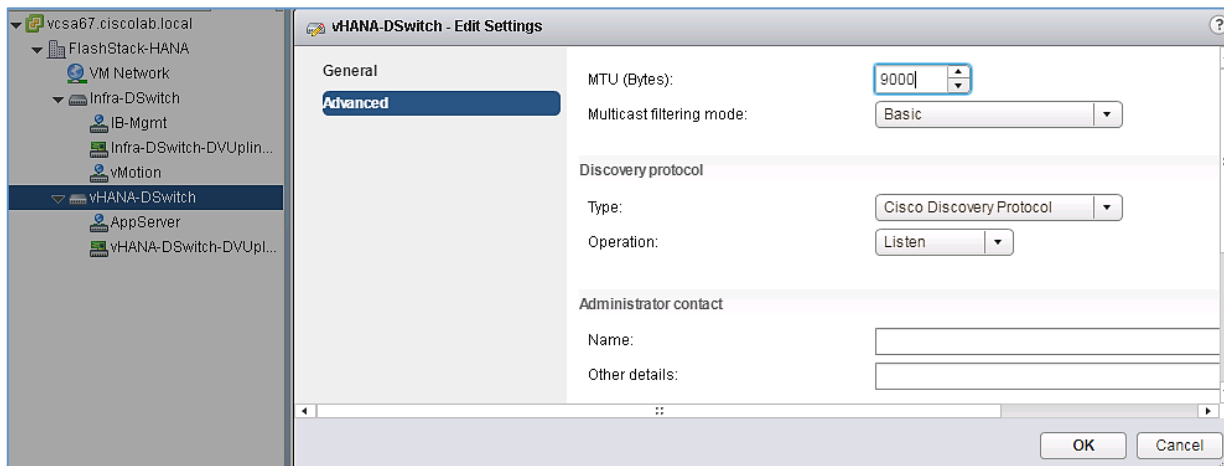
Suggested next actions

- New Distributed Port Group
- Add and Manage Hosts

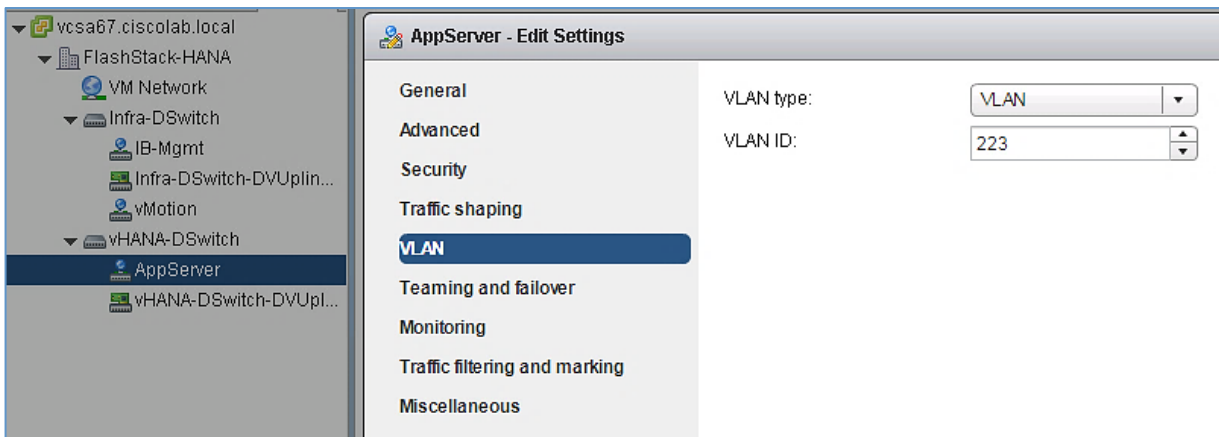
These actions will be available in the Actions menu of the new distributed switch.

Back Next Finish Cancel

5. Edit the settings of the newly created vHANA-DSwitch. Change the maximum transmission unit (MTU) setting from 1500 to 9000.



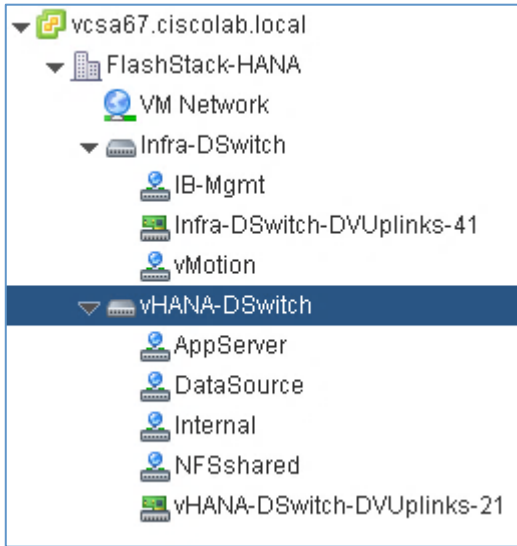
6. Edit the properties of the first distributed port group created for AppServer. Change the VLAN type from None to VLAN, and enter the appropriate VLAN number for this designated network (VLAN 223 in this example). The important settings for application server network distributed port group are shown here:



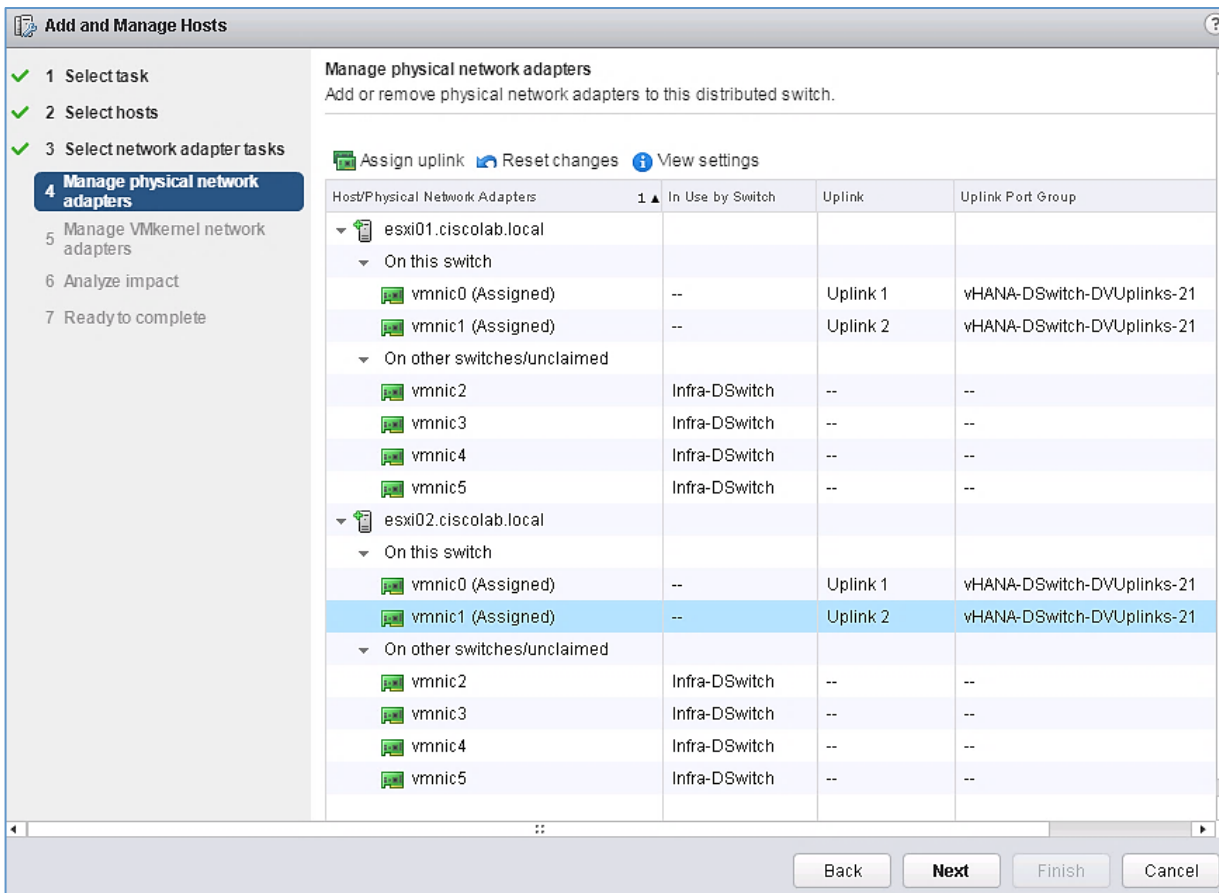
Note: You do not need to adjust NIC teaming for the application distributed port groups. The groups will be active-active within the two vNIC uplinks associated with vHANA-DSwitch, using the default VMware route based on the originating virtual port load-balancing algorithm.

7. Create additional distributed port groups for other application networks, setting the appropriate VLAN ID for each new distributed port group. In the scale-out system example discussed here, distributed port groups corresponding to AppServer, DataSource, internode, and NFS-shared networks are created.

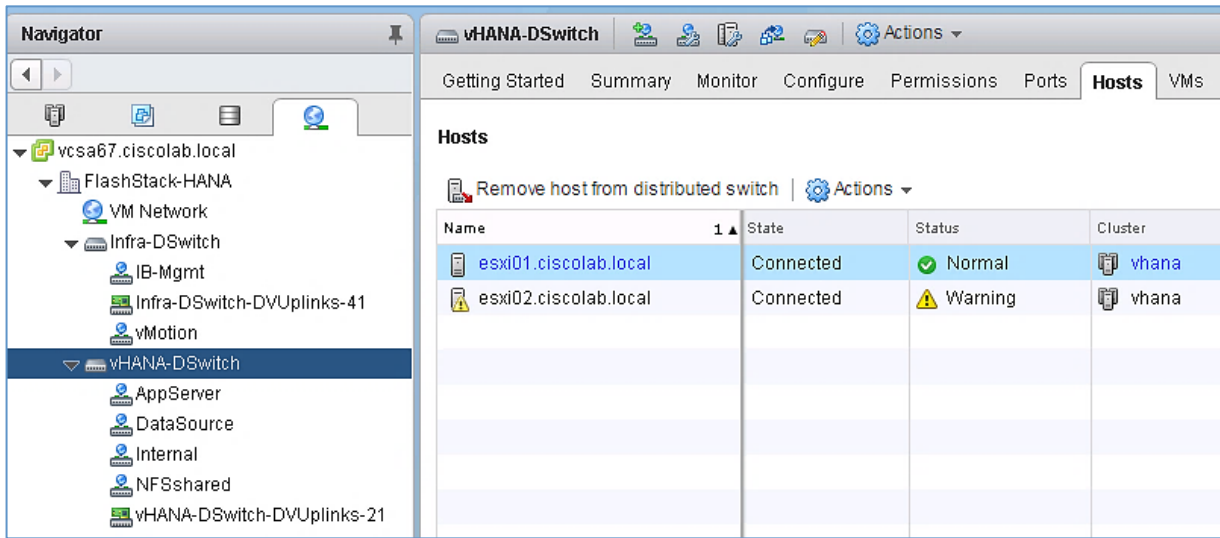
The resulting port group configuration after SAP HANA networks have been added is shown here:



- While adding hosts to manage the virtual network under the vCenter vHANA-DSwitch, assign the vmnics that correspond to the SAP HANA network vNICs added earlier (vmnic0 and vmnic1 in this example) as the uplink to the distributed virtual uplinks. The only VMkernel network adapter is for the management network that is already assigned to the IB-Mgmt distributed port group of Infra-DSwitch.



- Click Next to analyze the impact on iSCSI, and click Finish to migrate the SAP HANA network vmnics to the centralized distributed virtual switch.



The SAP HANA-specific vDS, vHANA-DSwitch, has two redundant uplinks. These are used by the SAP HANA network port groups in active-active mode.

Virtualization and OS layers

The virtualization and OS layers consist of the VMware ESXi, virtual machine, and OS configurations.

Multipath configuration

VMware vSphere ESXi provides the platform for the virtualized SAP HANA system virtual machines. ESXi uses its Native Multipathing Plugin (NMP) architecture to manage I/O multipathing to underlying SAN storage volumes.

FlashArray has an active-active front-end controller architecture. FlashArray volumes are preferably claimed, by default, by the Storage Array Type Plugin (SATP) for Asymmetric Logical Unit Access (ALUA) devices and use round-robin (RR) path-selection policy (PSP). That is, they use VMW_PSP_RR with an I/O operations limit of 1 in order to alternate logical paths after every I/O operation. Refer to [VMware Docs](#) for more information.

```
[root@esxi01:~] esxcli storage nmp satp rule list | grep "FlashArray"
VMW_SATP_ALUA      PURE      FlashArray      system      VMW_PSP_RR      iops=1
[root@esxi01:~] █
```

If this setup is not available in a particular ESXi release, the same result can be achieved by running the following command on each ESXi host prior to the presentation of FlashArray devices:

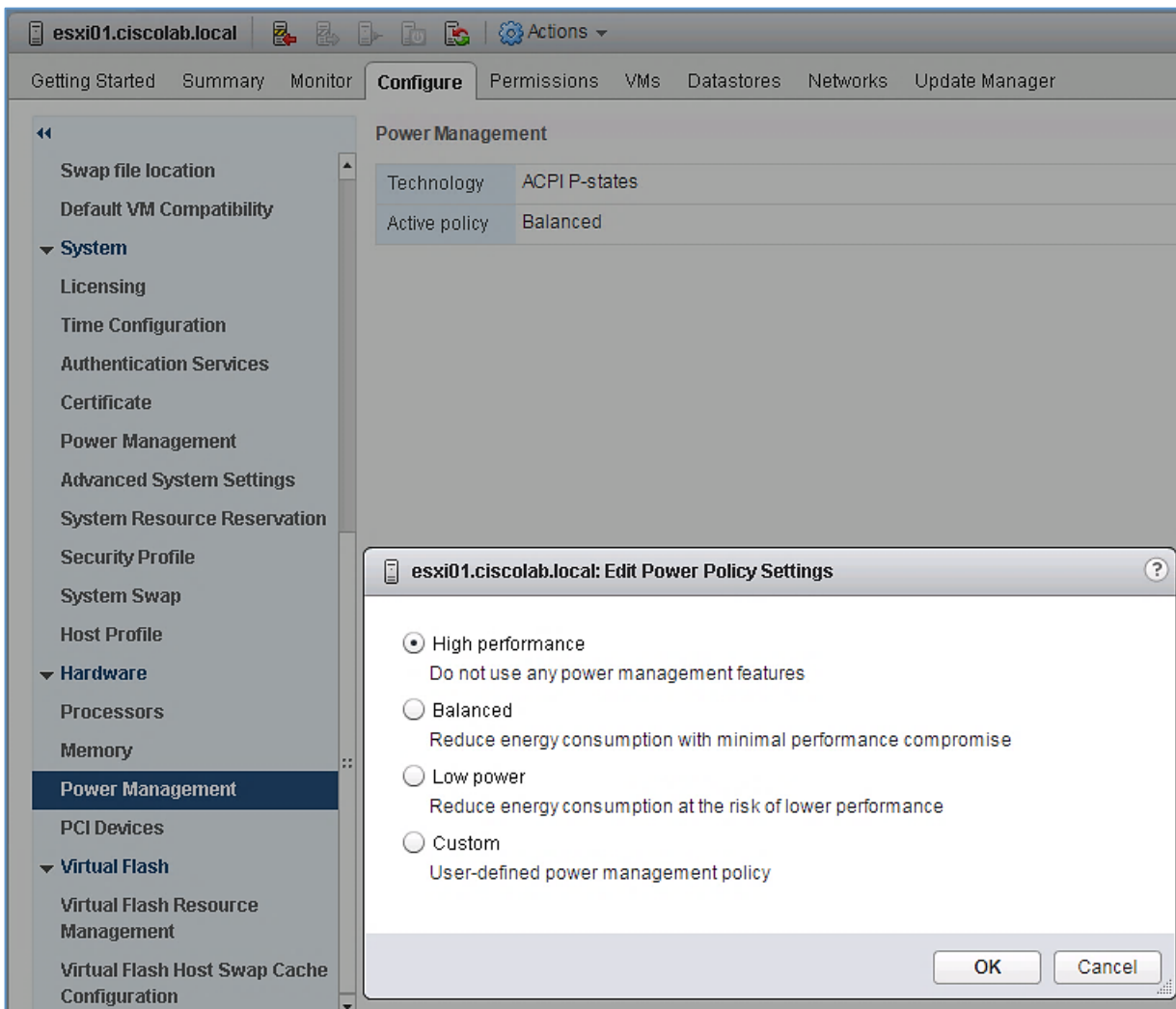
```
#esxcli storage nmp satp rule add -s "VMW_SATP_ALUA" -v "PURE" -M "FlashArray" -P "VMW_PSP_RR" -O "iops=1"
```

Power management

A Cisco UCS service profile defines a single server and its storage and networking characteristics. It is a logical representation of a server that encapsulates identity, configuration, and connectivity information. Service profiles also include operational policy information such as BIOS parameters, boot paths, and boot order.

SAP HANA workloads are sensitive to latency. Because achieving the lowest possible latency and saving power on the hosts are mutually exclusive, the recommended approach is to disable any form of power management to aid applications when performance needs are more important. In this case, you should disable the C-state and enhanced C-state (C1E) power management options in the Cisco UCS service profile BIOS policy settings.

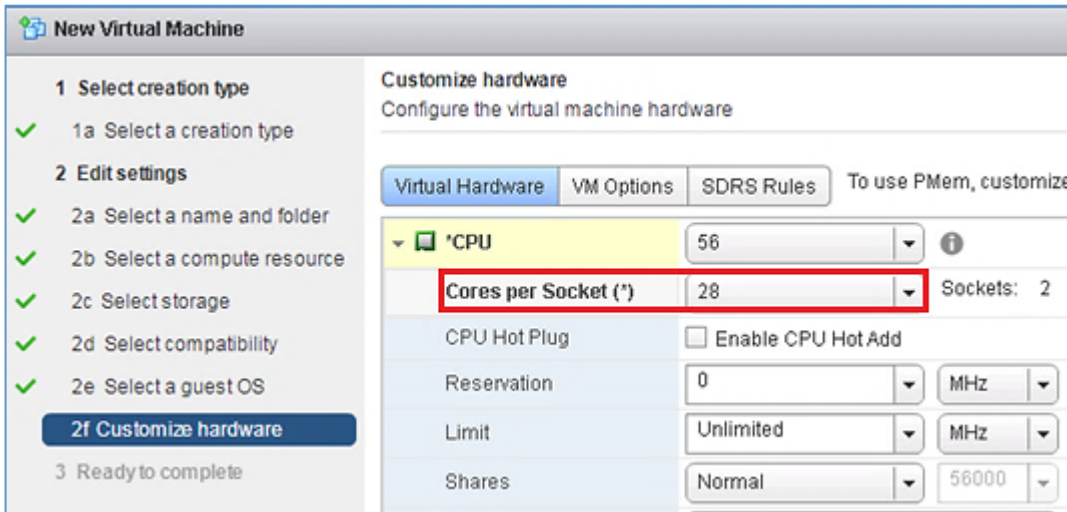
Additionally, set the ESXi host's hardware power management to high-performance mode.



Virtual machine configuration

Configure the virtual machine.

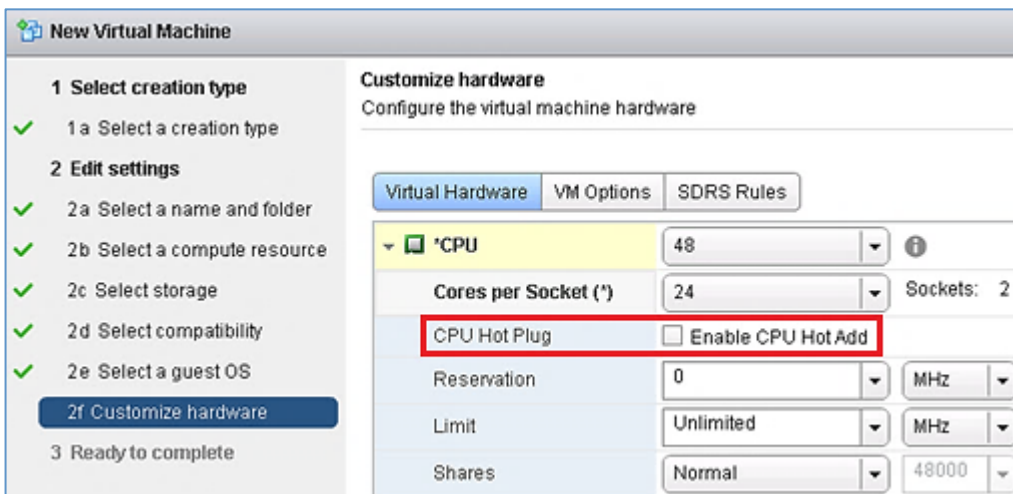
1. The recommended approach for configuring virtual machines is to configure the number of cores per socket to match the actual hardware configuration. For example, configure 22 cores per socket for Intel Xeon processor E7-8880 v4, 24 cores per socket for Intel Xeon processor E7-8890 v4, and 28 cores per socket for Intel Xeon Platinum 8180 and 8176 processors.



- Reserve CPU and, especially, memory resources for production virtual machines. Select the “Reserve all guest memory (All locked)” option.



- Be sure that the vCPU hot plug is not selected because it disables the virtual non-uniform memory access (vNUMA) optimization feature.



- Use paravirtual adapter VMXNET 3 vNICs to configure the network interfaces for all the networks defined.

cisvhana01 - Edit Settings

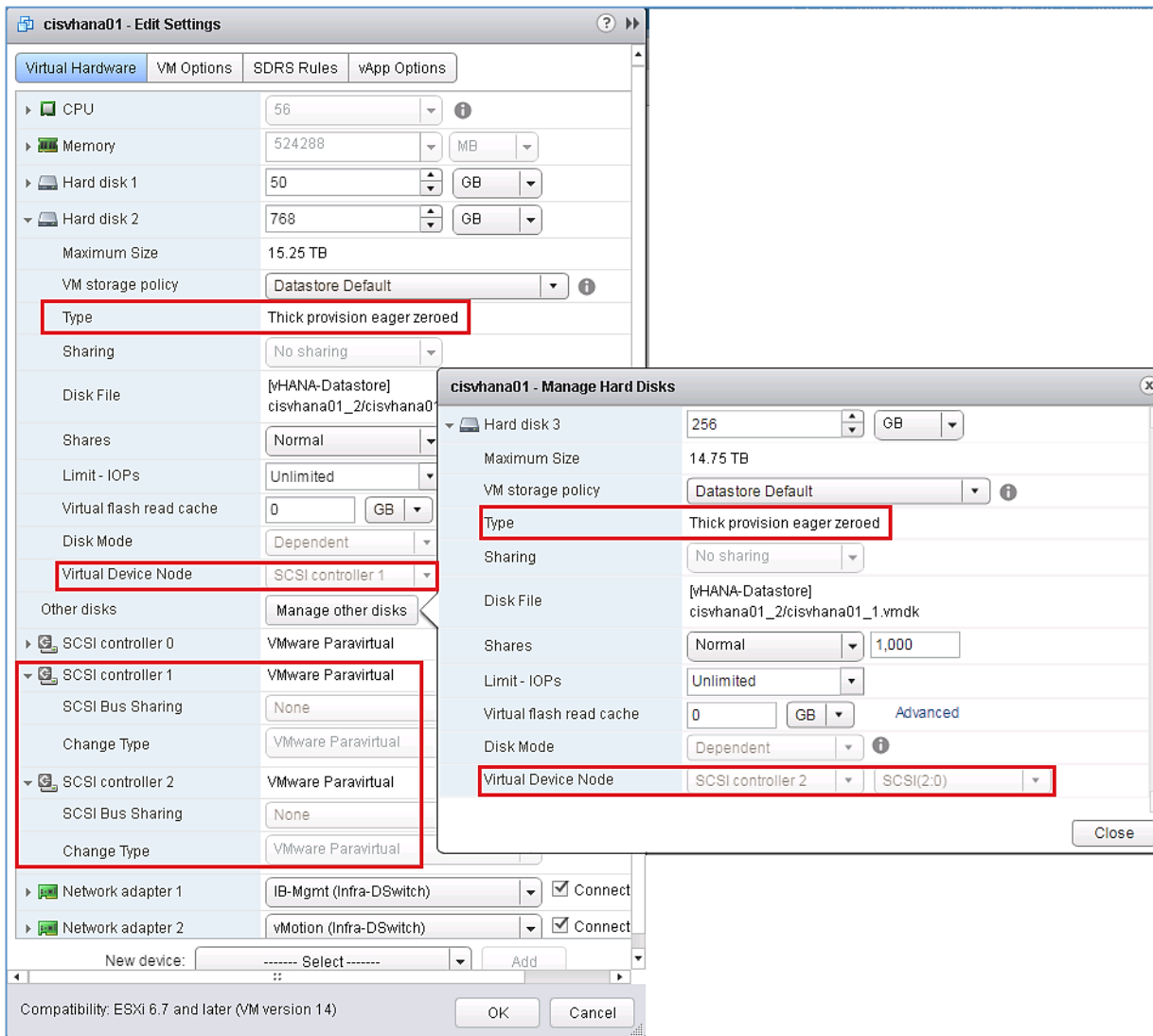
Virtual Hardware | VM Options | SDRS Rules | vApp Options

- CPU: 56
- Memory: 524288 MB
- Hard disk 1: 50 GB
- SCSI controller 0: VMware Paravirtual
- Network adapter 1:
 - IB-Mgmt (Infra-DSwitch) [Connected]
 - Status: Connect At Power On
 - Port ID: 3
 - Adapter Type: VMXNET 3**
 - DirectPath I/O: Enable
 - MAC Address: 00:0c:29:10:b0:eb [Automatic]
 - Shares: Normal, 50
 - Reservation: 0 Mbit/s
 - Limit: Unlimited Mbit/s
- Network adapter 2: vMotion (Infra-DSwitch) [Connected]
- Network adapter 3: NFSshared (vHANA-DSwitch) [Connected]
- Network adapter 4: AppServer (vHANA-DSwitch) [Connected]
- Network adapter 5: DataSource (vHANA-DSwitch) [Connected]
- Network adapter 6: Internal (vHANA-DSwitch) [Connected]
- CD/DVD drive 1: Datastore ISO File [Connected]
- USB controller: USB 2.0
- Video card: Specify custom settings
- VMCI device
- SATA controller 0
- Other Devices

New device: ----- Select ----- [Add]

Compatibility: ESXi 6.7 and later (VM version 14) [OK] [Cancel]

5. Use a dedicated SCSI controller of type VMware Paravirtual for each data, log, and /hana/shared disk (only for scale-up scenarios) to implement parallel I/O processing by separating the disk I/O streams. Also use eager-zeroed thick provisioning for SAP HANA data and log disks.



Operating system

To configure optimal settings for running SAP HANA on SLES or RHEL, refer to the SAP Notes that provide the SAP HANA database recommended OS settings guidelines as you would do for bare-metal implementations. See the “For more information” section of this document for all relevant SAP Notes.

ESXi has its own I/O scheduling mechanism, which not only makes guest OS I/O scheduling redundant but also adds unnecessary overhead. The recommended approach is to disable I/O scheduling at the virtual machine level. Append `elevator=noop` to the kernel boot arguments.

Application layer

Both scale-up and scale-out configurations are possible in the virtualized environment, just as they are in bare-metal scenarios. Note the following points when implementing these configurations on FlashStack:

- In a scale-up system configuration, /hana/shared can also be a virtual machine disk (VMDK) created from the same data store as the one that hosts the data and log disks of the SAP HANA instance because it is local to that instance. It does not necessarily have to be an NFS mount.
- In a scale-out configuration, /hana/shared must be accessible by all nodes of the scale-out cluster concurrently and at all times, requiring it to be an NFS mount. With Pure Storage Purity//FA 4.10.9 or later, virtual machine instances of Microsoft Windows Server 2016 can be running in each of the controllers, forming a Windows failover cluster. File servers will then be created within the cluster to serve as NFS shares.

Refer to [Pure Storage's Support Portal documentation for guidelines for configuring Windows File Services for the Purity Run platform](#). This process is also covered in detail in the [FlashStack for SAP HANA TDI Cisco Validated Design](#), in the section “Configure NFS share for /hana/shared.”

Storage layer

The Pure Storage Purity operating environment automatically handles tuning, encryption, solid-state disk (SSD) wear leveling, and data resiliency (among other operations) at the array level. You only need to name the volume (the target for the data store), enter the size, and attach the volume to the appropriate ESXi host groups.

An important benefit of Pure Storage FlashArray//X is that it enables customers to design their SAP HANA environment data stores with a logical approach rather than constraining them to the limitations of virtual machines per data store. However, as a good practice, customers should at least segregate the instance's OS boot disks and SAP HANA disks (data, log, and /hana/shared) in separate data stores.

A single data store hosting SAP HANA disks (data, log, and shared) would also suffice to support multiple virtualized SAP HANA instances for most use cases. Configuring separate data stores for data (requiring higher read performance) and logs (requiring higher write performance), though desirable, may not be necessary because the back-end all-flash array provides a uniform performance-class I/O subsystem, managed by the Purity operating environment.

For scale-out system scenarios, you should mount the NFS share created for /hana/shared directly in the SAP HANA virtual machine's guest OS using the dedicated network connection to the NFS server created within the Windows File Services framework of the Purity Run platform.

Refer to [FlashArray VMware Best Practices](#) for more information.

Sizing

This section provides sizing guidelines based on the virtual machine memory-to-vCPU ratio and the number of virtualized SAP HANA instances and hosts supported by Pure Storage FlashArray//X.

Computing

The CPU platform's generation number and SAP's guidelines for the memory range supported for the socket count are the basis for sizing virtualized SAP HANA instances. The vCPU and virtual RAM (vRAM) maximums for a specific vSphere ESXi version also influence the sizing. Additionally, some memory overhead should be considered because ESXi needs some for its own kernel and for hosting virtual machine memory pages. Refer to the [VMware documentation](#) for more information.

With the Intel Xeon Platinum platform, SAP allows memory configurations of 128 GB to 3 TB on four-way server systems for SAP Business Warehouse on HANA (BWoH). It allows up to 6 TB for SAP Suite on HANA (SoH) workloads. With SAP HANA TDI Phase 5, SAP extends the support for Intel E7 CPUs to include all Intel Broadwell E7 and Skylake (Platinum, Gold, and Silver) with eight or more cores per socket. This support makes a wide range of CPUs available for customers to choose from to serve their specific workloads.

Table 1 provides a reference matrix showing technically feasible virtual machine configurations with the current top-of-the-line Intel Xeon Platinum platform (supported only on Cisco UCS M5 servers) and previous Intel Xeon processor generations.

Table 1. Virtual machine sizing: vCPU and vRAM with processor platform matrix

vCPU (with hyperthreading on)								vRAM	
Intel Xeon E7 v4 8880			Intel Xeon E7 v4 8890				Intel Xeon Platinum 8180 and 8176		
BWoH		SoH	BWoH		SoH		BWoH	SoH	
≤SPS10	≥SPS11		≤SPS10	≥SPS11	≤SPS11	≥SPS12			
22	22	22	24	24	24	24	28	28	32
22	22	22	24	24	24	24	28	28	64
22	22	22	24	24	24	24	28	28	128
22	22	22	24	24	24	24	28	28	256
44	44	22	48	48	24	24	28	28	384
66	44	44	72	48	48	24	28	28	512
88	66	44	96	72	48	48	56	28	768
110	88	66	120	96	72	48	84	28	1024
	110	88		120	96	72	112	56	1536
		110			120	96		84	2048
						120		112	3072

Storage

SAP requires customers to meet key performance indicators (KPIs) for storage throughput for productive SAP HANA systems. The number of SAP HANA hosts differs for different storage systems, so the optimum ratio of storage systems to SAP HANA nodes is determined during the sizing process. Nonproduction SAP HANA systems do not need to meet the storage throughput KPIs; however, as a good practice you should include them in the sizing process to achieve the expected performance.

For more information about the HWCCT-based fsperf parameters, refer to SAP Note 1943937.

For more information

Consult the references listed here for additional information.

Certified SAP HANA Hardware Directory

Certified SAP HANA Hardware Directory: [Enterprise Storage](#)

SAP HANA TDI documentation

SAP HANA TDI: [Overview](#)

SAP HANA TDI: [FAQ](#)

SAP HANA TDI: [Storage requirements](#)

SAP HANA TDI: [Network requirements](#)

SAP Notes

[SAP Notes related to VMware](#)

SAP Note [2161991: VMware vSphere configuration guidelines](#)

SAP Note [1788665: SAP HANA Support for virtualized and partitioned \(multitenant\) environments](#)

SAP Note [2393917: SAP HANA on VMware vSphere 6.5 in production](#)

SAP Note [1943937: Hardware Configuration Check Tool—Central note](#)

SAP Note [2235581: SAP HANA: Supported operating systems](#)

SAP Note [2205917: SAP HANA DB: Recommended OS settings for SLES 12 and SLES for SAP Applications 12](#)

SAP Note [2292690: SAP HANA DB: Recommended OS settings for RHEL 7](#)

Additional resources

SAP Community Network: [SAP HANA TDI on Cisco UCS and VMware vSphere](#)

SAP Document Archive: <https://archive.sap.com/documents/docs/DOC-60312>

Cisco UCS: [Design Zone for SAP applications](#) (technical documentation)

Cisco UCS: [Data center solutions for SAP](#) (customer references)

VMware blog: [SAP on VMware updates](#)

Pure Storage, Pure1: [Microsoft Windows Files Services on Purity Best Practices](#)

Pure Storage Support portal web guide: [FlashArray VMware Best Practices](#)

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