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BEST PRACTICES

SAP HANA on AHV

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Contents

1. Executive Summary

SAP helps customers migrate from traditional relational databases to their in-memory SAP HANA database to gain more agility in their business processes. Many SAP customers are searching for ways to deploy SAP HANA in an efficient, simple way that minimizes risk and preserves the benefits of an agile platform. Nutanix provides such an option.

This document outlines mandatory steps and best practices for deploying SAP HANA on the Nutanix Cloud Platform to help you achieve the best possible performance and obtain production support from SAP for your SAP HANA database VMs.

This SAP HANA on Nutanix best practices guide describes all the relevant technical settings and considerations you need to get the most out of your SAP HANA scale-up and scale-out environments running on Nutanix AOS with VMware ESXi. Nutanix, in collaboration with SAP Engineering, developed the requirements and recommendations presented in this document by extensively testing SAP HANA on the Nutanix Cloud Platform. These settings ensure that you're running a fully supported production SAP HANA system.

Compared to traditional three-tier virtualization implementations, deploying SAP HANA on Nutanix lets you realize several key benefits, including dramatic reductions in complexity, significant risk avoidance, gains in flexibility, and a shorter time to market.

2. Introduction

Audience

This best practice guide is part of the Nutanix Solutions Library. We wrote it for customers, partners, and internal employees responsible for working on any SAP HANA project. Readers of this document should already be familiar with Nutanix and SAP HANA. You need credentials for the SAP Knowledge Base to access some of the SAP notes mentioned in this guide.

Purpose

We cover all necessary guidelines and prerequisites for successfully deploying SAP HANA in production on Nutanix AOS using Nutanix AHV as the hypervisor.

If you're deploying SAP HANA on Nutanix AOS using VMware vSphere as the hypervisor, refer to the SAP HANA on vSphere best practice guide.

Document Version History

Version Number	Published	Notes
1.0	August 2018	Original publication.
1.1	January 2019	Updated the SAP HANA Best Practices and References sections.
1.2	June 2019	Added Fujitsu certification information.
1.3	July 2019	Updated the SAP HANA Best Practices section.
1.4	January 2020	Added Nutanix Support Portal link.

Version Number	Published	Notes
1.5	October 2020	Added and updated content throughout.
1.6	January 2021	Updated for consistency with companion SAP best practice guides.
1.7	April 2022	Updated the Prerequisites, Design Considerations and Caveats, Hardware and Hypervisor, and VM and Application sections and added the Live-Migrating SAP HANA VMs section.
1.8	August 2022	Updated the Hardware and Hypervisor section.
1.9	September 2022	Updated the Hardware and Hypervisor section.

3. SAP HANA Deployment Requirements

To ensure that you're running your SAP HANA VMs in a way that allows for maximum performance while assuring full production support, work through the following lists to verify your settings and complete any modifications. These requirements and recommendations are the direct results of intensive testing and validation exercises run by Nutanix with guidance from SAP HANA Engineering.

> Note: Unless otherwise noted, these requirements are mandatory to achieve full support for the implementation from SAP and Nutanix.

To make it easier for you to confirm that everything is covered, we have grouped our best practices in four main categories:

- Prerequisites
- Design considerations and caveats
- Live migration for SAP HANA VMs
- Hardware and hypervisor
- VM and application

Prerequisites

Before you install a system, verify that it meets the following prerequisites. For production landscapes these prerequisites are mandatory; for nonproduction landscapes, we strongly recommend adhering to the same prerequisites.

- Ensure that you're using a supported OS for your VM, per the SAP Product Availability Matrix (PAM) (SAP account required).
- Both major enterprise Linux distributions SUSE and Red Hat are now supported for use with Nutanix AHV for SAP HANA workloads. Currently (as of version 1.7 of this document), AHV-based VMs can't be part of a Red Hat

Cluster. Nutanix and Red Hat are working together to allow support for this solution in the future.

- Ensure that your version of Nutanix AHV is either AHV20170830.nnn, AHV20190916.nnn, or AHV20201105.nnn and supported by the compatible AOS versions listed in the next bullet point.
- Ensure that your version of Nutanix AOS is either 5.15.nn or 5.20.nn. These versions are Long-Term Support (LTS) releases that ensure longer support cycles. Nutanix only qualifies AOS LTS releases for SAP HANA. Review our Support Policies and FAQs for more detailed information about Nutanix product releases and support cycles. Nutanix strongly recommends updating to the newest available AOS LTS release validated for SAP HANA as soon as possible.
- Ensure that you're using a supported version of SAP HANA; both SAP HANA 1 and 2 are supported.
- SAP HANA on HCI is only supported on Intel® Xeon® Scalable Processors of the Intel Cascade Lake microarchitectures.
- Check the SAP HANA HCI Hardware directory for supported and certified solutions from Nutanix original equipment manufacturers (OEMs).

Review the appendix of this document for guidance on how to verify your current version.

Design Considerations and Caveats

When you design your environment, keep the following caveats in mind for production SAP HANA database systems:

- The maximum memory size of a single production SAP HANA VM is 4.5 TB.
- The maximum number of virtual CPUs for a single production SAP HANA VM is 168 vCPU. This maximum assumes the VM has hyperthreading enabled.
- Don't place the SAP HANA production database on the same socket as the CVM.

- Resource sharing between production SAP HANA VMs and any other VMs isn't allowed.
- You can live-migrate SAP HANA VMs on Nutanix AHV. See the section Live Migration for SAP HANA VMs for more details and conditions.
- For production SAP HANA database VMs, adhere to the resource combinations outlined in the following table.

Table: Resource Combinations for Production SAP HANA Database VMs

Platform	VMs	CPU / Memory Sockets per VM	Notes
Dual Socket	1	1	Example: 56 vCPU and 768 GB of RAM on an Intel® Xeon® Platinum 8280 Processor
Quad Socket	3	1	3 VMs with 1 socket's worth of CPU and memory
Quad Socket	2	1 / 2	1 VM with 1 socket's worth of CPU and memory; 1 VM with 2 sockets' worth of CPU and memory
Quad Socket	1	3	Example: 168 vCPU and 4.5 TB of RAM on an Intel® Xeon® Platinum 8280 Processor

Memory configuration for SAP HANA production VMs must follow these rules:

- You must assign each SAP HANA production VM the full memory amount of its assigned sockets.
- Reserve some memory for hypervisor overhead. The amount of memory depends on several different configuration specifics, such as the number of

vCPUs, the number of disk devices, and so on, but plan for approximately 3–6 percent of the available memory.

- When installing SAP HANA and using the scale-out architecture for your tenant databases, configure your network environment for jumbo frames. To do so, follow the steps in Nutanix KB 3529.
- Using Nutanix encryption methods for security reasons is fully supported. When using software-based encryption, incorporate additional CPU resources for the CVM into the design. Nutanix SAP Engineering tested encryption with SAP HANA and it passed all necessary key performance indicators (KPIs). You can find more detailed information in the Data-at-Rest Encryption section of the AOS Security Guide.

For more details about memory configuration and NUMA, review the Nutanix AHV best practice guide.

We support nonproduction SAP HANA database systems as follows:

- For nonproduction databases, we support the listed production VM configurations, as well as database VMs that consume half a socket's worth of CPU and memory resources.
- For nonproduction databases, we support running the database VM in parallel with other nonproduction VMs, including the CVM.
- For nonproduction databases, you don't need to follow the strict memory and NUMA configuration rules described earlier in this section.

For your Nutanix cluster design, consider the following points:

- Always plan for failover capacity in the form of n + 1. Your Nutanix cluster should always be able to sustain a complete node loss without any manual intervention.
- If you plan to use live migration, make sure you have enough free resources in your cluster to migrate large SAP HANA database VMs.
- If you plan to use live migration for SAP HANA VMs with more than 1 TB of assigned memory, use 25 Gbps network connectivity for your Nutanix cluster.

- If possible, Nutanix recommends starting with a four-node cluster. A four-node cluster allows you to complete maintenance operations without worrying about free space or timing.
- When you size usable storage on the cluster, ensure the following:
  - For production VMs, assume three times the SAP HANA database memory footprint per VM, available locally on the node where the VM is running.
  - For nonproduction VMs, assume twice the SAP HANA database memory footprint, available locally on the node where the VM is running.
- Don't configure storage-saving functionalities such as compression, deduplication, or erasure coding (EC-X) on a storage container that holds production database files. Because of how the SAP HANA Persistence Engine stores data, these features deliver no benefits. Nutanix SAP Engineering has tested compression with SAP HANA workloads; the tests indicate no noticeable performance impact but also show no reduction in the space the SAP HANA workload consumes.

Live Migration for SAP HANA VMs

While Nutanix has conducted extensive tests to ensure full functionality while live-migrating SAP HANA VMs, we can't guarantee a successful migration under all circumstances due to the high active memory nature of SAP HANA as an in-memory database. We therefore strongly recommend and only support using live migrations for SAP HANA production instances in low-utilization scenarios or during maintenance windows.

Nutanix conducted live migration tests using SAP HANA instances with 2 TB of memory under 35 percent CPU load with a mixed load (ML4) test. This test mimics real-world user activity with thousands of simulated users. In these tests, we successfully moved a VM from one AHV host to another without impacting the stability or creating any errors in the ML4 testbed.

There are many factors that contribute to a successful live migration, such as available network bandwidth. Nutanix SAP Engineering strongly recommends using 25 Gbps networking if you plan to use live migration with any SAP HANA database VM. If you have questions, visit the Nutanix SAP solution page.

Hardware and Hypervisor

SAP maintains the list of supported systems available from different OEMs on its Certified HCI Solutions page. We recommend that you check this page regularly for newly certified systems and OEMs. For your SAP HANA on Nutanix deployment to be supported, you must select a system listed on the SAP HANA HCI Hardware directory.

When you choose and set up your hardware, follow the SAP HANA networking recommendations described in SAP HANA Network Requirements to ensure the availability of enough physical and virtual network interfaces.

> Note: It's mandatory to separate HANA network traffic (for example, database access and HANA replication) from all other types of traffic.

Nutanix recommends different configurations for your storage subsystem depending on the use case. For production systems with low latency requirements and workloads that are generally transactional, we recommend using SSDs with NVMe. Data warehouse workloads and systems with less strict latency requirements can use all-flash (SSD only) configurations. Hybrid disk (SSD and HDD) configurations aren't supported for SAP HANA.

> Note: All-flash configurations must have a minimum of four SSD devices.

For systems with strict latency requirements, we recommend using network cards that support Remote Direct Memory Access (RDMA) technology. When you select these cards, ensure that your connecting Ethernet switches support the RDMA over Converged Ethernet (RoCE) standard.

RDMA networking isn't required to pass SAP HANA storage performance requirements, but we recommend using RDMA whenever you have strict latency requirements for your SAP HANA workloads.

Verify the best way to set the hardware-specific BIOS settings to the equivalent of "Maximum performance" with your specific hardware vendor. These hardware settings can have a significant impact on latency performance for the overall solution.

Adjust the following hypervisor settings:

- To save energy when a CPU is idle, you can instruct the CPU to enter a low-power mode. There are various power modes available to each CPU; the various power modes are referred to as C-states. On Nutanix AHV, we recommend disabling C-states 3 and 4. To disable these modes automatically, run the following commands from one of the CVMs:

```
$ hostssh systemctl enable cstate; hostssh systemctl start cstate
```

- When you plan for n + 1, we recommend following the steps in the Enabling High Availability for the Cluster section of the Prism Web Console Guide to configure the cluster for high availability. For more details, refer to the Virtual Machine High Availability tech note.

VM and Application

Note the following sizing limitations when creating your SAP HANA production VMs:

- On Intel Cascade Lake CPU family dual-socket hardware:
  - An SAP HANA production VM can't have more than 56 vCPU. This maximum assumes the VM has hyperthreading enabled.
  - A VM can't have more than 1.5 TB of RAM.
- On Intel Cascade Lake CPU family quad-socket hardware:
  - A VM can't have more than 168 vCPU. This maximum assumes the VM has hyperthreading enabled.
  - A VM can't have more than 4.5 TB of RAM. There is some overhead, which varies depending on the hardware platform configuration. To avoid VM startup issues, we recommend staying below 4,500 GB. The overhead is specific to the system and VM configuration; it varies across setups.
- Using UEFI boot: Check the Nutanix Compatibility and Interoperability Matrix: AHV Guest OS page for the limitations on guest OS versions using UEFI boot.

In addition to these sizing limitations, there are several guidelines for creating your VMs:

- Stay within NUMA boundaries for each VM's vCPU and memory configurations. To find out more about NUMA, refer to the AHV best practice guide.
- OS settings:
  - When using SUSE SLES 12: Apply OS settings for SAP HANA inside the VM as recommended in SAP note 2205917: SAP HANA DB: Recommended OS settings for SLES 12 (SAP account required).
  - When using SUSE SLES 15: Apply OS settings for SAP HANA inside the VM as recommended in SAP note 2684254: SAP DB: Recommended OS settings for SLES15 (SAP account required).
  - When using Red Hat RHEL 7: Apply OS settings for SAP HANA inside the VM as recommended in SAP note 2292690: SAP HANA DB: Recommended OS settings for RHEL 7 (SAP account required).
  - When using Red Hat RHEL 8: Apply OS settings for SAP HANA inside the VM as recommended in SAP note 2777782: SAP HANA DB: Recommended OS Settings for RHEL 8 (SAP account required).
- Use a minimum of four virtual hard disks for the database log and four virtual hard disks for the database data volume.
- Depending on your usage pattern, it might be beneficial to use a similar construct of multiple virtual hard disks for your other SAP HANA volume requirements.
- Use a supported file system as described in SAP note 405827: Journaled file system and raw devices on Linux (SAP account required).
- SAP fully supports the use of the Linux Logical Volume Manager (LVM), as described in SAP note 597415: Logical volume manager (LVM) on Linux (SAP account required). Keep the disks for the data volume and the disk for the log volume in separate LVM volume groups. When you create the logical volume, create a striped logical volume using all the physical volumes in the volume group.
- Check the SAP HANA Master Guide for disk space requirements for SAP HANA log, data, and shared volumes.

The following step shows an efficient way to generate multiple virtual hard disks from the command line:

```
$ acli vm.disk_create <VM name> container=<storage container name>
 create_size=<size of disk in GB>G bus=scsi
```

To create the respective file systems, follow these steps:

- Create log and data volume groups for SAP HANA (note that the following code block is an example; replace the sample letters with those from your setup):

```
$ vgcreate hanalog /dev/sd{b,c,d,e}
$ vgcreate hanadata /dev/sd{f,g,h,i}
$ vgcreate hanashared /dev/sdj
```

- Create logical volumes for log and data striped across four virtual hard disks with 64 K stripe size and readahead=none. Use all logical extents of a volume group for the logical volumes:

```
$ lvcreate -i <# of virtual disks for log> -I 64K -l 100%VG -r none -n vol
 hanalog
$ lvcreate -i <# of virtual disks for data> -I 64K -l 100%VG -r none -n vol
 hanadata
$ lvcreate -l 100%VG -r none –n vol hanashared
```

- Create XFS file systems on the log and data volumes:

```
$ mkfs.xfs /dev/mapper/hanalog-vol
$ mkfs.xfs /dev/mapper/hanadata-vol
$ mkfs.xfs /dev/mapper/hanashared-vol
```

- Create mount points /hana/log, /hana/data and /hana/shared:

```
$ mkdir -p /hana/{log,data,shared}
```

- When using XFS, add the following mount parameters to the relevant entries in /etc/fstab:

```
$ inode64,largeio,swalloc 1 2
```

- Mount the volumes accordingly.

The previous steps show one example of a possible configuration that you need to adjust to the actual requirements for your configuration.

Creating SAP HANA VMs

When you create SAP HANA VMs, verify the following configuration changes:

- Define the VM CPU topology:


```
$ acli vm.update <vm name> num_vcpus=<number of virtual sockets>
 num_vnuma_nodes=<number of virtual numa nodes> num_cores_per_vcpu=<amount
 of virtual cores> num_threads_per_core=<1 for no hyperthreading, 2 for
 hyperthreading> vcpu_hard_pin=<True or False>
```

The following examples are based on a physical CPU with 28 cores (56 threads).

- Example 1: This command updates the settings for an SAP HANA VM with three CPU sockets. Each vCPU has 28 cores and hyperthreading enabled. This update results in a VM with three virtual sockets, three NUMA nodes, and a total of 168 vCPU (including hyperthreads).

  ```
  $ acli vm.update SAP-HANA num_vcpus=3 num_vnuma_nodes=3 num_cores_per_vcpu=28
   num_threads_per_core=2 vcpu_hard_pin=True
  ```

- Example 2: This command updates the settings for an SAP HANA VM with two CPU sockets. Each vCPU has 28 cores and hyperthreading enabled. This update results in a VM with two virtual sockets, two NUMA nodes, and a total of 112 vCPU (including hyperthreads).

  ```
  $ acli vm.update SAP-HANA num_vcpus=2 num_vnuma_nodes=2 num_cores_per_vcpu=28
   num_threads_per_core=2 vcpu_hard_pin=True
  ```

- Example 3: This command updates the settings for an SAP HANA VM with one CPU socket. Each vCPU has 28 cores and hyperthreading enabled. This update results in a VM with one virtual socket, one NUMA node, and a total of 56 vCPU (including hyperthreads).

  ```
  $ acli vm.update SAP-HANA num_vcpus=1 num_vnuma_nodes=1 num_cores_per_vcpu=28
   num_threads_per_core=2 vcpu_hard_pin=True
  ```

- Enable the VM metrics host daemon as described in SAP note 2656072 (SAP account required).

SAP HANA Specifics

- Review the SAP HANA Master Guide and the SAP HANA Server Installation and Update Guide.
- Always check the relevant SAP notes for updates before you install any SAP HANA–specific software.
- Change the current clock source to TSC (Time Stamp Counter) to ensure proper SAP HANA timer operation. You can set the clock source in different

ways depending on your chosen guest OS (SUSE or Red Hat). Consult the OEM documentation for the necessary procedures to change this setting.

- SAP HANA System Replication is supported on Nutanix to ensure application availability.
- Nutanix SAP Engineering has conducted extensive tests to find the optimal settings for the SAP HANA persistent layer. We strongly recommend setting the max_parallel_io_requests to 256. To set this parameter, navigate to Configuration and Monitoring in SAP HANA Studio. Click Open Administration and select global.ini, then fileio. For max_parallel_io_requests, change the setting to 256.
  - Alternatively, you can set this parameter with the following hdbsql command:

```
$ <sidadm>@<hostname>:/usr/sap/<SID>/HDB00> hdbsql -n <hostname> -i 00 -user
 <system user> -password <password>

$ hdbsql QO1=> ALTER SYSTEM ALTER CONFIGURATION ('global.ini', 'SYSTEM') SET
 ('fileio','max_parallel_io_requests') = '256' WITH RECONFIGURE;
```


4. Conclusion

When you choose Nutanix for your SAP HANA implementation, you benefit from reduced complexity and improved agility. Following the recommendations provided in this document can help ensure the successful implementation and operation of SAP HANA on Nutanix.

Nutanix AOS software is certified for production SAP HANA deployments, and you can choose between Nutanix AHV and VMware ESXi as the hypervisor. Customers can use either Linux enterprise distribution (SUSE or Red Hat) as the guest OS to run SAP HANA.

If you have questions regarding this document, visit the Nutanix SAP solution page.

5. Appendix

References

For SAP support information and verification, see SAP note 2686722: SAP HANA virtualized on Nutanix AOS (SAP account required).

Version Information

To view the Nutanix version running in the cluster, click the user icon in the main menu, then select About Nutanix from the dropdown list. The About Nutanix window that appears displays the AOS and Nutanix cluster check (NCC) version numbers. It also includes a link to Nutanix patent information.

About Nutanix

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