2777782 - SAP HANA DB: Recommended OS Settings for RHEL 8

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Component	HAN-DB (SAP HANA Database)		

Please find the original document at **https://launchpad.support.sap.com/#/notes/ 2777782**

Symptom

You want to configure optimal settings for running SAP HANA2 on RHEL 8 with RHEL for SAP Solutions

Other Terms

HANA, DB, BW on HANA, Suite on HANA, S/4HANA, BW/4HANA, RedHat, Linux

Reason and Prerequisites

You are planning to run SAP HANA on Red Hat Enterprise Linux 8 (RHEL 8) for SAP Solutions.

Solution

To optimize the use of SAP HANA with RHEL 8, apply the following settings. There might be architectural limitations in virtual and cloud environments, so that some recommendations might not apply or deviate. For example, CPU power management might be unavailable. Please refer to the virtualization or cloud provider for any such limitations.

You must have a valid Red Hat Enterprise Linux for SAP Solutions subscription for all RHEL 8 servers running SAP HANA. To ensure that these systems remain on the minor releases which are supported by SAP for SAP HANA, all RHEL 8 servers running SAP HANA must be subscribed to the "RHEL for SAP HANA - Extended Update Support" ("eus") channel or to the "RHEL for SAP HANA - Update Services for SAP Solutions" ("e4s") channel. These two channels are included in the Red Hat Enterprise Linux for SAP Solutions subscription.

Update Services for SAP Solutions is planned for RHEL 8.1, 8.2, 8.4, 8.6, and 8.8 (see the RHEL Product Life Cycle web page). For RHEL 8.0 for SAP Solutions, Red Hat provides support until 31-Dec-2020.

Please refer to the following Red Hat knowledge base article for instructions on how to configure your system accordingly (Red Hat customer portal login required): How to subscribe to Update Services for SAP Solutions on RHEL 8

Supported Kernel versions and patches

You can use official RHEL 8 Linux Kernels and packages shipped by Red Hat for the RHEL 8 minor releases supported by SAP HANA, including security and bug fixes provided via "Extended Update Support" for the supported RHEL 8 minor releases. Please see below for release-specific requirements. Using updated Linux Kernels and packages from RHEL 8 minor releases not listed in SAP Note 2235581 - SAP HANA: Supported OperatingSystems - is not supported and will break the certification.

Release-specific requirements

In order to install HANA 2.0 SPS04 in a scale-out configuration on RHEL 8, please use one of the following options:

1. Pass the additional root_password parameter to hdblcm or hdbinst so it can authenticate via user/password combination instead of user/key, or
2. Use the command 'ssh-keygen -m PEM -t rsa' to generate old format SSH keys.

- **RHEL 8.0 - specific package requirements**
  On IBM Power machines, the minimum supported kernel is version 4.18.0-80.15.1.el8_0.ppc64le or newer.
- **RHEL 8.1 - specific package requirements**
  The minimum supported Linux kernel version is 4.18.0-147.5.1.el8_1 or newer.

Additional 3rd-party kernel modules

If you are using additional 3rd-party binary kernel modules, the following SAP Note applies: SAP note 784391 - SAP support terms and 3rd-party Linux kernel drivers.

Disable SELinux

Red Hat Enterprise Linux uses SELinux technology which is enabled by default. Since there is no SELinux policy available for SAP HANA, leaving SELinux enabled can lead to problems when running SAP HANA on RHEL.

For checking the SELinux mode, use the getenforce command, as in the following example:

```
# getenforce
Enforcing
```

Changing the SELinux mode from "Enforcing" to "Disabled" immediately on a running system is not possible.

For setting the SELinux mode to "Disabled" permanently, use the following command and reboot the server:

```
# sed -i 's/\(SELINUX=enforcing\|SELINUX=permissive\)/SELINUX=disabled/g' /etc/selinux/config
```

This will change file /etc/selinux/config so that any other SELINUX parameter setting than "disabled" will be changed to this value. The change will only become effective after a system reboot. Note the different spelling in file /etc/selinux/config vs. in the getenforce/setenforce usage and outputs: All characters of the SELINUX value in file /etc/selinux/config are in lowercase, whereas the SELINUX value in the mentioned commands is capitalized.

Configure tuned to use profile "sap-hana"

The tuned profile "sap-hana", which is provided by Red Hat as part of the RHEL for SAP Solutions subscription, contains many of the settings mentioned below and configures some additional settings. Therefore the "sap-hana" tuned profile must be activated on all systems running SAP HANA:

Use the following commands to install and activate the tuned profile "sap-hana" and check if it is active:

```
# yum install tuned-profiles-sap-hana
# systemctl start tuned
# systemctl enable tuned
# tuned-adm profile sap-hana
# tuned-adm active
```


The output of "tuned-adm active" should look like:
Current active profile: sap-hana

For SAP HANA on RHEL 8.0, there is no minimum version requirement for package tuned-profiles-sap-hana.

For SAP HANA on RHEL 8.0 on platform ppc64le only, three parameters must be set differently from the defaults:

kernel.sched_min_granularity_ns = 3000000
kernel.sched_wakeup_granularity_ns = 4000000
readahead = 128k

To achieve this, the following additional steps have to be performed on ppc64le:

1. Create a directory named /etc/tuned/sap-hana-ppc64le:
   # mkdir /etc/tuned/sap-hana-ppc64le
2. Create a file named /etc/tuned/sap-hana-ppc64le/tuned.conf with the following contents:
   [main]
   summary=Adjustments for SAP HANA on RHEL 8.0 on ppc64le
   [sysctl]
   kernel.sched_min_granularity_ns=3000000
   kernel.sched_wakeup_granularity_ns=4000000
   [disk]
   replace=true
3. Activate tuned profiles sap-hana and sap-hana-ppc64le. The second one has precedence over the first one, causing settings in tuned profile sap-hana to be replaced by those in sap-hana-ppc64le:
   # tuned-adm profile sap-hana sap-hana-ppc64le
4. Verify that the two profiles are active:
   # tuned-adm active
   The output should look like:
   Current active profile: sap-hana sap-hana-ppc64le

For SAP HANA on RHEL 8.1, the minimum required version of package tuned-profiles-sap-hana is 2.12.0-3.el8_1.1, which is also the default version for RHEL 8.1.

Disable ABRT, Core Dumps and kdump

All crashes of SAP HANA are typically analyzed by SAP support, so they do not rely on operating system mechanisms for crash reporting. To avoid delays when a Linux kernel crash or a core dump occurs, disable the application crash and core file handling of the operating system.

The Automatic Bug Reporting Tool (ABRT), which handles application crashes, is not installed by default when installing RHEL 8 with the Server environment group. The corresponding packages are (for example) abrt and abrt-addon-ccpp. If installed, they can be disabled with the following commands:

systemctl stop abrtd
systemctl stop abrt-ccpp
systemctl disable abrtd
systemctl disable abrt-ccpp

To disable core core file creation for all users, open or create file /etc/security/limits.d/99-sap.conf and add the following lines:

* soft core 0

* hard core 0

The kernel crash dump facility (kdump) can be disabled with the following commands:

systemctl stop kdump
systemctl disable kdump

In case you want to leave kdump enabled, have a look at the following Red Hat Customer Portal articles (Red Hat Customer Portal login required):
How to troubleshoot kernel crashes, hangs, or reboots with kdump on Red Hat Enterprise Linux
How to reduce the size of a vmcore file?

Turn off auto-numa balancing

In RHEL 8, auto-numa balancing is switched off by default. To verify, use the following command:
# sysctl kernel.numa_balancing
kernel.numa_balancing = 0

If package numad is installed on your server, please make sure that it is switched off and disabled:

systemctl stop numad
systemctl disable numad

Disable Transparent Hugepages (THP)

With RHEL 8, the usage of transparent hugepages (THP) is generally activated in the Linux kernel. THP allow the handling of multiple pages as hugepages, reducing the translation lookaside buffer footprint (TLB) in situations where it might be useful. Due to the special manner of SAP HANA's memory management, the usage of THP may lead to hanging situations and performance degradations.

If you use the "sap-hana" tuned profile as described above, THP will be disabled via the profile and you don’t need to change this setting manually. If you do not use the "sap-hana" tuned profile, to disable the usage of transparent hugepages during runtime, set the kernel settings at runtime with the command:

echo never > /sys/kernel/mm/transparent_hugepage/enabled

There is no need to shut down the database to apply this setting. For making this change to persist across system reboots, it is necessary to edit the OS bootloader configuration as follows:

Modify the file /etc/default/grub and append the following parameter to the line starting with “GRUB_CMDLINE_LINUX”:

transparent_hugepage=never

Then rebuild the GRUB2 configuration as follows:

On a system without UEFI, activate this option by issuing:
grub2-mkconfig -o /boot/grub2/grub.cfg

On a system with UEFI, activate this option by issuing:
grub2-mkconfig -o /boot/efi/EFI/redhat/grub.cfg

Afterwards, a reboot is required. In a scale-out environment, those changes have to be done on every server of the landscape.
See Chapter 3.4. Setting kernel command line parameters in the RHEL 8 Managing, monitoring and updating the kernel guide for more information on setting kernel parameters at boot time.

To verify that THP have been disabled, use the following command:

cat /sys/kernel/mm/transparent_hugepage/enabled
always madvise [never]

Cluster-On-Die (COD) / sub-NUMA clustering technology (Intel 64 platform only)

SAP HANA neither supports use of Intel Cluster-On-Die (COD) technology nor n sub-NUMA clustering technology.

Configure C-States for lower latency in Linux (Intel platform only)

The Linux kernel shipped with RHEL 8 on the x86_64 platform includes a cpuidle driver for recent Intel CPUs: intel_idle. This driver leads to a different behavior in C-states switching. The normal operating state is C0, when the processor is put to a higher C state, which saves power. But for low latency applications, the additional time needed to stop and start the execution of the code again will cause performance degradations. Therefore it is recommended to limit the C-states to C0 and C1 by setting the following parameter:

processor.max_cstate=1

Additionally you should also configure the intel_idle kernel module to allow C-State C1:

intel_idle.max_cstate=1

You can set this parameter in the kernel command line by modifying /etc/default/grub. Append the following parameter to the line starting with GRUB_CMDLINE_LINUX:

processor.max_cstate=1 intel_idle.max_cstate=1

To enable these changes, the GRUB2 configuration needs to be rebuilt:

On non-UEFI systems, run:
grub2-mkconfig -o /boot/grub2/grub.cfg

On UEFI systems, run:
grub2-mkconfig -o /boot/efi/EFI/redhat/grub.cfg

Afterward, a reboot is required. In a scale-out environment, those changes have to be done on every server of the landscape.
See Chapter 3.4. Setting kernel command line parameters in the RHEL 8 Managing, monitoring and updating the kernel guide for more information on setting kernel parameters at boot time.
For more information on setting C-States, see the following Red Hat KnowledgeBase article: What are CPU "C-states" and how to disable them if needed? (Red Hat Customer Portal login required).

Configure CPU Governor for performance (Intel 64 platform only)

Linux is using a technology for power saving called CPU governors to control CPU frequency and power consumption. By default, Linux uses the governor "ondemand", which will dynamically scale frequency and voltage up and down depending on CPU load. If you want to maximize CPU performance at the cost of increased energy consumption, SAP recommends to use the governor "performance". If you use the "sap-hana" tuned profile as described above, the governor "performance" is configured via the profile and you don't need to change this setting manually. If not using "sap-hana" tuned profile, insert the following code in a system startup script such as /etc/rc.d/rc.local :

cpupower frequency-set -g performance

The setting will be applied during system boot. To take effect immediately, the script or the command must be executed.

Configure Energy Performance Bias (EPB, Intel 64 platform only)

The Linux kernel obeys the EPB bit in the CPU flags. Consequently, it configures the CPUs according to the global "energy performance bias" setting in the BIOS.

We suggest to set the EPB using either one of the following options:

1. Set Energy Performance Bias or EPB in the BIOS to "Maximum performance"
2. Activate the 'sap-hana' tuned profile as described above which will set EPB to 'performance
3. Add the following command to a script executed on system boot, such as /etc/init.d/boot.local:
   # cpupower set -b 0
   (see 'cpupower help set' for more information)
   To verify that EPB has been set correctly, you can run the following command:
   # cpupower info
   If the command reports 'perf-bias: 0', EPB has been set to the correct value.

Disable Kernel samepage merging (KSM)

The KSM feature helps reduce physical memory overhead by detecting memory pages with identical content. The feature is useful for VMs, but the space-time tradeoff does not pay off for SAP HANA instances not running in VMs.

If KSM is enabled, we recommend to disable it by adding the following command to a script executed on system boot, such as /etc/init.d/boot.local:

echo 0 > /sys/kernel/mm/ksm/run

Execute the command to turn off KSM immediately.

The following command can be used to show the status of KSM:

cat /sys/kernel/mm/ksm/run

The result of "0" confirms that KSM is deactivated.

Increase kernel.pid_max

The default of systemd parameter TasksMax, which limits the number of tasks per user on RHEL 8, can be too low for SAP HANA workloads. This parameter is set to 80% of kernel parameters kernel.pid_max or kernel.threads-max, whatever is less, in RHEL 8. In order to automatically increase TasksMax to a more reasonable value, it is necessary to increase kernel.pid_max to the maximum possible value:

1. To increase the value of kernel.pid_max on a running system, run the following command:
   # sysctl -w kernel.pid_max=4194304
   kernel.pid_max = 4194304
2. To permanently set the new default value, add the following line to /etc/sysctl.d/sap.conf (create the file if it doesn't already exist):
   kernel.pid_max=4194304

To enable this change, a system reboot is required. In a scale-out environment, those changes have to be

done on every server of the landscape. In case you already have a running SAP HANA instance, rebooting the server should only be done when a standby server is configured. Do not reboot all servers at once. For single node instances, a downtime has to be considered.

IBM EnergyScale for POWER9 Processor-Based Systems (applies to IBM Power systems only)

EnergyScale provides functions that help the user to understand and control IBM server power and cooling usage. SAP HANA performance benefits from high frequency. However, clients may choose any mode except for "Static Power Saver Mode" for their productive instances. If the experienced performance is capped by the CPU, the first step is to ensure the "Maximum Performance Mode" is selected. The package pseries-energy must not be installed. Changing the power management mode can be accomplished via the ASMI interface or on the HMC only. Kindly refer to IBM's EnergyScale documentation for this feature at https://www.ibm.com/downloads/cas/6GZMODN3.

Further system configuration settings

Please see SAP note 2382421 - Optimizing the Network Configuration on HANA- and OS-Level - for network related configuration parameter settings which may apply.

Please note: Unless noted otherwise, all changes mentioned above require root access on operating system level. It is recommended to reboot the system after the changes have been applied. Future implementations might lead to changes of these recommendations.

Other Components

Component	Description
BC-OP-LNX-RH	Red Hat Linux

This document refers to

SAP Note/KBA	Title
784391	SAP support terms and 3rd-party Linux kernel drivers
2772999	Red Hat Enterprise Linux 8.x: Installation and Configuration
2526952	Red Hat Enterprise Linux for SAP Solutions
2235581	SAP HANA: Supported Operating Systems
2009879	SAP HANA Guidelines for Red Hat Enterprise Linux (RHEL) Operating System
1943937	Hardware Configuration Check Tool - Central Note
1514967	SAP HANA: Central Note

This document is referenced by

SAP Note/KBA	Title
2235581	SAP HANA: Supported Operating Systems