SUSE

SUSE Linux Enterprise Server 15 SP6

Release Notes

SUSE Linux Enterprise Server is a modern, modular operating system for both multimodal and traditional IT. This document provides a high-level overview of features, capabilities, and limitations of SUSE Linux Enterprise Server 15 SP6 and highlights important product updates.

These release notes are updated periodically. The latest version of these release notes is always available at https://www.suse.com/releasenotes ↗. General documentation can be found at https://documentation.suse.com/sles/15-SP6 ↗.

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Contents

1   About the release notes

These Release Notes are identical across all architectures, and the most recent version is always available online at https://www.suse.com/releasenotes ↗.

Entries are only listed once but they can be referenced in several places if they are important and belong to more than one section.

Release notes usually only list changes that happened between two subsequent releases. Certain important entries from the release notes of previous product versions are repeated. To make these entries easier to identify, they contain a note to that effect.

However, repeated entries are provided as a courtesy only. Therefore, if you are skipping one or more service packs, check the release notes of the skipped service packs as well. If you are only reading the release notes of the current release, you could miss important changes.

2   SUSE Linux Enterprise Server

SUSE Linux Enterprise Server 15 SP6 is a multimodal operating system that paves the way for IT transformation in the software-defined era. It is a modern and modular OS that helps simplify multimodal IT, makes traditional IT infrastructure efficient and provides an engaging platform for developers. As a result, you can easily deploy and transition business-critical workloads across on-premises and public cloud environments.

SUSE Linux Enterprise Server 15 SP6, with its multimodal design, helps organizations transform their IT landscape by bridging traditional and software-defined infrastructure.

2.1   Interoperability and hardware support

Designed for interoperability, SUSE Linux Enterprise Server integrates into classical Unix and Windows environments, supports open standard interfaces for systems management, and has been certified for IPv6 compatibility.

This modular, general-purpose operating system runs on four processor architectures and is available with optional extensions that provide advanced capabilities for tasks such as real-time computing and high-availability clustering.

SUSE Linux Enterprise Server is optimized to run as a high-performance guest on leading hypervisors. This makes SUSE Linux Enterprise Server the perfect guest operating system for virtual computing.

2.2 What is new?

2.2.1 General changes in SLE 15

SUSE Linux Enterprise Server 15 introduces many innovative changes compared to SUSE Linux Enterprise Server 12. The most important changes are listed below.

Migration from openSUSE Leap to SUSE Linux Enterprise Server

SLE 15 SP2 and later support migrating from openSUSE Leap 15 to SUSE Linux Enterprise Server 15. Even if you decide to start out with the free community distribution, you can later easily upgrade to a distribution with enterprise-class support. For more information, see the *Upgrade Guide* at https://documentation.suse.com/sles/15-SP6/html/SLES-all/cha-upgrade-online.html#sec-upgrade-online-opensuse-to-sle ↗.

Extended package search

Use the new Zypper command `zypper search-packages` to search across all SUSE repositories available for your product, even if they are not yet enabled. For more information see *Section 5.10.2, "Searching packages across all SLE modules"*.

Software Development Kit

In SLE 15, packages formerly shipped as part of the Software Development Kit are now integrated into the products. Development packages are packaged alongside other packages. In addition, the *Development Tools* module contains tools for development.

RMT replaces SMT

SMT (Subscription Management Tool) has been removed. Instead, RMT (Repository Mirroring Tool) now allows mirroring SUSE repositories and custom repositories. You can then register systems directly with RMT. In environments with tightened security, RMT can also proxy other RMT servers. If you are planning to migrate SLE 12 clients to version 15, RMT is the supported product to handle such migrations. If you still need to use SMT for these migrations, beware that the migrated clients will have *all* installation modules enabled. For more information see *Section 4.2.3, "SMT has been replaced by RMT"*.

Media changes

The *Unified Installer* and *Packages* media known from SUSE Linux Enterprise Server 15 SP1 have been replaced by the following media:

- **Online Installation Medium:** Allows installing all SUSE Linux Enterprise 15 products. Packages are fetched from online repositories. This type of installation requires a registration key. Available SLE modules are listed in *Section 3.1, "Modules in the SLE 15 SP6 product line"*.

- **Full Installation Medium:** Allows installing all SUSE Linux Enterprise Server 15 products without a network connection. This medium contains all packages from all SLE modules. SLE modules need to be enabled manually during installation. RMT (Repository Mirroring Tool) and SUSE Manager provide additional options for disconnected or managed installations.

SLE for HPC product removal

Instead of a separate product, HPC is now available as a module in SUSE Linux Enterprise Server. For more information see *Section 2.2.4, "SLE for HPC HPC no longer a separate product"*.

MAJOR UPDATES TO THE SOFTWARE SELECTION:

Salt

SLE 15 SP6 can be managed via Salt, making it integrate better with modern management solutions such as SUSE Manager.

Python 3

As the first enterprise distribution, SLE 15 offers full support for Python 3 development in addition to Python 2.

Directory Server

389 Directory Server replaces OpenLDAP as the LDAP directory service.

2.2.2 Changes in 15 SP6

SUSE Linux Enterprise Server 15 SP6 introduces changes compared to SUSE Linux Enterprise Server 15 SP5. The most important changes are listed below:

2.2.3　Package and module changes in 15 SP6

The full list of changed packages compared to 15 SP5 can be seen at this URL:

- https://documentation.suse.com/package-lists/sle/15-SP6/package-changes_SLE-15-SP5-GA_SLE-15-SP6-GA.txt ↗

The full list of changed modules compared to 15 SP5 can be seen at this URL:

- https://documentation.suse.com/package-lists/sle/15-SP6/module-changes_SLE-15-SP5-GA_SLE-15-SP6-GA.txt ↗

2.2.4　SLE for HPC HPC no longer a separate product

As of 15 SP6, SUSE Linux Enterprise for High-Performance Computing is no longer a separate product. As a result:

- the HPC Module can now be enabled in SUSE Linux Enterprise Server

- when migrating from SUSE Linux Enterprise for High-Performance Computing 15 SP3, SP4, and SP5, only SUSE Linux Enterprise Server 15 SP6 will be available as migration target. The result of such a migration will be an installation of SUSE Linux Enterprise Server with all the previously enabled modules.

Modules

For an HPC installation the user should enable the following modules:

- `Development Tools Module`

- `HPC Module`

On SUSE Linux Enterprise Server system, make sure the following modules are all enabled:

- `Server Application Module`

- `Web and Scripting Module`

- `HPC Module`

- `Desktop Applications Module`

- `Development Tools Module`

Roles

The HPC system roles are no longer available:

- HPC Management Server (Head Node)

- HPC Compute Node

- HPC Login and Development Node

It is recommended to start with a `Text Mode` or `Minimal System` istallation. The admin should make sure that the system is partitioned to the respective requirements and the firewall is configured appropriately. Also, the admin should select the software components required. This may include `slurm` for the management server, `slurm-node` for the compute nodes. For login and compute nodes the pattern HPC Modularized Libraries (`patterns-hpc-libraries`) is available.

2.3   Important sections of this document

If you are upgrading from a previous SUSE Linux Enterprise Server release, you should review at least the following sections:

- *Section 2.7, "Support statement for SUSE Linux Enterprise Server"*

- *Section 4.2, "Upgrade-related notes"*

- *Section 5, "Changes affecting all architectures"*

2.4   Security, standards, and certification

SUSE Linux Enterprise Server 15 SP6 will be submitted for certification to both the Common Criteria and NIST FIPS 140-3. As a practice, SUSE only submits even-numbered Service Packs (for example: SLES 15, SP2, SP4, etc.) for certification.

For more information about certification, see https://www.suse.com/support/security/certifications/ ↗ .

2.5 Documentation and other information

2.5.1 Available on the product media

- Read the READMEs on the media.

- Get the detailed change log information about a particular package from the RPM (where `FILENAME.rpm` is the name of the RPM):

```
rpm --changelog -qp FILENAME.rpm
```

- Check the `ChangeLog` file in the top level of the installation medium for a chronological log of all changes made to the updated packages.

- Find more information in the `docu` directory of the installation medium of SUSE Linux Enterprise Server 15 SP6. This directory includes PDF versions of the SUSE Linux Enterprise Server 15 SP6 Installation Quick Start Guide.

2.5.2 Online documentation

- For the most up-to-date version of the documentation for SUSE Linux Enterprise Server 15 SP6, see https://documentation.suse.com/sles/15-SP6 ↗.

2.6 Support and life cycle

SUSE Linux Enterprise Server is backed by award-winning support from SUSE, an established technology leader with a proven history of delivering enterprise-quality support services.

SUSE Linux Enterprise Server 15 has a 13-year life cycle, with 10 years of General Support and three years of Extended Support. The current version (SP6) will be fully maintained and supported until six months after the release of SUSE Linux Enterprise Server 15 SP7.

If you need additional time to design, validate and test your upgrade plans, Long Term Service Pack Support can extend the support duration. You can buy an additional 12 to 36 months in twelve month increments. This means that you receive a total of three to five years of support per Service Pack.

For more information, see the pages Support Policy (https://www.suse.com/support/policy.html) ↗ and Long Term Service Pack Support (https://www.suse.com/support/programs/long-term-service-pack-support.html) ↗ .

2.7   Support statement for SUSE Linux Enterprise Server

To receive support, you need an appropriate subscription with SUSE. For more information, see https://www.suse.com/support/?id=SUSE_Linux_Enterprise_Server ↗ .

The following definitions apply:

L1

Problem determination, which means technical support designed to provide compatibility information, usage support, ongoing maintenance, information gathering, and basic troubleshooting using the documentation.

L2

Problem isolation, which means technical support designed to analyze data, reproduce customer problems, isolate the problem area, and provide a resolution for problems not resolved by Level 1 or prepare for Level 3.

L3

Problem resolution, which means technical support designed to resolve problems by engaging engineering to resolve product defects which have been identified by Level 2 Support.

For contracted customers and partners, SUSE Linux Enterprise Server is delivered with L3 support for all packages, except for the following:

- Technology Previews, see *Section 2.8, "Technology previews"*

- Sound, graphics, fonts and artwork

- Packages that require an additional customer contract, see *Section 2.7.2, "Software requiring specific contracts"*

- Some packages shipped as part of the module *Workstation Extension* are L2-supported only

- Packages with names ending in `-devel` (containing header files and similar developer resources) will only be supported together with their main packages.

SUSE will only support the usage of original packages. That is, packages that are unchanged and not recompiled.

2.7.1 General support

To learn about supported features and limitations, refer to the following sections in this document:

- *Section 5.4, "Kernel"*

- *Section 5.8, "Storage and file systems"*

- *Section 5.11, "Virtualization"*

- *Section 9, "Removed and deprecated features and packages"*

2.7.2 Software requiring specific contracts

Certain software delivered as part of SUSE Linux Enterprise Server may require an external contract. Check the support status of individual packages using the RPM metadata that can be viewed with `rpm`, `zypper`, or YaST.

Major packages and groups of packages affected by this are:

- PostgreSQL (all versions, including all subpackages)

2.7.3 Software under GNU AGPL

SUSE Linux Enterprise Server 15 SP6 (and the SUSE Linux Enterprise modules) includes the following software that is shipped *only* under a GNU AGPL software license:

- Ghostscript (including subpackages)

SUSE Linux Enterprise Server 15 SP6 (and the SUSE Linux Enterprise modules) includes the following software that is shipped under multiple licenses that include a GNU AGPL software license:

- MySpell dictionaries and LightProof

- ArgyllCMS

2.8   Technology previews

Technology previews are packages, stacks, or features delivered by SUSE to provide glimpses into upcoming innovations. Technology previews are included for your convenience to give you a chance to test new technologies within your environment. We would appreciate your feedback! If you test a technology preview, contact your SUSE representative and let them know about your experience and use cases. Your input is helpful for future development.

Technology previews come with the following limitations:

- Technology previews are still in development. Therefore, they may be functionally incomplete, unstable, or in other ways not suitable for production use.

- Technology previews are **not** supported.

- Technology previews may only be available for specific hardware architectures. Details and functionality of technology previews are subject to change. As a result, upgrading to subsequent releases of a technology preview may be impossible and require a fresh installation.

- Technology previews can be removed from a product at any time. This may be the case, for example, if SUSE discovers that a preview does not meet the customer or market needs, or does not comply with enterprise standards.

2.8.1   Technology previews for Arm 64-Bit (AArch64)

2.8.1.1   KVM virtualization with 64K page size kernel flavor

As a technology preview, SUSE Linux Enterprise Server for Arm 15 SP3 added a kernel flavor `64kb`. SUSE Linux Enterprise Server for Arm 15 SP5 introduced support for this `64kb` kernel flavor (*Section 8.5, "64K page size kernel flavor is supported"*).

KVM virtualization with this `64kb` kernel flavor remains a technology preview. Use the `default` kernel flavor for virtualization support.

2.8.1.2   Driver enablement for NVIDIA BlueField-2 DPU as host platform

SUSE Linux Enterprise Server for Arm 15 SP1 and later kernels include drivers for installing on NVIDIA* BlueField* Data Processing Unit (DPU) based server platforms and SmartNIC (Network Interface Controller) cards.

As a technology preview, the SUSE Linux Enterprise Server for Arm 15 SP5 and SP6 kernels include drivers for running on NVIDIA BlueField-2 DPU.

Should you wish to use SUSE Linux Enterprise Server for Arm on NVIDIA BlueField-2 or BlueField-2X (or BlueField-3) in production, contact your SUSE representative.

> ## Note: Host drivers and tools for NVIDIA BlueField-2 SmartNICs
>
> This Technology Preview status applies only to installing SUSE Linux Enterprise Server for Arm 15 SP6 **on** NVIDIA BlueField-2 DPUs.
>
> For an NVIDIA BlueField-2 DPU PCIe card inserted as **SmartNIC** into a SUSE Linux Enterprise Server 15 SP6 or SUSE Linux Enterprise Server for Arm 15 SP6 based server, check *Section 2.8, "Technology previews"* and *Section 5.4, "Kernel"* for support status or known limitations of NVIDIA ConnectX* network drivers for BlueField-2 DPUs (`mlx5_core` and others).
>
> The `rshim` tool is available from SUSE Package Hub (*Section 5.9, "SUSE Package Hub"*).

2.8.1.3   etnaviv drivers for Vivante GPUs are available

The NXP* Layerscape* LS1028A/LS1018A System-on-Chip (SoC) contains a Vivante GC7000UL Graphics Processor Unit (GPU), and the NXP i.MX 8M SoC contains a Vivante GC7000L GPU.

As a technology preview, the SUSE Linux Enterprise Server for Arm 15 SP6 kernel includes `etnaviv`, a Display Rendering Infrastructure (DRI) driver for Vivante GPUs, and the `Mesa-dri` package contains a matching `etnaviv_dri` graphics driver library. Together they can avoid the need for third-party drivers and libraries.

> ## Note
>
> To use them, the Device Tree passed by the bootloader to the kernel needs to include a description of the Vivante GPU for the kernel driver to get loaded. You may need to contact your hardware vendor for a bootloader firmware upgrade.

2.8.1.4   lima driver for Arm Mali Utgard GPUs available

The Xilinx* Zynq* UltraScale*+ MPSoC contains an Arm* Mali*-400 Graphics Processor Unit (GPU).

Prior to SUSE Linux Enterprise Server for Arm 15 SP2, this GPU needed third-party drivers and libraries from your hardware vendor.

As a technology preview, the SUSE Linux Enterprise Server for Arm 15 SP2 kernel added `lima`, a Display Rendering Infrastructure (DRI) driver for Mali *Utgard* microarchitecture GPUs, such as Mali-400, and the `Mesa-dri` package contains a matching `lima_dri` graphics driver library.

Note

To use them, the Device Tree passed by the bootloader to the kernel needs to include a description of the Mali GPU for the kernel driver to get loaded. You may need to contact your hardware vendor for a bootloader firmware upgrade.

Note

The `panfrost` driver for Mali *Midgard* microarchitecture GPUs is supported since SUSE Linux Enterprise Server for Arm 15 SP2.

2.8.1.5   mali-dp driver for Arm Mali Display Processors available

The NXP* Layerscape* LS1028A/LS1018 System-on-Chip contains an Arm* Mali*-DP500 Display Processor.

As a technology preview, the SUSE Linux Enterprise Server for Arm 15 SP2 kernel added `mali-dp`, a Display Rendering Manager (DRM) driver for Mali Display Processors. It has undergone only limited testing because it requires an accompanying physical-layer driver for DisplayPort* output (see *Section 8.6.3, "No DisplayPort graphics output on NXP LS1028A and LS1018A"*).

2.8.1.6   Btrfs file system is enabled in U-Boot bootloader

For Raspberry Pi* devices, SUSE Linux Enterprise Server for Arm 12 SP3 and later include *Das U-Boot* as bootloader, in order to align the boot process with other platforms. By default, it loads GRUB as UEFI application from a FAT-formatted partition, and GRUB then loads Linux kernel and ramdisk from a file system such as Btrfs.

As a technology preview, SUSE Linux Enterprise Server for Arm 15 SP2 added a Btrfs driver to U-Boot for the Raspberry Pi (package `u-boot-rpiarm64`). This allows its commands `ls` and `load` to access files on Btrfs-formatted partitions on supported boot media, such as microSD and USB.

The U-Boot command `btrsubvol` lists Btrfs subvolumes.

2.8.2 Technology previews for Intel 64/AMD64 (x86-64)

2.8.2.1 Support for AMD Wheat Nas GPU

SLES 15 SP6 includes the kernel driver support for AMD Wheat Nas GPU (Navi32 dGPU). However because the corresponding firmware is still not publicly released yet, this feature is considered a technology preview.

2.8.2.2 Add IAA Crypto Driver

SLES 15 SP6 includes the Intel Analytics Accelerators (IAA) crypto compression kernel driver. Since this is a new upstream feature, is is considered a technology preview.

3 Modules, extensions, and related products

This section comprises information about modules and extensions for SUSE Linux Enterprise Server 15 SP6. Modules and extensions add functionality to the system.

Note: Package and module changes in 15 SP6

For more information about all package and module changes since the last version, see *Section 2.2.3, "Package and module changes in 15 SP6"*.

3.1 Modules in the SLE 15 SP6 product line

The SLE 15 SP6 product line is made up of modules that contain software packages. Each module has a clearly defined scope. Modules differ in their life cycles and update timelines.

The modules available within the product line based on SUSE Linux Enterprise 15 SP6 at the release of SUSE Linux Enterprise Server 15 SP6 are listed in the *Modules and Extensions Quick Start* at https://documentation.suse.com/sles/15-SP6/html/SLES-all/article-modules.html.

Not all SLE modules are available with a subscription for SUSE Linux Enterprise Server 15 SP6 itself (see the column *Available for*).

For information about the availability of individual packages within modules, see https://scc.suse.com/packages ↗.

3.2 SLE extensions

SLE Extensions add extra functionality to the system and require their own registration key, usually at additional cost. Most extensions have their own release notes documents that are available from https://www.suse.com/releasenotes ↗.

The following extensions are available for SUSE Linux Enterprise Server 15 SP6:

- SUSE Linux Enterprise Live Patching: https://www.suse.com/products/live-patching ↗

- SUSE Linux Enterprise High Availability: https://www.suse.com/products/highavailability ↗

- SUSE Linux Enterprise Workstation Extension: https://www.suse.com/products/workstation-extension ↗

The following extension is not covered by SUSE support agreements, available at no additional cost and without an extra registration key:

- SUSE Package Hub: https://packagehub.suse.com/ ↗ (see *Section 5.9, "SUSE Package Hub"*)

3.3 Derived and related products

This sections lists derived and related products. Usually, these products have their own release notes documents that are available from https://www.suse.com/releasenotes ↗.

- SUSE Linux Enterprise JeOS: https://www.suse.com/products/server/jeos ↗ (see *Section 4.3, "Minimal VM and Minimal Image"*)

- SUSE Linux Enterprise Desktop: https://www.suse.com/products/desktop ↗

- SUSE Linux Enterprise Server for SAP Applications: https://www.suse.com/products/sles-for-sap ↗

- SUSE Linux Enterprise for High-Performance Computing: https://www.suse.com/products/server/hpc ↗

- SUSE Linux Enterprise Real Time: https://www.suse.com/products/realtime ↗

- SUSE Manager: https://www.suse.com/products/suse-manager ↗

4 Installation and upgrade

SUSE Linux Enterprise Server can be deployed in several ways:

- Physical machine

- Virtual host

- Virtual machine

- System containers

- Application containers

4.1 Installation

This section includes information related to the initial installation of SUSE Linux Enterprise Server 15 SP6.

> **❗ Important: Installation documentation**
>
> The following release notes contain additional notes regarding the installation of SUSE Linux Enterprise Server. However, they do not document the installation procedure itself.
>
> For installation documentation, see the *Deployment Guide* at https://documentation.suse.com/sles/15-SP6/html/SLES-all/book-deployment.html ↗ .

4.1.1 New media layout

The set of media has changed with 15 SP2. There still are two different installation media, but the way they can be used has changed:

- You can install with registration using either the online-installation medium (as with SUSE Linux Enterprise Server 15 SP1) or the full medium.

- You can install without registration using the full medium. The installer has been added to the full medium and the full medium can now be used universally for all types of installations.

- You can install without registration using the online-installation medium. Point the installer at the required SLE repositories, combining the `install=` and `instsys=` boot parameters:

  - With the `install=` parameter, select a path that contains either just the product repository or the full content of the media.

  - With the `inst-sys=` parameter, point at the installer itself, that is, `/boot/ARCHITECTURE/root` on the medium.

  For more information about the parameters, see https://en.opensuse.org/SDB:Linuxrc#p_install ↗ .

4.2 Upgrade-related notes

This section includes upgrade-related information for SUSE Linux Enterprise Server 15 SP6.

> **! Important: Upgrade documentation**
>
> The following release notes contain additional notes regarding the upgrade of SUSE Linux Enterprise Server. However, they do not document the upgrade procedure itself.
>
> For upgrade documentation, see the *Upgrade Guide* at https://documentation.suse.com/sles/15-SP6/html/SLES-all/cha-upgrade-online.html ↗ .

4.2.1 Make sure the current system is up-to-date before upgrading

Upgrading the system is only supported from the most recent patch level. Make sure the latest system updates are installed by either running `zypper patch` or by starting the YaST module *Online Update*. An upgrade on a system that is not fully patched may fail.

4.2.2 Skipping service packs requires LTSS

Skipping service packs during an upgrade is only supported if you have a Long Term Service Pack Support contract. Otherwise, you need to first upgrade to SLE 15 SP5 before upgrading to SLE 15 SP6.

4.2.3 SMT has been replaced by RMT

SLE 12 is the last codestream that SMT (Subscription Management Tool) is available for.

When upgrading your OS installation to SLE 15, we recommend also upgrading from SMT to its replacement RMT (Repository Mirroring Tool). RMT provides the following functionality:

- Mirroring of SUSE-originated repositories for the SLE 12-based and SLE 15-based products your organization has valid subscriptions for.

- Synchronization of subscriptions from SUSE Customer Center using your organization's mirroring credentials. (These credentials can be found in SCC under *Select Organization, Organization, Organization Credentials*)

- Selecting repositories to be mirrored locally via `rmt-cli` tool.

- Registering systems directly to RMT to get required updates.

- Adding custom repositories from external sources and distributing them via RMT to target systems.

- Improved security with proxying: If you have strict security requirements, an RMT instance with direct Internet access can proxy to another RMT instance without direct Internet access.

- Nginx as Web server: The default Web server of RMT is Nginx which has a smaller memory footprint and comparable performance than that used for SMT.

Note that unlike SMT, RMT does not support installations of SLE 11 and earlier.

For more feature comparison between RMT and SMT, see https://github.com/SUSE/rmt/blob/master/docs/smt_and_rmt.md ↗.

For more information about RMT, also see the new RMT Guide at https://documentation.suse.com/sles/15-SP3/html/SLES-all/book-rmt.html ↗.

4.3 Minimal VM and Minimal Image

SUSE Linux Enterprise Server Minimal VM and Minimal Image is a slimmed-down form factor of SUSE Linux Enterprise Server that is ready to run in virtualization environments and the cloud. With SUSE Linux Enterprise Server Minimal VM and Minimal Image, you can choose the right-sized SUSE Linux Enterprise Server option to fit your needs.

SUSE provides virtual disk images for Minimal VM and Minimal Image in the file formats `.qcow2`, `.vhdx`, and `.vmdk`, compatible with KVM, Xen, OpenStack, Hyper-V, and VMware environments. All Minimal VM and Minimal Image images set up the same disk size (24 GB) for the system. Due to the properties of different file formats, the size of Minimal VM and Minimal Image image downloads differs between formats.

4.4 JeOS renamed Minimal VM and Minimal Image

We have received feedback from users confused by the name JeOS, as a matter of fact the acronym JeOS, which meant Just enough Operating System, was not well understood and could be confused with other images provided by SUSE or openSUSE.

We have decided to go with simplicity and rename JeOS by "Minimal VM" for all our Virtual Machine Images and "Minimal Image" for the Raspberry Pi Image. We have also removed a few other characters, in the full images name to make it more simple and clear:

- `SLES15-SP4-Minimal-VM.x86_64-kvm-and-xen-GM.qcow2`

- `SLES15-SP4-Minimal-VM.x86_64-OpenStack-Cloud-GM.qcow2`

- `SLES15-SP4-Minimal-VM.x86_64-MS-HyperV-GM.vhdx.xz`

- `SLES15-SP4-Minimal-VM.x86_64-VMware-GM.vmdk.xz`

- `SLES15-SP4-Minimal-VM.aarch64-kvm-GM.qcow2`

- `SLES15-SP4-Minimal-Image.aarch64-RaspberryPi-GM.raw.xz`

4.5 For more information

For more information, see *Section 5, "Changes affecting all architectures"* and the sections relating to your respective hardware architecture.

5 Changes affecting all architectures

Information in this section applies to all architectures supported by SUSE Linux Enterprise Server 15 SP6.

5.1 Containers

5.1.1 Default container registries

The container registry entries for Docker Hub and openSUSE Registry, which were previously included by default, have now been removed. If you want to pull container images from either of them, add them to the `/etc/containers/registries.conf` file.

5.1.2 `suse/sle15` container uses NDB as the database back-end for RPM

Starting with SUSE Linux Enterprise 15 SP3, the `rpm` package in the `suse/sle15` container image no longer supports the BDB back-end (based on Berkeley DB) and switches to the NDB back-end. Tools for scanning, diffing, and building container image using the `rpm` binary of the host for introspection can fail or return incorrect results if the host's version of `rpm` does not recognize the NDB format.

To use such tools, make sure that the host supports reading NDB databases, such as hosts with SUSE Linux Enterprise 15 SP2 and later.

5.2 Databases

5.2.1 pgAdmin has been updated

The `pgadmin4` package has been updated to version 8.5. It is now part of the *Python 3 Module.*

5.3 Development

5.3.1 `glibc` 2.38

The `glibc` package has been updated to version 2.38.

- A couple of internal `glibc` interfaces has changed; if an application uses these internal interfaces, the application needs fixing (note that internal interfaces should never be used)

- Split deprecated library `libnsl1` into separate package

5.3.2 Supported Java versions

The following Java implementations are available in SUSE Linux Enterprise Server 15 SP6:

> ✋ **Warning**
>
> IBM Java will be removed in 15 SP7.

Name (Package Name)	Version	Module	Support
IBM Java (`java-1_8_0-ibm`)	1.8.0	Legacy	External, until 2025-04-30
OpenJDK (`java-1_8_0-openjdk`)	1.8.0	Legacy	SUSE, L3, until 2026-12-31
OpenJDK (`java-11-openjdk`)	11	Legacy	SUSE, L3, until 2026-12-31
OpenJDK (`java-17-openjdk`)	17	Legacy	SUSE, L3, until 2027-12-31
OpenJDK (`java-21-openjdk`)	21	Base System	SUSE, L3, until 2031-06-30, pending upstream release

5.4 Kernel

5.4.1 `CONFIG_HZ` value changes

The SUSE Linux Enterprise Server 15 SP5 kernels diverged from latest `CONFIG_HZ` default settings for multiple architectures.

The SUSE Linux Enterprise Server for Arm 15 SP6 kernel changed the `CONFIG_HZ` value (*Section 8.3, "Changed kernel* `CONFIG_HZ` *value"*): x86-64 and Arm* architectures now use the same value of 250 Hz.

PowerPC and IBM Z architectures continue to share a value of 100 Hz.

These configuration values cannot be overridden from the kernel command line. If your applications run into issues, contact your SUSE representative.

5.4.2 Kernel limits

This table summarizes the various limits which exist in our recent kernels and utilities (if related) for SUSE Linux Enterprise Server 15 SP6.

SLES 15 SP6 (Linux 6.4)	AMD64/Intel 64 (x86_64)	IBM Z (s390x)	POWER (ppc64le)	Armv8 (AArch64)
CPU bits	64	64	64	64
Maximum number of logical CPUs	8192	256	2048	768
Maximum amount of RAM (theoretical/certified)	>1 PiB/ 64 TiB	10 TiB/ 256 GiB	1 PiB/64 TiB	256 TiB/n.a.
Maximum amount of user space/kernel space	128 TiB/ 128 TiB	n.a.	512 TiB[1]/ 2 EiB	256 TiB/ 256 TiB
Maximum amount of swap space	Up to 29 * 64 GB	Up to 30 * 64 GB		
Maximum number of processes	1,048,576			

SLES 15 SP6 (Linux 6.4)	AMD64/Intel 64 (x86_64)	IBM Z (s390x)	POWER (ppc64le)	Armv8 (AArch64)
Maximum number of threads per process	Upper limit depends on memory and other parameters (tested with more than 120,000)[2].			
Maximum size per block device	Up to 8 EiB on all 64-bit architectures			
FD_SETSIZE	1024			

[1] By default, the user space memory limit on the POWER architecture is 128 TiB. However, you can explicitly request mmaps up to 512 TiB.

[2] The total number of all processes and all threads on a system may not be higher than the "maximum number of processes".

5.4.3　Restoring default Btrfs file compression

Previously in kernel 5.14, it was possible to disable compression by passing an empty string instead of explicitly mentioning `none` or `no`.

In SLES 15 SP6, this behavior is changed to the more expected one. From kernel 5.14 onwards, empty string will reset the default setting instead of disabling compression.

5.5　Miscellaneous

5.5.1　`xorriso` split

The `xorriso` package has been split into `xorriso` (command-line only) and `xorriso-tcltk` (a GUI frontend).

5.5.2　`sysctl` monitoring tool

The `sysctl-logger` package has been added. It is a sysctl monitoring tool that tracks changes to `sysctl` value based on BPF.

5.5.3 IMA EVM signing plugin

A RPM plugin for IMA (Integrity Measurement Architecture)/EVM (Linux Extended Verification Module) signing has been added. The plugin is installed as part of the following package:

- `rpm-imaevmsign`

5.5.4 Installer update URL changed

Previously, the self-updater URL on the installation media was pointing to `updates.suse.com`. In SUSE Linux Enterprise Server 15 SP6 it now points to `installer-updates.suse.com`. If you are behind a firewall you might need to update your system as per the support article at https://www.suse.com/support/kb/doc/?id=000021034 ↗ .

5.5.5 kdump output directory format changed

The `kdump` output directory format has been changed. The format has changed from `YYYY-MM-DD-HH:MN` to `YYYY-MM-DD-HH-MN`. That is, the separator between hours and minutes has changed from ":" to "-".

For more information see the full changelog (https://github.com/openSUSE/kdump/releases/tag/v1.9) ↗ .

5.5.6 SSH between different architectures

By default, recent versions of the X.org and Xwayland servers do not accept connections from clients on different architectures.

For more information see https://documentation.suse.com/sles/15-SP6/single-html/SLES-deployment/#adm-ssh-x-byte-swapping ↗ .

5.5.7 systemd updated to 254

systemd has been updated from 249 to version 254.

Some of the changes in this version include:

New

- Support for encrypted and authenticated credentials has been added. (v250)

- The default maximum numbers of inodes have been raised from 64k to 1M for `/dev`, and from 400k to 1M for `/tmp`. (v250)

Breaking changes

- The minimum kernel version required has been bumped from 3.13 to 4.15, and `CLOCK_BOOTTIME` is now assumed to always exist. (v251)

- `busctl` capture now writes output in the newer `pcapng` format instead of `pcap`. (v251)

- `systemctl` will now warn when invoked without `/proc/` mounted (for example, when invoked after `chroot()` into an directory tree without the API mount points like `/proc/` being set up). Operation in such an environment is not fully supported. (v252)

- 'udevadm hwdb' subcommand is deprecated and will emit a warning. `systemd-hwdb` (added in 2014) should be used instead.

- `udev` rules in `60-evdev.rules` have been changed to load `hwdb` properties for all `modalias` patterns. Previously only the first matching pattern was used. This could change what properties are assigned if the user has more and less specific patterns that could match the same device, but it is expected that the change will have no effect for most users. (v253)

- `after-local` SysV init script has been removed. However for existing systems backward compatibility is kept by creating the relevant symlink/file in `/etc` during upgrades.

See https://github.com/systemd/systemd/releases/tag/v254↗ for the full changelog.

5.5.8   systemd uses cgroup v2 by default

SUSE Linux Enterprise Server 15 SP6 changes default cgroup mode to unified (cgroup v2). Hybrid mode can be enabled using a boot parameter for workloads that depend on cgroup v1, see https://documentation.suse.com/sles/15-SP6/html/SLES-all/cha-tuning-cgroup-s.html#sec-cgroups-hybrid-hierarchy↗.

5.6 Networking

5.6.1 `bind` version 9.18

The `bind` package has been updated from version 9.16 to version 9.18. This is a major update that removes several options but also adds, among others, the following features:

- DoT and DoH (DNS over TLS and DNS over HTTPS) support

- OpenSSL version 3.0.0

See the full changelog (https://kb.isc.org/docs/changes-to-be-aware-of-when-moving-from-bind-916-to-918)↗ for more information.

5.6.2 Samba

The version of Samba shipped with SUSE Linux Enterprise Server 15 SP6 delivers integration with Windows Active Directory domains. In addition, we provide the clustered version of Samba as part of SUSE Linux Enterprise High Availability 15 SP6.

5.6.3 NFS

5.6.3.1 NFSv4

NFSv4 with IPv6 is only supported for the client side. An NFSv4 server with IPv6 is not supported.

5.7 Security

5.7.1 OpenSSH and crypto policies update

The `openssh` package has been updated to version 9.6p1, aligning with system crypto policies from the `crypto-policies` package. This update excludes insecure cryptographic algorithms, notably disallowing RSA keys under 2048 bits. This change may affect users with RSA host keys under 2048 bits for server connections.

To check for affected keys:

```
grep ssh-rsa ~/.ssh/known_hosts | ssh-keygen -lf -
```

The output lists key sizes and associated hostnames/IPs. After upgrade, connections to hosts with 1024 bit keys will fail if no alternative valid key exists.

Note: Troubleshooting

Before upgrade

a. Either update openssh to version 8.4p1, which enables `UpdateHostkeys` by default, allowing ssh to update `known_hosts` with all server's host keys. Users must connect to the host with a 1024-bit RSA key after updating to this version and before upgrading to SP6.

b. Or, manually add host keys:

```
ssh-keyscan hostname >> ~/.ssh/known_hosts
```

Note that this method adds keys without verification; use only if manual host verification is possible.

After upgrade

a. Either temporarily use insecure algorithms by setting the crypto policy to LEGACY:

```
sudo update-crypto-policies --set LEGACY
```

Then, revert to the default secure policy after connecting:

```
sudo update-crypto-policies --set DEFAULT
```

b. Or, remove the invalid host key from `known_hosts` and reconnect, manually verifying the new host key.

5.7.2 Automatic CPU mitigations and how to change them

By default, the CPU mitigations setting to prevent CPU side-channel attacks is set to `Auto`. However, the kernel boot parameters included in the `Auto` option may change from one Service Pack to the next due to the necessity of applying new security patches. This may result in performance loss in some scenarios. You might want to change these to achieve a different tradeoff between performance and security.

For more information on how to configure these settings, see https://documentation.suse.com/sles/15-SP6/single-html/SLES-administration/#vle-grub2-yast2-cpu-mitigations ↗.

5.7.3 OpenSSL 3.1.4 is now default

In SLES 15 SP6, OpenSSL has been updated to version 3.1.4, replacing OpenSSL 1.1.1.

Because the development packages of different versions are mutually exclusive and automatic conflict resolution is not performed during updates, `libopenssl1_1-devel` should be manually selected for de-installation.

5.7.4 TLS 1.1 and 1.0 are no longer recommended for use

The TLS 1.0 and 1.1 standards have been superseded by TLS 1.2 and TLS 1.3. TLS 1.2 has been available for considerable time now.

SUSE Linux Enterprise Server packages using OpenSSL, GnuTLS, or Mozilla NSS already support TLS 1.3. We recommend no longer using TLS 1.0 and TLS 1.1, as SUSE plans to disable these protocols in a future service pack. However, not all packages, for example, Python, are TLS 1.3-enabled yet as this is an ongoing process.

5.8 Storage and file systems

5.8.1 Reusing LVM no longer default

The installer no longer tries to re-use existing LVM configurations. See the *Deployment Guide* at https://documentation.suse.com/sles/15-SP6/single-html/SLES-deployment/#yast-installer-reuse-lvm ↗ for more information.

5.8.2 LUKS2 support in the installer

LUKS2 is no longer technical preview but is now fully supported in YaST Partitioner.

For more information see the Partioning section of the *AutoYaST Guide* at https://documentation.suse.com/sles/15-SP6/single-html/SLES-autoyast/#CreateProfile-Partitioning ↗

5.8.3 Comparison of supported file systems

SUSE Linux Enterprise was the first enterprise Linux distribution to support journaling file systems and logical volume managers in 2000. Later, we introduced XFS to Linux, which allows for reliable large-scale file systems, systems with heavy load, and multiple parallel reading and writing operations. With SUSE Linux Enterprise 12, we started using the copy-on-write file system Btrfs as the default for the operating system, to support system snapshots and rollback.

The following table lists the file systems supported by SUSE Linux Enterprise.

Support status: + supported / − unsupported

Feature	Btrfs	XFS	Ext4	OCFS 2[1]
Supported in product	SLE	SLE	SLE	SLE HA
Data/metadata journaling	N/A[2]	− / +	+ / +	− / +
Journal internal/external	N/A[2]	+ / +	+ / +	+ / −
Journal checksumming	N/A[2]	+	+	+
Subvolumes	+	−	−	−
Offline extend/shrink	+ / +	− / −	+ / +	+ / −[3]
Inode allocation map	B-tree	B+-tree	Table	B-tree
Sparse files	+	+	+	+
Tail packing	−	−	−	−
Small files stored inline	+ (in metadata)	−	+ (in inode)	+ (in inode)
Defragmentation	+	+	+	−

Feature	Btrfs	XFS	Ext4	OCFS 2[1]
Extended file attributes/ACLs	+ / +	+ / +	+ / +	+ / +
User/group quotas	– / –	+ / +	+ / +	+ / +
Project quotas	–	+	+	–
Subvolume quotas	+	N/A	N/A	N/A
Data dump/restore	–	+	–	–
Block size default	4 KiB[4]			
Maximum file system size	16 EiB	8 EiB	1 EiB	4 PiB
Maximum file size	16 EiB	8 EiB	1 EiB	4 PiB

[1] OCFS 2 is fully supported as part of the SUSE Linux Enterprise High Availability.

[2] Btrfs is a copy-on-write file system. Instead of journaling changes before writing them in-place, it writes them to a new location and then links the new location in. Until the last write, the changes are not "committed". Because of the nature of the file system, quotas are implemented based on subvolumes (`qgroups`).

[3] To extend an OCFS 2 file system, the cluster must be online but the file system itself must be unmounted.

[4] The block size default varies with different host architectures. 64 KiB is used on POWER, 4 KiB on other systems. The actual size used can be checked with the command `getconf PAGE_SIZE`.

Additional notes

Maximum file size above can be larger than the file system's actual size because of the use of sparse blocks. All standard file systems on SUSE Linux Enterprise Server have LFS, which gives a maximum file size of 2^{63} bytes in theory.

The numbers in the table above assume that the file systems are using a 4 KiB block size which is the most common standard. When using different block sizes, the results are different.

In this document:

- 1024 Bytes = 1 KiB

- 1024 KiB = 1 MiB;

- 1024 MiB = 1 GiB

- 1024 GiB = 1 TiB

- 1024 TiB = 1 PiB

- 1024 PiB = 1 EiB.

See also http://physics.nist.gov/cuu/Units/binary.html ↗.

Some file system features are available in SUSE Linux Enterprise Server 15 SP6 but are not supported by SUSE. By default, the file system drivers in SUSE Linux Enterprise Server 15 SP6 will refuse mounting file systems that use unsupported features (in particular, in read-write mode). To enable unsupported features, set the module parameter `allow_unsupported=1` in `/etc/modprobe.d` or write the value `1` to `/sys/module/MODULE_NAME/parameters/allow_unsupported`. However, note that setting this option will render your kernel and thus your system unsupported.

5.8.4 Supported Btrfs features

The following table lists supported and unsupported Btrfs features across multiple SLES versions.

Support status: + supported / − unsupported

Feature	SLES 11 SP4	SLES 12 SP5	SLES 15 GA	SLES 15 SP1	SLES 15 SP2	SLES 15 SP3
Copy on write	+	+	+	+	+	+
Free space tree (Free Space Cache v2)	−	−	−	+	+	+
Snapshots/subvolumes	+	+	+	+	+	+
Swap files	−	−	−	+	+	+
Metadata integrity	+	+	+	+	+	+
Data integrity	+	+	+	+	+	+

Feature	SLES 11 SP4	SLES 12 SP5	SLES 15 GA	SLES 15 SP1	SLES 15 SP2	SLES 15 SP3
Online metadata scrubbing	+	+	+	+	+	+
Automatic defragmentation	–	–	–	–	–	–
Manual defragmentation	+	+	+	+	+	+
In-band deduplication	–	–	–	–	–	–
Out-of-band deduplication	+	+	+	+	+	+
Quota groups	+	+	+	+	+	+
Metadata duplication	+	+	+	+	+	+
Changing metadata UUID	–	–	–	+	+	+
Multiple devices	–	+	+	+	+	+
RAID 0	–	+	+	+	+	+
RAID 1	–	+	+	+	+	+
RAID 5	–	–	–	–	–	–
RAID 6	–	–	–	–	–	–
RAID 10	–	+	+	+	+	+
Hot add/remove	–	+	+	+	+	+
Device replace	–	–	–	–	–	–

Feature	SLES 11 SP4	SLES 12 SP5	SLES 15 GA	SLES 15 SP1	SLES 15 SP2	SLES 15 SP3
Seeding devices	–	–	–	–	–	–
Compression	–	+	+	+	+	+
Big metadata blocks	–	+	+	+	+	+
Skinny metadata	–	+	+	+	+	+
Send without file data	–	+	+	+	+	+
Send/receive	–	+	+	+	+	+
Inode cache	–	–	–	–	–	–
Fallocate with hole punch	–	+	+	+	+	+

5.9 SUSE Package Hub

SUSE Package Hub brings open-source software packages from openSUSE to SUSE Linux Enterprise Server and SUSE Linux Enterprise Desktop.

Usage of software from SUSE Package Hub is not covered by SUSE support agreements. At the same time, usage of software from SUSE Package Hub does not affect the support status of your SUSE Linux Enterprise systems. SUSE Package Hub is available at no additional cost and without an extra registration key.

5.10   System management

5.10.1   Effective user limits in systemd setup

Before, the lookup of the effective session limit in a systemd setup was not trivial. Now these new properties have been added:

- `EffectiveMemoryMax`

- `EffectiveMemoryHigh`

- `EffectiveTasksMax`

5.10.2   Searching packages across all SLE modules

In SLE 15 SP6 you can search for packages both within and outside of currently enabled SLE modules using the following command:

```
zypper search-packages SEARCH_TERM
```

This command contacts the SCC and searches all modules for matching packages. This functionality makes it easier for administrators and system architects to find the software packages needed. This feature is now also available when a system is registered against RMT.

5.11   Virtualization

For more information about acronyms used below, see https://documentation.suse.com/sles/15-SP6/html/SLES-all/book-virtualization.html ↗ .

> **⚠ Important: Virtualization limits and supported hosts/guests**
>
> These release notes only document changes in virtualization support compared to the immediate previous service pack of SUSE Linux Enterprise Server. Full information regarding virtualization limits for KVM and Xen as well as supported guest and host systems is now available as part of the SUSE Linux Enterprise Server documentation.
>
> See the *Virtualization Guide* at https://documentation.suse.com/sles/15-SP6/html/SLES-all/cha-virt-support.html ↗ .

5.11.1 Xen

Xen has been updated to version 4.18, for more information: https://wiki.xenproject.org/wiki/Xen_Project_4.18_Release_Notes ↗

5.11.2 QEMU

QEMU has been updated to version 8.2, full list of changes are available at https://wiki.qemu.org/ChangeLog/8.2 ↗

Highlights include:

- New virtio-sound device emulation

- New hv-balloon for dynamic memory protocol device for Hyper-V guests

- New Universal Flash Storage device emulation

- Network Block Device (NBD) 64-bit offsets for improved performance

- dump-guest-memory now supports the standard kdump format

- VFIO: improved live migration support, no longer an experimental feature

- x86: CPU model support for GraniteRapids and SapphireRapids

- Removed features: https://qemu-project.gitlab.io/qemu/about/removed-features.html ↗

- Deprecated features: https://qemu-project.gitlab.io/qemu/about/deprecated.html ↗

5.11.3 libvirt

`libvirt` has been updated to version 10.0.0, this include many incremental improvements and bug fixes, see https://libvirt.org/news.html#v10-0-0-2024-01-15 ↗

`libvirt` provides two daemon deployment options: monolithic or modular daemons. Modular daemons are now enabled by default, but a deployment can be switched to the traditional monolithic daemon by disabling the individual daemons and enabling `libvirtd`.

5.11.4 VMware

5.11.4.1 open-vm-tools

`open-vm-tools` has been updated to version 12.3.5 that addresses a few critical problems and bug fixes. See https://github.com/vmware/open-vm-tools/blob/stable-12.3.5/ReleaseNotes.md ↗

5.11.5 Others

5.11.5.1 NVIDIA GRID

Support for NVIDIA Virtual GPU (vGPU) v16.2 has been added, including migration under some specific scenarios.

5.11.5.2 sanlock

`sanlock` has been updated to version 3.8.5 which contains several bug fixes.

5.11.5.3 libguestfs

`libguestfs` has been updated to version 1.52.0:

- Add support for lzma and zstd compression methods in tar APIs (like guestfs_tar_in)

- The guestfish(1) --key option now recognizes LVM names like /dev/mapper/rhel_bootp—73—75—123-root

- guestfish --key option also supports a new --key all:… selector to try the same key on all devices.

- Dropped the virt-dib tool

- Add --chown option for virt-customize

- Add new virt-customize --tar-in operation

- Various bug fixes and language translations

5.11.5.4 virt-v2v

Update to version 2.4.0, see main changes at: https://libguestfs.org/virt-v2v-release-notes-2.4.1.html ↗

5.11.5.5 sevctl

The `sevctl` package has been updated to version 0.4.3.

6 POWER-specific changes (ppc64le)

Information in this section applies to SUSE Linux Enterprise Server for POWER 15 SP6.

6.1 Storage

6.1.1 DLPAR remove operation fails with Emulex FC adapters

Broadcom Emulex Fibre Channel (FC) adapters might fail to be properly removed with DLPAR operations in SUSE Linux Enterprise Server 15 SP6. All POWER 9 and Power10 systems with any Emulex FC adapter are affected.

When you perform DLPAR remove operations on Emulex FC adapters, there is a possibility that the adapter is not properly removed from the system. This operation can cause future DLPAR operations to fail. A future DLPAR add operation on the same FC adapter might cause symptoms including an EEH error followed by a kernel oops and system crash. The following messages might be seen on a failing system:

```
EEH: Recovering PHB#204-PE#800000
EEH: PE location: N/A, PHB location: N/A
EEH: Frozen PHB#204-PE#800000 detected
EEH: Call Trace:
EEH: [c00000000005674c] __eeh_send_failure_event+0x6c/0x120
EEH: [c00000000004f8a0] eeh_dev_check_failure+0x270/0x6b0
EEH: [c00000000004fd78] eeh_check_failure+0x98/0x110
EEH: [c008000023ba6e00] lpfc_sli4_wait_bmbx_ready+0x118/0x1c0 [lpfc]
EEH: [c008000023ba702c] lpfc_sli4_post_sync_mbox+0x184/0x5a0 [lpfc]
EEH: [c008000023ba99ac] lpfc_sli_issue_mbox_s4+0x7a4/0xce0 [lpfc]
EEH: [c008000023bb4574] lpfc_sli_issue_mbox+0x2c/0x50 [lpfc]
EEH: [c008000023c0220c] __lpfc_reg_congestion_buf+0xd4/0x1d0 [lpfc]
EEH: [c008000023c0ef58] lpfc_pci_remove_one+0xc0/0xe50 [lpfc]
EEH: [c000000000983dc4] pci_device_remove+0x64/0x110
EEH: [c000000000b0a7e4] device_remove+0x74/0xd0
EEH: [c000000000b0c350] device_release_driver_internal+0x120/0x210
EEH: [c000000000974b98] pci_stop_bus_device+0x98/0xf0
EEH: [c000000000974db8] pci_stop_and_remove_bus_device+0x28/0x40
EEH: [c000000000077df0] pci_hp_remove_devices+0x90/0x130
EEH: [c008000026510568] disable_slot+0x40/0x90 [rpaphp]
EEH: [c0000000009abaf8] power_write_file+0xa8/0x170
EEH: [c0000000009a1504] pci_slot_attr_store+0x44/0x60
EEH: [c0000000006a2ed4] sysfs_kf_write+0x64/0x90
EEH: [c0000000006a19e4] kernfs_fop_write_iter+0x204/0x2b0
EEH: [c0000000005a378c] vfs_write+0x36c/0x440
EEH: [c0000000005a3a8c] ksys_write+0xdc/0x130
EEH: [c000000000034b18] system_call_exception+0x158/0x320
EEH: [c00000000000d05c] system_call_vectored_common+0x15c/0x2ec
Kernel attempted to read user page (18) - exploit attempt? (uid: 0)
BUG: Kernel NULL pointer dereference on read at 0x00000018
Faulting instruction address: 0xc008000023baf314
Oops: Kernel access of bad area, sig: 11 [#1]
```

FIGURE 1: SCREENSHOT OF AN ERROR ON A FAILING SYSTEM

There is currently no workaround nor fix available for this issue. Instead of using the DLPAR operation, you can shutdown the logical partition before you remove or add Emulex FC adapters to the configuration.

6.2 Miscellaneous

6.2.1 Out of memory during installation

There is a limit on the memory available to the GRUB bootloader. The installer ramdisk is particularly large because it includes kernel drivers for all possible installation scenarios as well as tools for loading the installer from different types of media. Enabling secure boot and vTPM on the LPAR further increases memory requirements.

When loading the OS from the installation medium the following message might appear:

```
Loading kernel ...
Loading initial ramdisk ...
error: ../../grub-core/kern/mm.c:548:out of memory.

Press any key to continue...
```

The recommended workaround is to disable vTPM support during installation.

7   IBM Z-specific changes (s390x)

Information in this section applies to SUSE Linux Enterprise Server for IBM Z and LinuxONE 15 SP6. For more information, see https://www.ibm.com/docs/en/linux-on-systems?topic=distributions-suse-linux-enterprise-server ⬀

7.1 Security

7.1.1 Secure boot IPL requirements

Secure boot IPL has the following minimum system requirements, depending on the boot device to be IPLed:

- NVMe disk: IBM LinuxONE III or newer.

- FC-attached SCSI disk: IBM LinuxONE III, IBM z15 or newer.

- ECKD DASD with CDL layout: IBM z16, LinuxONE 4 or newer.

If these requirements are not met, the system can be IPLed in non-secure mode only.

8 Arm 64-bit-specific changes (AArch64)

Information in this section applies to SUSE Linux Enterprise Server for Arm 15 SP6.

8.1 System-on-Chip driver enablement

SUSE Linux Enterprise Server for Arm 15 SP6 includes driver enablement for the following System-on-Chip (SoC) chipsets:

- AMD* Opteron* A1100

- Ampere* X-Gene*, eMAG*, Altra*, *Altra Max*, AmpereOne*

- AWS* Graviton, Graviton2, Graviton3

- Broadcom* BCM2837/BCM2710, BCM2711

- Fujitsu* A64FX

- Huawei* Kunpeng* 916, Kunpeng 920

- Marvell* ThunderX*, ThunderX2*; OCTEON TX*; Armada* 7040, Armada 8040

- NVIDIA* Grace; Tegra* X1, Tegra X2, Xavier*, Orin; BlueField*, *BlueField-2*

- NXP* i.MX 8M, 8M Mini; Layerscape* LS1012A, LS1027A/LS1017A, LS1028A/LS1018A, LS1043A, LS1046A, LS1088A, LS2080A/LS2040A, LS2088A, LX2160A

- Qualcomm* Centriq* 2400

- Rockchip RK3399

- Socionext* SynQuacer* SC2A11

- Xilinx* Zynq* UltraScale*+ MPSoC

> **Note**
>
> Driver enablement is done as far as available and requested. Refer to the following sections for any known limitations.

Some systems might need additional drivers for external chips, such as a Power Management Integrated Chip (PMIC), which may differ between systems with the same SoC chipset.

For booting, systems need to fulfill either the Server Base Boot Requirements (SBBR) or the Embedded Base Boot Requirements (EBBR), that is, the Unified Extensible Firmware Interface (UEFI) either implementing the Advanced Configuration and Power Interface (ACPI) or providing a Flat Device Tree (FDT) table. If both are implemented, the kernel will default to the Device Tree; the kernel command line argument `acpi=force` can override this default behavior.

Check for SUSE *YES!* certified systems, which have undergone compatibility testing.

8.2   New features

8.2.1   Memory Tagging in GNU C Library

SUSE Linux Enterprise Server for Arm 15 SP4 and SP5 prepared their kernels for the Armv8.5 Memory Tagging Extension (`FEAT_MTE`). Their `glibc` packages were based on version 2.31 and did not yet support Memory Tagging.

SUSE Linux Enterprise Server for Arm 15 SP6 updates `glibc` base version to 2.38 and enables Memory Tagging in the GNU C Library as well.

8.3   Changed kernel `CONFIG_HZ` value

SUSE Linux Enterprise Server for Arm 15 SP5 and earlier kernels have used a `CONFIG_HZ` value of 100 Hz.

The SUSE Linux Enterprise Server for Arm 15 SP6 kernel instead uses a value of 250 Hz. This matches the latest default and the value for x86-64 architecture (*Section 5.4.1, "*`CONFIG_HZ` *value changes"*).

8.4 Changed kernel I/O MMU default

SUSE Linux Enterprise Server for Arm 15 SP5 and earlier kernels have defaulted the I/O MMU (Input/Output Memory Management Unit) to **passthrough** mode. This was the most performant setting, but did not work on all machines. It then required the user to override the default via `iommu.passthrough=0` kernel command line option.

SUSE Linux Enterprise Server for Arm 15 SP6 kernel instead defaults to **translated** mode. This achieves a greater hardware compatibility.

To force the previous behavior, use the kernel command line option `iommu.passthrough=1`.

8.5 64K page size kernel flavor is supported

SUSE Linux Enterprise Server for Arm 12 SP2 and later kernels have used a page size of 4K. This offers the widest compatibility also for small systems with little RAM, allowing to use Transparent Huge Pages (THP) where large pages make sense.

As a technology preview, SUSE Linux Enterprise Server for Arm 15 SP3 added a kernel flavor `64kb`, offering a page size of 64 KiB and physical/virtual address size of 52 bits. Same as the `default` kernel flavor, it does not use preemption.

SUSE Linux Enterprise Server for Arm 15 SP5 largely removed this technology preview status, offering support for `kernel-64kb` on select platforms, such as NVIDIA Grace*. KVM virtualization remains a technology preview on this `64kb` kernel flavor (*Section 2.8.1.1, "KVM virtualization with 64K page size kernel flavor"*).

Note: Default file system no longer needs to be changed

SUSE Linux Enterprise Server for Arm 15 SP6 SP4 and later allow the use of Btrfs based file systems with 4 KiB block size also with 64 KiB page size kernels.

ⓘ Important: Swap needs to be re-initialized

After booting the 64K kernel, any swap partitions need to re-initialized to be usable. To do this, run the `swapon` command with the `--fixpgsz` parameter on the swap partition. Note that this process deletes data present in the swap partition (for example, suspend data). In this example, the swap partition is on `/dev/sdc1`:

```
swapon --fixpgsz /dev/sdc1
```

✋ Warning: RAID 5 uses page size as stripe size

It is currently possible to configure stripe size by setting the following kernel parameter:

```
echo 16384 > /sys/block/md1/md/stripe_size
```

Keep in mind that `stripe_size` must be in multiples of 4KB and not bigger than `PAGE_SIZE`. Also, it is only supported on systems where `PAGE_SIZE` is not 4096, such as arm64.

Avoid RAID 5 volumes when benchmarking 64K vs. 4K page size kernels.

See the *Storage Guide* for more information on software RAID.

✎ Note: Cross-architecture compatibility considerations

The SUSE Linux Enterprise Server 15 SP6 kernels on x86-64 use 4K page size.

The SUSE Linux Enterprise Server for POWER 15 SP6 kernel uses 64K page size.

8.6 Known limitations

8.6.1 No graphics drivers on NVIDIA Grace Hopper

The NVIDIA Grace Hopper* System-on-Chip contains an integrated, *Hopper* microarchitecture-based Graphics Processor Unit (GPU).

SUSE Linux Enterprise Server for Arm 15 SP6 maintenance updates currently provide packages `nvidia-open-driver-G06-signed-kmp-default` and `kernel-firmware-nvidia-gspx-G06` in version `535.104.05`, which does not yet enable NVIDIA Grace Hopper GH200.

Check for maintenance updates of those packages with version `545.29.02` or later, or contact the system vendor or chip vendor NVIDIA for whether third-party graphics drivers are available for SUSE Linux Enterprise Server for Arm 15 SP6.

> 🖊 Note: PCIe GPUs not affected
>
> Discrete GPU cards with *Hopper* microarchitecture, such as NVIDIA H100, are already enabled in shipping package versions.

8.6.2 No graphics drivers on NVIDIA Jetson

The NVIDIA* Tegra* System-on-Chip chipsets include an integrated Graphics Processor Unit (GPU).

SUSE Linux Enterprise Server for Arm 15 SP6 does not include graphics drivers for any of the NVIDIA Jetson*, NVIDIA IGX or NVIDIA DRIVE* platforms.

Contact the chip vendor NVIDIA for whether third-party graphics drivers are available for SUSE Linux Enterprise Server for Arm 15 SP6.

8.6.3 No DisplayPort graphics output on NXP LS1028A and LS1018A

The NXP* Layerscape* LS1028A/LS1018A System-on-Chip contains an Arm* Mali*-DP500 Display Processor, whose output is connected to a DisplayPort* TX Controller (HDP-TX) based on Cadence* High Definition (HD) Display Intellectual Property (IP).

A Display Rendering Manager (DRM) driver for the Arm Mali-DP500 Display Processor is available as technology preview (*Section 2.8.1.5, "mali-dp driver for Arm Mali Display Processors available"*).

However, there was no HDP-TX physical-layer (PHY) controller driver ready yet. Therefore no graphics output will be available, for example, on the DisplayPort* connector of the NXP LS1028A Reference Design Board (RDB).

Contact the chip vendor NXP for whether third-party graphics drivers are available for SUSE Linux Enterprise Server for Arm 15 SP6.

Alternatively, contact your hardware vendor for whether a bootloader update is available that implements graphics output, allowing to instead use `efifb` framebuffer graphics in SUSE Linux Enterprise Server for Arm 15 SP6.

> **Note**
>
> The Vivante GC7000UL GPU driver (`etnaviv`) is available as a technology preview (*Section 2.8.1.3, "etnaviv drivers for Vivante GPUs are available"*).

9 Removed and deprecated features and packages

This section lists features and packages that were removed from SUSE Linux Enterprise Server or will be removed in upcoming versions.

> **Note: Package and module changes in 15 SP6**
>
> For more information about all package and module changes since the last version, see *Section 2.2.3, "Package and module changes in 15 SP6"*.

9.1 Removed features and packages

The following features and packages have been removed in this release.

- `timezone-java` has been removed.

- `numad` has been removed.

- Adaptec's I2O based RAID controllers (dpt_i2o) has been removed due to security issues.

9.1.1 Public Cloud module removals

The following packages in the Public Cloud module have been removed:

- `azure-cli-acr`

- `azure-cli-acs`

- `azure-cli-advisor`

- `azure-cli-ams`

- `azure-cli-appservice`

- `azure-cli-backup`

- azure-cli-batch
- azure-cli-batchai
- azure-cli-billing
- azure-cli-cdn
- azure-cli-cloud
- azure-cli-cognitiveservices
- azure-cli-component
- azure-cli-configure
- azure-cli-consumption
- azure-cli-container
- azure-cli-cosmosdb
- azure-cli-dla
- azure-cli-dls
- azure-cli-dms
- azure-cli-eventgrid
- azure-cli-eventhubs
- azure-cli-extension
- azure-cli-feedback
- azure-cli-find
- azure-cli-interactive
- azure-cli-iot
- azure-cli-keyvault
- azure-cli-lab
- azure-cli-monitor
- azure-cli-network

- `azure-cli-profile`

- `azure-cli-rdbms`

- `azure-cli-redis`

- `azure-cli-reservations`

- `azure-cli-resource`

- `azure-cli-role`

- `azure-cli-search`

- `azure-cli-servicebus`

- `azure-cli-servicefabric`

- `azure-cli-sql`

- `azure-cli-storage`

- `azure-cli-taskhelp`

- `azure-cli-vm`

- `blue-horizon-config-deploy-cap-eks`

- `cfn-lint`

- `gcimagebundle`

- `google-cloud-sdk`

- `google-compute-engine`

- `google-daemon`

- `google-startup-scripts`

- `python-azure-storage`

- `python-ravello-sdk`

- `python-vsts-cd-manager`

- `python-vsts`

- `regionServiceClientConfigHP`

- `regionServiceClientConfigSAPAzure`

- `regionServiceClientConfigSAPEC2`

- `regionServiceClientConfigSAPGCE`

- `terraform-provider-aws`

- `terraform-provider-azurerm`

- `terraform-provider-external`

- `terraform-provider-google`

- `terraform-provider-helm`

- `terraform-provider-kubernetes`

- `terraform-provider-local`

- `terraform-provider-null`

- `terraform-provider-openstack`

- `terraform-provider-random`

- `terraform-provider-susepubliccloud`

- `terraform-provider-template`

- `terraform-provider-tls`

- `WALinuxAgent`

9.1.2   Miscellaneous

- `openmpi2` and `openmpi3` have been removed.

9.2   Deprecated features and packages

The following features and packages are deprecated and will be removed in a future version of SUSE Linux Enterprise Server.

- IBM Java will be removed in 15 SP7. See *Section 5.3.2, "Supported Java versions"*.

- `sev-tool` has been deprecated. Use `sevctl` instead.

- `gnote` has been deprecated. Use `bijiben` instead.

9.3 ceph client packages deprecation

The following `ceph` client packages have been deprecated and will be removed in 15 SP7:

- `ceph-common`

- `libcephfs-devel`

- `python3-ceph-common`

- `python3-rbd`

- `python3-rgw`

9.4 intel-opencl and intel-graphics-compiler packages deprecation

Since SLE15 SP5, Intel stopped requesting updates intel-opencl and intel-graphics-compiler packages, the packages have been deprecated. They will be removed in 15 SP7, and moved to Package Hub.

10 Obtaining source code

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A Changelog for 15 SP6

A.1 2024-05-15

A.1.1 New

- Added note about `timezone-java` removal in *Section 9, "Removed and deprecated features and packages"* (Jira (https://jira.suse.com/browse/PED-8162) ⬈)

- *Section 5.5.1, "`xorriso` split"* (Jira (https://jira.suse.com/browse/PED-5016) ⬈)

- *Section 2.8.2.2, "Add IAA Crypto Driver"* (Jira (https://jira.suse.com/browse/PED-7757) ↗)

- *Section 5.5.2, "sysctl monitoring tool"* (Jira (https://jira.suse.com/browse/PED-8070) ↗)

- *Section 5.6.1, "bind version 9.18"* (Jira (https://jira.suse.com/browse/PED-7933) ↗)

- *Section 5.2.1, "pgAdmin has been updated"* (Jira (https://jira.suse.com/browse/PED-8160) ↗)

- *Section 5.5.3, "IMA EVM signing plugin"* (Jira (https://jira.suse.com/browse/PED-7247) ↗)

- *Section 5.8.1, "Reusing LVM no longer default"* (Jira (https://jira.suse.com/browse/PED-7980) ↗)

- *Section 5.5.4, "Installer update URL changed"* (Jira (https://jira.suse.com/browse/PED-7561) ↗)

- *Section 5.1.1, "Default container registries"* (Jira (https://jira.suse.com/browse/PED-8291) ↗)

- *Section 5.8.2, "LUKS2 support in the installer"* (Jira (https://jira.suse.com/browse/PED-3881) ↗)

- *Section 6.1.1, "DLPAR remove operation fails with Emulex FC adapters"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1222895) ↗)

- *Section 6.2.1, "Out of memory during installation"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1223982) ↗)

- *Section 5.5.5, "kdump output directory format changed"* (Jira (https://jira.suse.com/browse/DOCTEAM-1384) ↗)

A.1.2   Updated

- Changed kernel version throughout the document to 6.4 (Jira (https://jira.suse.com/browse/PED-4594) ↗)

A.2   2024-04-17

A.2.1   New

- *Section 5.7.1, "OpenSSH and crypto policies update"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1222831) ↗)

- *Section 5.7.2, "Automatic CPU mitigations and how to change them"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1217940) ↗)

- *Section 5.5.6, "SSH between different architectures"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1216868) ↗)

- *Section 5.3.1, "glibc 2.38"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1220966) ↗)

- *Section 2.2.4, "SLE for HPC HPC no longer a separate product"* (Jira (https://jira.suse.com/browse/PED-7684) ↗)

- *Section 7.1.1, "Secure boot IPL requirements"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1222353) ↗)

- *Section 5.7.3, "OpenSSL 3.1.4 is now default"* (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1220091) ↗)

- *Section 5.10.1, "Effective user limits in systemd setup"* (Jira (https://jira.suse.com/browse/PED-7978) ↗)

A.2.2   Updated

- Changed product names:

  - SLE-HA to SLE HA

  - Minimal-VM and Minimal-Image to Minimal VM and Minimal Image, respectively

  - SLE High Availability Extension to SUSE Linux Enterprise High Availability

  - SUSE Linux Enterprise-WE to SUSE Linux Enterprise WE

  - SLES-SAP to SLES for SAP

  - SLE-Software Development Kit to SLE Software Development Kit

- Updated *Section 5.10.2, "Searching packages across all SLE modules"* to mention availability on RMT-registered systems (Bugzilla (https://bugzilla.suse.com/show_bug.cgi?id=1220964) ↗)

- Changed *Section 2.4, "Security, standards, and certification"* to say that 15 SP6 **will be** submitted for certification

A.3 2024-03-11

A.3.1 New

- *Section 5.11.1, "Xen"* (Jira (https://jira.suse.com/browse/PED-4983) ↗)

- *Section 5.11.5.2, "sanlock"* (Jira (https://jira.suse.com/browse/PED-7196) ↗)

- *Section 5.11.5.3, "libguestfs"* (Jira (https://jira.suse.com/browse/PED-4979) ↗)

- *Section 5.11.5.5, "sevctl"* (Jira (https://jira.suse.com/browse/PED-7066) ↗)

- *Section 5.11.2, "QEMU"* (Jira (https://jira.suse.com/browse/PED-4978) ↗)

A.4 2024-02-21

A.4.1 New

- *Section 5.5.7, "systemd updated to 254"* (Jira (https://jira.suse.com/browse/PED-4846) ↗)

- *Section 9.3, "ceph client packages deprecation"* (Jira (https://jira.suse.com/browse/PED-6808) ↗)

- *Section 5.5.8, "systemd uses cgroup v2 by default"* (Jira (https://jira.suse.com/browse/PED-1447) ↗)

- Added `numad` to *Section 9, "Removed and deprecated features and packages"*

A.4.2 Updated

- *Section 5.3.2, "Supported Java versions"*:

  - Add deprecation warning about IBM Java to *Section 9, "Removed and deprecated features and packages"*

  - Move Java 11 to Legacy

- Move Java 17 to Legacy

- Add Java 21

A.5 2023-10-19

- Initial SP6 release

A.5.1 New

- *Section 9.1.1, "Public Cloud module removals"* (Jira (https://jira.suse.com/browse/PED-3806) ↗)

B Kernel parameter changes

✋ Warning

This list of changes may not be exhaustive.

B.1 Changes from SP5 to SP6

These Linux kernel parameters have been changed since SLES 15 SP5.