

## SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease)

# Release Notes

SUSE Linux Enterprise for High-Performance Computing is a highly-scalable, high-performance open-source operating system designed to utilize the power of parallel computing. This document provides an overview of high-level general features, capabilities, and limitations of SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease) and important product updates.

*This product will be released in June 2024.* The latest version of these release notes is always available at <https://www.suse.com/releasesnotes> . Drafts of the general documentation can be found at <https://susedoc.github.io/sle-hpc/main> .

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# 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/releasesnotes> .

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 for High-Performance Computing

SUSE Linux Enterprise for High-Performance Computing is a highly scalable, high performance open-source operating system designed to utilize the power of parallel computing for modeling, simulation and advanced analytics workloads.

SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease) provides tools and libraries related to High Performance Computing. This includes:

- Workload manager
- Remote and parallel shells
- Performance monitoring and measuring tools
- Serial console monitoring tool
- Cluster power management tool
- A tool for discovering the machine hardware topology
- System monitoring
- A tool for monitoring memory errors
- A tool for determining the CPU model and its capabilities (x86-64 only)

- User-extensible heap manager capable of distinguishing between different kinds of memory (x86-64 only)
- Serial and parallel computational libraries providing the common standards BLAS, LAPACK, ...
- Various MPI implementations
- Serial and parallel libraries for the HDF5 file format

## 2.1 Hardware Platform Support

SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease) is available for the Intel 64/AMD64 (x86-64) and AArch64 platforms.

## 2.2 Important Sections of This Document

If you are upgrading from a previous SUSE Linux Enterprise for High-Performance Computing release, you should review at least the following sections:

- *Section 2.4, “Support statement for SUSE Linux Enterprise for High-Performance Computing”*

## 2.3 Support and life cycle

SUSE Linux Enterprise for High-Performance Computing 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 for High-Performance Computing 15 has a 13-year life cycle, with 10 years of General Support and 3 years of Extended Support. The current version (SP6) will be fully maintained and supported until 6 months after the release of SUSE Linux Enterprise for High-Performance Computing 15 SP7.

Any release package is fully maintained and supported until the availability of the next release. Extended Service Pack Overlay Support (ESPOS) and Long Term Service Pack Support (LTSS) are also available for this product. If you need additional time to design, validate and test your upgrade plans, Long Term Service Pack Support (LTSS) can extend the support you get by an additional 12 to 36 months in 12-month increments, providing a total of 3 to 5 years of support on any given Service Pack.

For more information, see:

- The support policy at <https://www.suse.com/support/policy.html> ↗
- Long Term Service Pack Support page at <https://www.suse.com/support/programs/long-term-service-pack-support.html> ↗

## 2.4 Support statement for SUSE Linux Enterprise for High-Performance Computing

To receive support, you need an appropriate subscription with SUSE. For more information, see [https://www.suse.com/support/programs/subscriptions/?id=SUSE\\_Linux\\_Enterprise\\_Server](https://www.suse.com/support/programs/subscriptions/?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 available documentation.

### L2

Problem isolation, which means technical support designed to analyze data, reproduce customer problems, isolate 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 for High-Performance Computing is delivered with L3 support for all packages, except for the following:

- Technology Previews, see [Section 4, “Technology previews”](#)
- Sound, graphics, fonts and artwork
- Packages that require an additional customer contract, see [Section 2.4.1, “Software requiring specific contracts”](#)

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

### 2.4.1 Software requiring specific contracts

Certain software delivered as part of SUSE Linux Enterprise for High-Performance Computing 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.

### 2.4.2 Software under GNU AGPL

SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease) (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 for High-Performance Computing 15 SP6 (prerelease) (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

## 2.5 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 for High-Performance Computing 15 SP6 (prerelease). This directory includes PDF versions of the SUSE Linux Enterprise for High-Performance Computing 15 SP6 (pre-release) Installation Quick Start Guide.

### 2.5.2 Online documentation

- For the most up-to-date version of the documentation for SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease), see <https://susedoc.github.io/sle-hpc/main> (draft version).
- Find a collection of White Papers in the SUSE Linux Enterprise for High-Performance Computing Resource Library at <https://www.suse.com/products/server#resources>.

## 3 Modules, extensions, and related products

This section comprises information about modules and extensions for SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease) Modules and extensions add functionality to the system.

### 3.1 Modules in the SLE 15 SP6 (prerelease) product line

The SLE 15 SP6 (prerelease) 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 (prerelease) at the release of SUSE Linux Enterprise for High-Performance Computing 15 SP6 (pre-release) are listed in the *Modules and Extensions Quick Start* at <https://documentation.suse.com/sles/15-SP3/html/SLES-all/article-modules.html>.

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

For information about the availability of individual packages within modules, see <https://sc-c.suse.com/packages>.

## 3.2 Available extensions

The following extension is not covered by SUSE support agreements, available at no additional cost and without an extra registration key: SUSE Package Hub, see <https://package-hub.suse.com/> .

## 3.3 Related products

This section lists related products. Usually, these products have their own release notes documents that are available from <https://www.suse.com/releasesnotes> .

- SUSE Linux Enterprise Server: <https://www.suse.com/products/server> 
- SUSE Linux Enterprise JeOS: <https://www.suse.com/products/server/jeos> 
- 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 Real Time: <https://www.suse.com/products/realtime> 
- SUSE Manager: <https://www.suse.com/products/suse-manager> 

# 4 Technology previews

Technology previews are packages, stacks, or features delivered by SUSE which are not supported. They may be functionally incomplete, unstable or in other ways not suitable for production use. They are included for your convenience and give you a chance to test new technologies within an enterprise environment.

Whether a technology preview becomes a fully supported technology later depends on customer and market feedback. Technology previews can be dropped at any time and SUSE does not commit to providing a supported version of such technologies in the future.

Give your SUSE representative feedback about technology previews, including your experience and use case.



## 4.1 64K page size kernel flavor has been added

SUSE Linux Enterprise for High-Performance Computing 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 for High-Performance Computing for Arm 15 SP6 (prerelease) adds 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.

Main purpose at this time is to allow for side-by-side benchmarking for High Performance Computing, Machine Learning and other Big Data use cases. Contact your SUSE representative if you notice performance gains for your specific workloads.



### Important: Swap needs to be re-initialized

After booting the 64K kernel, any swap partitions need to be 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
```



### Important: Btrfs file system uses page size as block size

It is currently not possible to use Btrfs file systems across page sizes. Block sizes below page size are not yet supported and block sizes above page size might never be supported. During installation, change the default partitioning proposal and choose another file system, such as Ext4 or XFS, to allow rebooting from the default 4K page size kernel of the Installer into `kernel-64kb` and back.

See the *Storage Guide* for a discussion of supported file systems.



### Warning: RAID 5 uses page size as stripe size

It is currently not yet possible to configure stripe size on volume creation. This will lead to sub-optimal performance if page size and block size differ.

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 for High-Performance Computing 15 SP6 (prerelease) kernels on x86-64 use 4K page size.

The SUSE Linux Enterprise for High-Performance Computing for POWER 15 SP6 (prerelease) kernel uses 64K page size.

## 5 Modules

### 5.1 HPC module

The HPC module contains HPC specific packages. These include the workload manager Slurm, the node deployment tool `clustduct`, `munge` for user authentication, the remote shell `mrsh`, the parallel shell `pdsh`, as well as numerous HPC libraries and frameworks.

This module is available with the SUSE Linux Enterprise for High-Performance Computing only. It is selected by default during the installation. It can be added or removed using the YaST UI or the `SUSEConnect` CLI tool. Refer to the system administration guide for further details.

### 5.2 NVIDIA Compute Module

The NVIDIA Compute Module provides the NVIDIA CUDA repository for SUSE Linux Enterprise 15. Note that any software within this repository is under a 3rd party EULA. For more information check <https://docs.nvidia.com/cuda/eula/index.html>.

This module is not selected for addition by default when installing SUSE Linux Enterprise for High-Performance Computing. It may be selected manually during installation from the *Extension and Modules* screen. You may also select it on an installed system using YaST. To do so, run from a shell as root `yast registration`, select: `Select Extensions` and search for `NVIDIA Compute Module` and press `Next`.

## Important

Do not attempt to add this module with the SUSEConnect CLI tool. This tool is not yet capable of handling 3rd party repositories.

Once you have selected this module you will be asked to confirm the 3rd party license and verify the repository signing key.

## 6 Changes affecting all architectures

Information in this section applies to all architectures supported by SUSE Linux Enterprise for High-Performance Computing 15 SP6 (prerelease).

### 6.1 Enriched system visibility in the SUSE Customer Center (SCC)

SUSE is committed to helping provide better insights into the consumption of SUSE subscriptions regardless of where they are running or how they are managed; physical or virtual, on-prem or in the cloud, connected to SCC or Repository Mirroring Tool (RMT), or managed by SUSE Manager. To help you identify or filter out systems in SCC that are no longer running or decommissioned, SUSEConnect now features a daily “ping”, which will update system information automatically. For more details see the documentation at <https://documentation.suse.com/subscription/suseconnect/single-html/SLE-suseconnect-visibility/>.

### 6.2 Automatically opened ports

Installing the following packages automatically opens the following ports:

- dolly - TCP ports 9997 and 9998
- slurm - TCP ports 6817, 6818, and 6819

## Important

These release notes only document changes in SUSE Linux Enterprise for High-Performance Computing compared to the immediate previous service pack of SUSE Linux Enterprise for High-Performance Computing. The full changes and fixes can be found on the respective web site of the packages.

### 6.3 GNU compiler suite version 12

SLE HPC 15 SP6 (prerelease) now supports the GNU compiler suite version 12. To install the runtime environments (environment modules) for version 12, run: `zypper install gnu12-compilers-hpc`. To install all the packages required for development (C, C and Fortran compilers), run `zypper install gnu12-compilers-hpc-devel`. To load the environment, run `module load gnu/12` in your shell. When the `-devel` package is installed, the compilers (`gcc-12`, `g-12`, `gfortran-12`) will become available in this shell under their standard names (`gcc`, `g++`, `gfortran`).

### 6.4 conman

`conman` has been updated to version 0.3.1:

- Fixed username/password use in `libipmiconsole.conf`.
- Added `-T` command-line option to specify terminal emulator.
- General move of files from `/usr/lib/conman` to `/usr/share/conman`.

### 6.5 dolly

`dolly` has been updated to version 0.64.2. The tool is less verbose by default and the `dolly` service can be activated through a socket.

## 6.6 imb

imb is shipped in version 2021.3:

- Change default value for mem\_alloc\_type to device.
- Added new IMB-MPI1-GPU benchmarks as technical preview.
- Added -msg\_pause option.
- Changed default window\_size from 64 to 256.
- Added -window\_size option for IMB-MPI1.

## 6.7 memkind

memkind has been updated to version 1.14.0. The full list of changes is available at <http://memkind.github.io/memkind/> .

## 6.8 openblas

openblas has been updated to version 0.3.21. It contains performance regression fixes and optimizations. For more information see <https://github.com/xianyi/OpenBLAS/releases/tag/v0.3.21> .

## 6.9 munge

munge has been updated to version 0.5.15:

- Fixed systemd service unit configuration to wait until network is online.
- Fixed sending repeated SIGTERMs to signal stop.

## 6.10 cpuid

cpuid has been updated to version 20221201.

This update includes:

- Added and updated identification of many CPU models and variants.
- Updated hypervisor support.
- Improved synth information and u-architecture decoding.

## 6.11 `lmod`

`lmod` has been updated to version 8.7.17.

The user visible changes include:

- Add option `--miniConfig` to report configuration differences from default.
- Move cache file location from `~/.lmod.d/.cache/*` to `~/.cache/lmod/*`
- Transitional support for using `~/.config/lmod` for collections. Currently collect are written to both `~/.lmod.d/` and `~/.config/lmod`.
- `setenv` and `pushenv` change local environment when running spider (and avail).
- Allow bash users to export `SUPPORT_KSH=no` so that they can avoid bash startup setting `FPATH`
- Add `--location` option to show to write to stderr the file location.
- Only rebuild spider caches if there are any loaded or pending modules. `module avail <name1> <name2> ...` now only prints matching aliases. Search names are resolved.
- Print `dataT` table when there is an Exception.
- New command added: `module overview`.
- Add `spiderPathFilter` hook so that sites can control what paths are kept or ignored.
- Added `$LMOD_SITE_MODULEPATH` support to prepend to `MODULEPATH`
- Add support for `sh_to_modulefile` to support zsh, ksh, bash and tcsh with aliases and shell functions
- Support for `source_sh` added. Now support more than one shell script per modulefile.

## 6.12 PAPI

PAPI has been updated to version 7.0.0.

The highlights include:

- Added "intel\_gpu" component with monitoring capabilities support for Intel GPUs, including GPU hardware events and memory performance metrics.
- Added "sysdetect" component for detecting a machine's architectural details. Additionally, PAPI offers a new API that enables users to get "sysdetect" details from within their application.
- A major redesign of the "rocm" component for advanced monitoring features for the latest AMD GPUs. The PAPI "rocm" component is now thread-safe.
- Support for NVIDIA compute capability 7.0 and greater. This implies support for CUPTI's new Profiling and Perfworks APIs.
- Significant redesign of the "sde" component into two separate entities:
  1. a standalone library "libsde" with a new API for software developers to define software-based metrics from within their applications
  2. the PAPI "sde" component that enables monitoring of these new software-based events.
- New C++ interface for "libsde," which enables software developers to define software-defined events from within their C++ applications.
- New Counter Analysis Toolkit (CAT) benchmarks and refinements of PAPI's CAT data analysis.
- Support for FUGAKU's A64FX Arm architecture, including monitoring capabilities for memory bandwidth and other node-wide metrics. For further details check <https://bitbucket.org/icl/papi/wiki/PAPI-Releases.md> 

## 6.13 `warewulf4`

`warewulf4` is a popular SLE for HPC deployment tool whose latest version is a full rewrite in the Go programming language. It is applying lessons learned from its predecessors. It deploys minimal images which it obtains from container images stored in a registry and performs a minimal configuration for the image to be useful as a compute node image in a cluster. `warewulf4` is deprecating the former deployment tool `clustduct`.

## 6.14 Creating containers from current HPC environment

Usually users use environment modules to adjust their environment (that is, environment variables like `PATH`, `LD_LIBRARY_PATH`, `MANPATH` etc.) to pick exactly the tools and libraries they need for their work. The same can be achieved with containers by including only those components in a container that are part of this environment. This functionality is now provided using the `spack` and `singularity` applications.

## 6.15 `Spack`

### 6.15.1 `v0.19.1`

#### 6.15.1.1 `Spack Bugfixes`

- `buildcache create: make file exists` less verbose
- `spack mirror create: don't change paths to urls`
- Improve error message for requirements
- `uninstall: fix accidental cubic complexity`
- `scons: fix signature for install_args`
- Fix `combine_phase_logs` text encoding issues
- Use a module-like object to propagate changes in the MRO, when setting build env
- `PackageBase` should not define builder legacy attributes



- Forward lookup of the `run_tests` attribute
- Bugfix for timers
- Fix path handling in prefix inspections
- Fix libtool filter for Fujitsu compilers
- FileCache: delete the new cache file on exception
- Propagate exceptions from Spack python console
- Tests: Fix a bug/typo in a `config_values.py` fixture
- Various CI fixes
- Docs: remove monitors and analyzers, typos
- bump release version for tutorial command

## 6.15.2 v0.19.0

v0.19.0 is a major feature release.

### 6.15.2.1 Major features in this release

#### 1. Package requirements

Spack's traditional [package preferences](https://spack.readthedocs.io/en/latest/build_settings.html#package-preferences) ([https://spack.readthedocs.io/en/latest/build\\_settings.html#package-preferences](https://spack.readthedocs.io/en/latest/build_settings.html#package-preferences)) are soft, but we've added hard requirements to `packages.yaml` and `spack.yaml`. Package requirements use the same syntax as specs:

```
packages:
  libfabric:
    require: "@1.13.2"
  mpich:
    require:
      - one_of: ["+cuda", "+rocm"]
```

More details in [the docs](https://spack.readthedocs.io/en/latest/build_settings.html#package-requirements) ([https://spack.readthedocs.io/en/latest/build\\_settings.html#package-requirements](https://spack.readthedocs.io/en/latest/build_settings.html#package-requirements)).

#### 2. Environment UI Improvements

- Fewer surprising modifications to `spack.yaml` :
  - `spack install` in an environment will no longer add to the `specs:` list; you'll need to either use `spack add <spec>` or `spack install --add <spec>`.
  - Similarly, `spack uninstall` will not remove from your environment's `specs:` list; you'll need to use `spack remove` or `spack uninstall --remove`.  
This will make it easier to manage an environment, as there is clear separation between the stack to be installed (`spack.yaml` / `spack.lock`) and which parts of it should be installed (`spack install` / `spack uninstall`).
- `concretizer:unify:true` is now the default mode for new environments  
We see more users creating `unify:true` environments now. Users who need `unify:false` can add it to their environment to get the old behavior. This will concretize every spec in the environment independently.
- Include environment configuration from URLs ( [docs\(https://spack.readthedocs.io/en/latest/environments.html#included-configurations\)](https://spack.readthedocs.io/en/latest/environments.html#included-configurations) )  
You can now include configuration in your environment directly from a URL:

```
spack:
  include:
    - https://github.com/path/to/raw/config/compilers.yaml
```

### 3. Compiler and variant propagation

Currently, compiler flags and variants are inconsistent: compiler flags set for a package are inherited by its dependencies, while variants are not. We should have these be consistent by allowing for inheritance to be enabled or disabled for both variants and compiler flags.

Example syntax: `* package ++variant`: enabled variant that will be propagated to dependencies  
`* package +variant`: enabled variant that will NOT be propagated to dependencies  
`* package ~~variant`: disabled variant that will be propagated to dependencies  
`* package ~variant`: disabled variant that will NOT be propagated to dependencies  
`* package cflags==g: cflags` will be propagated to dependencies  
`* package cflags=-g: cflags` will NOT be propagated to dependencies

+ Syntax for non-boolean variants is similar to compiler flags. More in the docs for [variants\(https://spack.readthedocs.io/en/latest/basic\\_usage.html#variants\)](https://spack.readthedocs.io/en/latest/basic_usage.html#variants) and [compiler flags\(https://spack.readthedocs.io/en/latest/basic\\_usage.html#compiler-flags\)](https://spack.readthedocs.io/en/latest/basic_usage.html#compiler-flags).

### 4. Enhancements to git version specifiers

- v0.18.0 added the ability to use git commits as versions. You can now use the git. prefix to specify git tags or branches as versions. All of these are valid git versions in v0.19 :

```
foo@abcdef1234abcdef1234abcdef1234abcdef1234      # raw commit
foo@git.abcdef1234abcdef1234abcdef1234abcdef1234  # commit with git prefix
foo@git.develop                                    # the develop branch
foo@git.0.19                                       # use the 0.19 tag
```

- v0.19 also gives you more control over how Spack interprets git versions, in case Spack cannot detect the version from the git repository. You can suffix a git version with =<version> to force Spack to concretize it as a particular version :

```
# use mybranch, but treat it as version 3.2 for version comparison
foo@git.mybranch=3.2

# use the given commit, but treat it as develop for version comparison
foo@git.abcdef1234abcdef1234abcdef1234abcdef1234=develop
```

More in the docs ([https://spack.readthedocs.io/en/latest/basic\\_usage.html#version-specifier](https://spack.readthedocs.io/en/latest/basic_usage.html#version-specifier)) ↗

## 5. Changes to Cray EX Support

Cray machines have historically had their own platform within Spack, because we needed to go through the module system to leverage compilers and MPI installations on these machines. The Cray EX programming environment now provides standalone craycc executables and proper mpicc wrappers, so Spack can treat EX machines like Linux with extra packages .

We expect this to greatly reduce bugs, as external packages and compilers can now be used by prefix instead of through modules. We will also no longer be subject to reproducibility issues when modules change from Cray PE release to release and from site to site. This also simplifies dealing with the underlying Linux OS on cray systems, as Spack will properly model the machine's OS as either SuSE or RHEL.

## 6. Improvements to tests and testing in CI

- `spack ci generate --tests` will generate a `.gitlab-ci.yml` file that not only does builds but also runs tests for built packages. Public GitHub pipelines now also run tests in CI.
- `spack test run --explicit` will only run tests for packages that are explicitly installed, instead of all packages.

## 7. Experimental binding link model

You can add a new option to `config.yaml` to make Spack embed absolute paths to needed shared libraries in ELF executables and shared libraries on Linux ( [docs \(https://spack.readthedocs.io/en/latest/config\\_yaml.html#shared-linking-bind\)](https://spack.readthedocs.io/en/latest/config_yaml.html#shared-linking-bind)  )::

```
config:
  shared_linking:
    type: rpath
    bind: true
```

This can improve launch time at scale for parallel applications, and it can make installations less susceptible to environment variables like `LD_LIBRARY_PATH`, even especially when dealing with external libraries that use `RUNPATH`. You can think of this as a faster, even higher-precedence version of `RPATH`.

### 6.15.2.2 Other new features of note

- `spack spec` prints dependencies more legibly. Dependencies in the output now appear at the *earliest* level of indentation possible
- You can override `package.py` attributes like `url`, directly in `packages.yaml` ( [docs \(https://spack.readthedocs.io/en/latest/build\\_settings.html#assigning-package-attributes\)](https://spack.readthedocs.io/en/latest/build_settings.html#assigning-package-attributes)  )
- There are a number of new architecture-related format strings you can use in Spack configuration files to specify paths ( [docs \(https://spack.readthedocs.io/en/latest/configuration.html#config-file-variables\)](https://spack.readthedocs.io/en/latest/configuration.html#config-file-variables)  )

### 6.15.2.3 Performance Improvements

- Major performance improvements for installation from binary caches
- Test suite can now be parallelized using `xdist` (used in GitHub Actions)
- Reduce lock contention for parallel builds in environments

### 6.15.2.4 New binary caches and stacks

- We now build nearly all of E4S with `oneapi` in our buildcache
- Added 3 new machine learning-centric stacks to binary cache: `x86_64_v3`, CUDA, ROCm

### 6.15.2.5 Removals and Deprecations

- Support for Python 3.5 is dropped . Only Python 2.7 and 3.6+ are officially supported.
- This is the last Spack release that will support Python 2 . Spack `v0.19` will emit a deprecation warning if you run it with Python 2, and Python 2 support will soon be removed from the `develop` branch.
- `LD_LIBRARY_PATH` is no longer set by default by `spack load` or module loads. Setting `LD_LIBRARY_PATH` in Spack environments/modules can cause binaries from outside of Spack to crash, and Spack's own builds use `RPATH` and do not need `LD_LIBRARY_PATH` set in order to run. If you still want the old behavior, you can run these commands to configure Spack to set `LD_LIBRARY_PATH`:

```
spack config add modules:prefix_inspections:lib64:[LD_LIBRARY_PATH]
spack config add modules:prefix_inspections:lib:[LD_LIBRARY_PATH]
```

- The `spack:concretization:[together|separately]` has been removed after being deprecated in `v0.18`. Use `concretizer:unify:[true|false]`.
- `config:module_roots` is no longer supported after being deprecated in `v0.18`. Use configuration in module sets instead ( [docs \(https://spack.readthedocs.io/en/latest/module\\_file\\_support.html\)](https://spack.readthedocs.io/en/latest/module_file_support.html) ).
- `spack activate` and `spack deactivate` are no longer supported, having been deprecated in `v0.18`. Use an environment with a view instead of activating/deactivating ( [docs \(https://spack.readthedocs.io/en/latest/environments.html#configuration-in-spack-yaml\)](https://spack.readthedocs.io/en/latest/environments.html#configuration-in-spack-yaml) ).

- The old YAML format for buildcaches is now deprecated . If you are using an old buildcache with YAML metadata you will need to regenerate it with JSON metadata.
- `spack bootstrap trust` and `spack bootstrap untrust` are deprecated in favor of `spack bootstrap enable` and `spack bootstrap disable` and will be removed in v0.20.
- The `graviton2` architecture has been renamed to `neoverse_n1`, and `graviton3` is now `neoverse_v1`. Buildcaches using the old architecture names will need to be rebuilt.
- The terms `blacklist` and `whitelist` have been replaced with `include` and `exclude` in all configuration files . You can use `spack config update` to automatically fix your configuration files.

#### 6.15.2.6 Notable Bugfixes

- Permission setting on installation now handles effective uid properly
- `buildable:true` for an MPI implementation now overrides `buildable:false` for `mpi`
- Improved error messages when attempting to use an unconfigured compiler
- Do not punish explicitly requested compiler mismatches in the solver
- `spack stage: add missing` `-fresh` and `-reuse`
- Fixes for adding build system executables like `cmake` to package scope
- Bugfix for binary relocation with aliased strings produced by newer `binutils`

### 6.15.3 v0.18.1

#### 6.15.3.1 Spack Bugfixes

- Fix several bugs related to bootstrapping
- Fix a regression that was causing spec hashes to differ between Python 2 and Python 3
- Fixed compiler flags for oneAPI and DPC++
- Fixed several issues related to concretization

- Improved support for Cray manifest file and `spack external find`
- Assign a version to openSUSE Tumbleweed according to the GLIBC version in the system
- Improved Dockerfile generation for `spack containerize`
- Fixed a few bugs related to concurrent execution of commands

#### 6.15.3.2 Package updates

- WarpX: add v22.06, fixed libs property
- openPMD: add v0.14.5, update recipe for @develop

#### 6.15.4 v0.18.0

v0.18.0 is a major feature release.

##### 6.15.4.1 Major features in this release

###### 1. Concretizer now reuses by default

`spack install --reuse` was introduced in v0.17.0, and `--reuse` is now the default concretization mode. Spack will try hard to resolve dependencies using installed packages or binaries .

To avoid reuse and to use the latest package configurations, (the old default), you can use `spack install --fresh`, or add configuration like this to your environment or `concretizer.yaml`:

```
concretizer:
  reuse: false
```

###### 2. Finer-grained hashes

Spack hashes now include link, run, *and* build dependencies, as well as a canonical hash of package recipes. Previously, hashes only included link and run dependencies (though build dependencies were stored by environments). We coarsened the hash to reduce churn in user installations, but the new default concretizer behavior mitigates this concern and gets us reuse *and* provenance. You will be able to see the build dependencies of new installations with `spack find`. Old installations will not change and their hashes will not be affected.

### 3. Improved error messages

Error handling with the new concretizer is now done with optimization criteria rather than with unsatisfiable cores, and Spack reports many more details about conflicting constraints.

### 4. Unify environments when possible

Environments have thus far supported `concretization: together` or `concretization: separately`. These have been replaced by a new preference in `concretizer.yaml`:

```
concretizer:
  unify: [true|false|when_possible]
```

`concretizer:unify:when_possible` will *try* to resolve a fully unified environment, but if it cannot, it will create multiple configurations of some packages where it has to. For large environments that previously had to be concretized separately, this can result in a huge speedup (40-50x).

### 5. Automatically find externals on Cray machines

Spack can now automatically discover installed packages in the Cray Programming Environment by running `spack external find` (or `spack external read-cray-manifest` to *only* query the PE). Packages from the PE (e.g., `cray-mpich`) are added to the database with full dependency information, and compilers from the PE are added to `compilers.yaml`. Available with the June 2022 release of the Cray Programming Environment.

### 6. New binary format and hardened signing

Spack now has an updated binary format, with improvements for security. The new format has a detached signature file, and Spack verifies the signature before untarring or decompressing the binary package. The previous format embedded the signature in a `tar` file, which required the client to run `tar` *before* verifying. Spack can still install from build caches using the old format, but we encourage users to switch to the new format going forward.

Production GitLab pipelines have been hardened to securely sign binaries. There is now a separate signing stage so that signing keys are never exposed to build system code, and signing keys are ephemeral and only live as long as the signing pipeline stage.

### 7. Bootstrap mirror generation

The `spack bootstrap mirror` command can automatically create a mirror for bootstrapping the concretizer and other needed dependencies in an air-gapped environment.

### 8. Makefile generation



`spack env depfile` can be used to generate a `Makefile` from an environment, which can be used to build packages the environment in parallel on a single node. e.g.:

```
spack -e myenv env depfile > Makefile
make
```

Spack propagates `gmake` jobserver information to builds so that their jobs can share cores.

## 9. New variant features

In addition to being conditional themselves, variants can now have [conditional values](https://spack.readthedocs.io/en/latest/packaging_guide.html#conditional-possible-values) (https://spack.readthedocs.io/en/latest/packaging\_guide.html#conditional-possible-values) that are only possible for certain configurations of a package.

Variants can be [declared sticky](https://spack.readthedocs.io/en/latest/packaging_guide.html#sticky-variants) (https://spack.readthedocs.io/en/latest/packaging\_guide.html#sticky-variants), which prevents them from being enabled or disabled by the concretizer. Sticky variants must be set explicitly by users on the command line or in `packages.yaml`.

- Allow conditional possible values in variants
- Add a sticky property to variants

### 6.15.4.2 Other new features of note

- Environment views can optionally link only `run` dependencies with `link:run`
- `spack external find --all` finds library-only packages in addition to build dependencies
- Customizable `config:license_dir` option
- `spack external find --path PATH` takes a custom search path
- `spack spec` has a new `--format` argument like `spack find`
- `spack concretize --quiet` skips printing concretized specs
- `spack info` now has cleaner output and displays test info
- Package-level submodule option for git commit versions
- Using `/hash` syntax to refer to concrete specs in an environment now works even if `/hash` is not installed.

#### 6.15.4.3 Major internal refactors

- full hash (see above)
- new develop versioning scheme 0.19.0-dev0
- Allow for multiple dependencies/dependents from the same package
- Splice differing virtual packages

#### 6.15.4.4 Performance Improvements

- Concretization of large environments with unify: when\_possible is much faster than concretizing separately (see above)
- Single-pass view generation algorithm is 2.6x faster

#### 6.15.4.5 Archspec improvements

- oneapi and dpcpp flag support
- better support for M1 and a64fx

#### 6.15.4.6 Removals and Deprecations

- Spack no longer supports Python 2.6
- Removed deprecated --run-tests option of spack install; use spack test
- Removed deprecated spack flake8; use spack style
- Deprecate spack:concretization config option; use concretizer:unify
- Deprecate top-level module configuration; use module sets
- spack activate and spack deactivate are deprecated in favor of environments; will be removed in 0.19.0

#### 6.15.4.7 Notable Bugfixes

- Fix bug that broke locks with many parallel builds
- Many bugfixes and consistency improvements for the new concretizer and --reuse

#### 6.15.4.8 Packages

- `CMakePackage` uses `CMAKE_INSTALL_RPATH_USE_LINK_PATH`
- Refactored `lua` support: `lua-lang` virtual supports both `lua` and `luajit` via new `Lu-aPackage` build system
- `PythonPackage`: now installs packages with `pip`
- `Python`: improve `site_packages_dir` handling
- `Extends`: support spec, not just package name
- Use stable URLs and `?full_index=1` for all github patches

### 6.16 Slurm 23.02

#### 6.16.1 Important Notes on Upgrading Slurm from a Previous Version

If using the `slurmdbd` (Slurm DataBase Daemon) you must update this first.

If using a backup DBD you must start the primary first to do any database conversion, the backup will not start until this has happened.

The 23.02 `slurmdbd` will work with Slurm daemons of version 21.08 and above. You will not need to update all clusters at the same time, but it is very important to update `slurmdbd` first and having it running before updating any other clusters making use of it.

Slurm can be upgraded from version 22.05 to version 23.02 without loss of jobs or other state information. Upgrading directly from an earlier version of Slurm will result in loss of state information.

All `SPANK` plugins must be recompiled when upgrading from any Slurm version prior to 23.02.



#### Note

PMIx v1.x is no longer supported.

## 6.16.2 Highlights

- `slurmctld` - Add new RPC rate limiting feature. This is enabled through `SlurmctldParameters=rl_enable`, otherwise disabled by default.
- Make `scontrol` reconfigure and sending a `SIGHUP` to the `slurmctld` behave the same. If you were using `SIGHUP` as a 'lighter' `scontrol` reconfigure to rotate logs please update your scripts to use `SIGUSR2` instead.
- Change cloud nodes to show by default. `PrivateData=cloud` is no longer needed.
- `sreport` - Count planned (FKA reserved) time for jobs running in `IGNORE_JOBS` reservations. Previously was lumped into `IDLE` time.
- `job_container/tmpfs` - Support running with an arbitrary list of private mount points (`/tmp` and `/dev/shm` are the default, but not required).
- `job_container/tmpfs` - Set more environment variables in `InitScript`.
- Make all cgroup directories created by Slurm owned by root. This was the behavior in cgroup/v2 but not in cgroup/v1 where by default the step directories ownership were set to the user and group of the job.
- `accounting_storage/mysql` - change purge/archive to calculate record ages based on end time, rather than start or submission times.
- `job_submit/lua` - add support for `log_user()` from `slurm_job_modify()`.
- Run the following scripts in `slurmscriptd` instead of `slurmctld`: `ResumeProgram`, `ResumeFailProgram`, `SuspendProgram`, `ResvProlog`, `ResvEpilog`, and `RebootProgram` (only with `SlurmctldParameters=reboot_from_controller`).
- Only permit changing log levels with `srun --slurmd-debug` by root or `SlurmUser`.
- `slurmctld` will `fatal()` when reconfiguring the `job_submit` plugin fails.
- Add `PowerDownOnIdle` partition option to power down nodes after nodes become idle.
- Add “[jobid.stepid]” prefix from `slurmstepd` and “slurmscriptd” prefix from `slurmscriptd` to Syslog logging. Previously was only happening when logging to a file.
- Add purge and archive functionality for job environment and job batch script records.
- Extend support for Include files to all "configless" client commands.

- Make node weight usable for powered down and rebooting nodes.
- Removed “launch” plugin.
- Add “Extra” field to job to store extra information other than a comment.
- Add usage gathering for AMD (requires ROCM 5.5 + ) and NVIDIA gpus.
- Add job’s allocated nodes, features, oversubscribe, partition, and reservation to SLURM\_RESUME\_FILE output for power saving.
- Automatically create directories for stdout/stderr output files. Paths may use %j and related substitution characters as well.
- Add --tres-per-task to salloc/sbatch/srun.
- Allow nodefeatures plugin features to work with cloud nodes. e.g. - Powered down nodes have no active changeable features.
  - Nodes can’t be changed to other active features until powered down.
  - Active changeable features are reset/cleared on power down.
- Make slurmstepd cgroups constrained by total configured memory from slurm.conf (NodeName=<> RealMemory=#) instead of total physical memory.
- node\_features/helpers - add support for the OR and parentheses operators in a --constraint expression.
- slurmctld will fatal() when [Prolog|Epilog]Slurmctld are defined but are not executable.
- Validate node registered active features are a super set of node’s currently active changeable features.
- On clusters without any PrologFlags options, batch jobs with failed prologs no longer generate an output file.
- Add SLURM\_JOB\_START\_TIME and SLURM\_JOB\_END\_TIME environment variables.
- Add SuspendExcStates option to slurm.conf to avoid suspending/powering down specific node states.
- Add support for DCMI power readings in IPMI plugin.

- `slurmrestd` served `/slurm/v0.0.39` and `/slurmdb/v0.0.39` endpoints had major changes from prior versions. Almost all schemas have been renamed and modified. Sites using OpenAPI Generator clients are highly suggested to upgrade to using atleast version 6.x due to limitations with prior versions.
- Allow for `--nodelist` to contain more nodes than required by `--nodes`.
- Rename “nodes” to “nodes\_resume” in `SLURM_RESUME_FILE` job output.
- Rename “all\_nodes” to “all\_nodes\_resume” in `SLURM_RESUME_FILE` output.
- Add `jobcomp/kafka` plugin.
- Add new `PreemptParameters=reclaim_licenses` option which will allow higher priority jobs to preempt jobs to free up used licenses. (This is only enabled for with `Preempt-Modes` of `CANCEL` and `REQUEUE`, as Slurm cannot guarantee suspended jobs will release licenses correctly.)
- `hpe/slingshot` - add support for the instant-on feature.
- Add ability to update `SuspendExc*` parameters with `scontrol`.
- Add ability to restore `SuspendExc*` parameters on restart with `slurmctld -R` option.
- Add ability to clear a GRES specification by setting it to "0" via “scontrol update job”.
- Add `SLURM_JOB_OVERSUBSCRIBE` environment variable for `Epilog`, `Prolog`, `EpilogSlurmctld`, `PrologSlurmctld`, and mail output.
- System node down reasons are appended to existing reasons, separated by ':
- New command `scrunch` has been added. `scrunch` acts as an Open Container Initiative (OCI) runtime proxy to run containers seamlessly via Slurm.
- Fixed `GpuFreqDef` option. When set in `slurm.conf`, it will be used if `--gpu-freq` was not explicitly set by the job step.

### 6.16.3 Configuration File Changes (see appropriate man page for details)

- `job_container.conf` - Added “Dirs” option to list desired private mount points.
- `node_features` plugins - invalid users specified for `AllowUserBoot` will now result in `fatal()` rather than just an error.

- Deprecate AllowedKmemSpace, ConstrainKmemSpace, MaxKmemPercent, and MinKmemSpace.
- Allow jobs to queue even if the user is not in AllowGroups when EnforcePartLimits=no is set. This ensures consistency for all the Partition access controls, and matches the documented behavior for EnforcePartLimits.
- Add InfluxDBTimeout parameter to acct\_gather.conf.
- job\_container/tmpfs - add support for expanding %h and %n in BasePath.
- slurm.conf - Removed SlurmctldPlugstack option.
- Add new SlurmctldParameters=validate\_nodeaddr\_threads=<number> option to allow concurrent hostname resolution at slurmctld startup.
- Add new AccountingStoreFlags=job\_extra option to store a job's extra field in the database.
- Add new "defer\_batch" option to SchedulerParameters to only defer scheduling for batch jobs.
- Add new DebugFlags option "JobComp" to replace "Elasticsearch".
- Add configurable job requeue limit parameter - MaxBatchRequeue - in slurm.conf to permit changes from the old hard-coded value of 5.
- helpers.conf - Allow specification of node specific features.
- helpers.conf - Allow many features to one helper script.
- job\_container/tmpfs - Add "Shared" option to support shared namespaces. This allows autofs to work with the job\_container/tmpfs plugin when enabled.
- acct\_gather.conf - Added EnergyIPMIPowerSensors=Node=DCMI and Node=DCMI\_ENHANCED.
- Add new "getnameinfo\_cache\_timeout= <number>" option to CommunicationParameters to adjust or disable caching the results of getnameinfo().
- Add new PrologFlags=ForceRequeueOnFail option to automatically requeue batch jobs on Prolog failures regardless of the job --requeue setting.
- Add HealthCheckNodeState=NONDRAINED\_IDLE option.

- Add “explicit” to Flags in `gres.conf`. This makes it so the gres is not automatically added to a job’s allocation when `--exclusive` is used. Note that this is a per-node flag.
- Moved the “preempt\_” options from `SchedulerParameters` to `PreemptParameters`, and dropped the prefix from the option names. (The old options will still be parsed for backwards compatibility, but are now undocumented.)
- Add `LaunchParameters=ulimit_pam_adapt`, which enables setting `RLIMIT_RSS` in adopted processes.
- Update `SwitchParameters=job_vni` to enable/disable creating job VNIs for all jobs, or when a user requests them.
- Update `SwitchParameters=single_node_vni` to enable/disable creating single node VNIs for all jobs, or when a user requests them.
- Add ability to preserve `SuspendExc*` parameters on reconfig with `ReconfigFlags=Keep-PowerSaveSettings`.
- `slurmdbd.conf` - Add new `AllResourcesAbsolute` to force all new resources to be created with the `Absolute` flag.
- `topology/tree` - Add new `TopologyParam=SwitchAsNodeRank` option to reorder nodes based on switch layout. This can be useful if the naming convention for the nodes does not naturally map to the network topology.
- Removed the default setting for `GpuFreqDef`. If unset, no attempt to change the GPU frequency will be made if `--gpu-freq` is not set for the step.

#### 6.16.4 Command Changes (see man pages for details)

- `sacctmgr` - no longer force updates to the `AdminComment`, `Comment`, or `SystemComment` to lower-case.
- `sinfo` - Add `-F/--future` option to `sinfo` to display future nodes.
- `sacct` - Rename “Reserved” field to “Planned” to match `sreport` and the nomenclature of the 'Planned' node.
- `scontrol` - advanced reservation flag `MAINT` will no longer replace nodes, similar to `STATIC_ALLOC`



- sbatch - add parsing for #PBS -d and #PBS -w.
- scontrol show assoc\_mgr will show username(uid) instead of uid in QoS section.
- Add strigger --draining and -R/--resume options.
- Change --oversubscribe and --exclusive to be mutually exclusive for job submission. Job submission commands will now fatal if both are set. Previously, these options would override each other, with the last one in the job submission command taking effect.
- scontrol - Requested TRES and allocated TRES will now always be printed when showing jobs, instead of one TRES output that was either the requested or allocated.
- srun --ntasks-per-core now applies to job and step allocations. Now, use of --ntasks-per-core=1 implies --cpu-bind=cores and --ntasks-per-core>1 implies --cpu-bind=threads.
- salloc/sbatch/srun - Check and abort if ntasks-per-core > threads-per-core.
- scontrol - Add ResumeAfter=<secs> option to “scontrol update nodename=”.
- Add a new “nodes=” argument to scontrol setdebug to allow the debug level on the slurmd processes to be temporarily altered.
- Add a new “nodes=” argument to “scontrol setdebugflags” as well.
- Make it so scrontab prints client-side the job\_submit() error message (which can be set i.e. by using the log\_user() function for the lua plugin).
- scontrol - Reservations will not be allowed to have STATIC\_ALLOC or MAINT flags and REPLACE[\_DOWN] flags simultaneously.
- scontrol - Reservations will only accept one reoccurring flag when being created or updated.
- scontrol - A reservation cannot be updated to be reoccurring if it is already a floating reservation.
- squeue - removed unused “%s” and “SelectJobInfo” formats.
- squeue - align print format for exit and derived codes with that of other components (<exit\_status>:<signal\_number>).

- sacct - Add --array option to expand job arrays and display array tasks on separate lines.
- Partial support for “--json” and “--yaml” formatted outputs have been implemented for sacctmgr, sdiag, sinfo, squeue, and scontrol. The resultant data output will be filtered by normal command arguments. Formatting arguments will continue to be ignored.
- salloc/sbatch/srun - extended the --nodes syntax to allow for a list of valid node counts to be allocated to the job. This also supports a "step count" value (e.g., --nodes=20-100:20 is equivalent to --nodes=20,40,60,80,100) which can simplify the syntax when the job needs to scale by a certain "chunk" size.
- srun - add user requestible vnis with “--network=job\_vni” option.
- srun - add user requestible single node VNIs with the “--network=single\_node\_vni” option.

#### 6.16.5 API Changes

- job\_container plugins - container\_p\_stepd\_create() function signature replaced uint32\_t uid with stepd\_step\_rec\_t\* step.
- gres plugins - gres\_g\_get\_devices() function signature replaced pid\_t pid with stepd\_step\_rec\_t\* step.
- cgroup plugins - task\_cgroup\_devices\_constrain() function signature removed pid\_t pid.
- task plugins - replace task\_p\_pre\_set\_affinity(), task\_p\_set\_affinity(), and task\_p\_post\_set\_affinity() with task\_p\_pre\_launch\_priv() like it was back in slurm 20.11.
- Allow for concurrent processing of job\_submit\_g\_submit() and job\_submit\_g\_modify() calls. If your plugin is not capable of concurrent operation you must add additional locking within your plugin.
- Removed return value from slurm\_list\_append().
- The List and ListIterator types have been removed in favor of list\_t and list\_itr\_t respectively.

- burst\_buffer plugins - add bb\_g\_build\_het\_job\_script(). bb\_g\_get\_status() - added authenticated UID and GID. bb\_g\_run\_script() - added job\_info argument.
- burst\_buffer.lua - Pass UID and GID to most hooks. Pass job\_info (detailed job information) to many hooks. See etc/burst\_buffer.lua.example for a complete list of changes. WARNING: Backwards compatibility is broken for slurm\_bb\_get\_status: UID and GID are passed before the variadic arguments. If UID and GID are not explicitly listed as arguments to slurm\_bb\_get\_status(), then they will be included in the variadic arguments. Backwards compatibility is maintained for all other hooks because the new arguments are passed after the existing arguments.
- node\_features plugins - node\_features\_p\_reboot\_weight() function removed. node\_features\_p\_job\_valid() - added parameter feature\_list. node\_features\_p\_job\_xlate() - added parameters feature\_list and job\_node\_bitmap.
- New data\_parser interface with v0.0.39 plugin.

#### 6.16.6 Known Issues

- The --uid option for the srun command is broken: its use may lead to the error message job <job ID> queued and waiting for resources. This does not, however, affect the sbatch command.

## 7 Removed and deprecated features and packages

This section lists features and packages that were removed from SUSE Linux Enterprise for High-Performance Computing or will be removed in upcoming versions.

- dapl, rds-tools, and imgen are being deprecated due to lack of upstream activity.
- openmpi 2 and openmpi 3 are being deprecated due to being replaced by openmpi 4.

### 7.1 Removed features and packages

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

- Python 2 bindings for genders has been removed. These are now provided for Python 3.
- Ganglia is not supported anymore in 15 SP6 (prerelease). It has been replaced with Grafana (<https://grafana.com/> )
- Due to a lack of usage by customers, some library packages have been removed from the HPC module in SLE HPC 15 SP6 (prerelease). On SUSE Linux Enterprise you can build your own library using spack. These libraries will continue to be available through SUSE Package Hub. The following libraries have been removed:
  - boost
  - adios
  - gsl
  - fftw3
  - hypre
  - metis
  - mumps
  - netcdf
  - ocr
  - petsc
  - ptscotch
  - scalapack
  - superlu
  - trilinos

## 7.2 Deprecated features and packages

The following features and packages are deprecated and will be removed in a future version of SUSE Linux Enterprise for High-Performance Computing.

- `clustduct` is deprecated and will be removed in SUSE Linux Enterprise for High-Performance Computing 15 SP7. With SLE HPC 15 SP6 (prerelease), `warewulf4` has been introduced as cluster deployment tool, and users are advised to migrate to it.

## 8 Obtaining source code

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## A Changelog for 15 SP6 (prerelease)

### A.1 2023-10-19

- Initial SP6 release