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Adaptive Multi-tier Intelligent Data Manager for Exascale is a EuroHPC project aiming at addressing upcoming I/O challenges in Exascale systems. It gathers thirteen European partners to pioneer new ways of doing HPC I/Os.





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https://france.paratools.com/ADMIRE/SPACK.pdf





Use of Spack in E4S in ECP













alleable data solutions for HP



- Several components in interaction
- Need to deploy and sync multiple projects
- How to ship all the sources to the target system while holding all the direct dependencies ?
- Is there potential configuration knobs (configure arguments) to better set it up to a given system?
- How to connect to the machine's MPI?
- How to rebuild for another MPI?







• Several components in interaction

- Need to deploy and sync multiple projects
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- How to rebuild for another MPI ?



On all these the Spack Package manager can help !









Spack



ls in



- It is a user-level package manager allowing to build and customise programs from their sources on a target HPC system;
- Spack is designed to be easy to use and flexible;
- It supports multiple versions and configurations of packages, making it wellsuited for scientific computing and HPC environments.





Some notable features of Spack include:

- Support for over 5,000 software packages
- Support for multiple build systems (e.g. make, CMake, SCons)
- Support for multiple compilers and MPI libraries
- Ability to create custom package recipes
- Ability to create and manage package "environments" for different projects or purposes
- Ability to use Spack as a library for integrating with other tools and systems.





https://spack.readthedocs.io/en/latest/getting_started.html#installation

Setup dependencies on a Debian-based system:

\$ apt install build-essential ca-certificates coreutils curl environment-modules gfortran git gpg lsb-release python3 python3distutils python3-venv unzip zip

Clone the Spack repository:

\$ git clone https://github.com/spack/spack.git

Add Spack to your path by sourcing the environment script (other shells see doc):

\$. spack/share/spack/setup-env.sh

If you were to only add the \$SPACKROOT/bin directory to your path You would be able to manipulate packages but not able to load them.





To describe packages Spack uses « specs » A central concept in Spack

https://spack.readthedocs.io/en/latest/concepts.html#specs





To describe packages Spack uses « specs » A central concept in Spack

Spec hdf5 api=v114 +threadsafe^intel-mpi

≠



Speck





\$ spack spec hdf5

spack spec hdf5 Input spec ndf5 Concretized df5@1.12.2%gcc@10.2.1~cxx~fortran~hl~ipo~java+mpi+shared~szip~threadsafe+tools api=default build_system=cmake build_type=RelWithDebInfo arch= ^cmake@3.25.1%gcc@10.2.1~doc+ncurses+ownlibs~qt build_system=generic build_type=Release arch=linux-debian11-haswell ^ncurses@6.3%qcc@10.2.1~symlinks+termlib abi=none build_system=autotools arch=linux-debian11-haswell ^openssl@1.1.1s%gcc@10.2.1~docs~shared build_system=generic certs=mozilla arch=linux-debian11-haswell ^ca-certificates-mozilla@2022-10-11%gcc@10.2.1 build_system=generic arch=linux-debian11-haswell ^openmpi@4.1.4%gcc@10.2.1~atomics~cuda~cxx~cxx_exceptions~gpfs~internal-hwloc~java~legacylaunchers~lustre~memchecker~orterunprefix+romio+rs puild_system=autotools fabrics=none schedulers=none arch=linux-debian11-haswell ^hwloc@2.9.0%gcc@10.2.1~cairo~cuda~gl~libudev+libxml2~netloc~nvml~oneapi-level-zero~opencl+pci~rocm build_system=autotools libs=shared ^libpciaccess@0.16%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^util-macros@1.19.3%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^libxml2@2.10.3%gcc@10.2.1~python build_system=autotools arch=linux-debian11-haswell ^libiconv@1.16%gcc@10.2.1 build_system=autotools libs=shared,static arch=linux-debian11-haswell ^xz@5.2.7%gcc@10.2.1~pic build_system=autotools libs=shared,static arch=linux-debian11-haswell ^numactl@2.0.14%gcc@10.2.1 build_system=autotools patches=4e1d78c,62fc8a8,ff37630 arch=linux-debian11-haswell ^autoconf@2.69%gcc@10.2.1 build_system=autotools patches=35c4492,7793209,a49dd5b arch=linux-debian11-haswell ^automake@1.16.5%qcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^libtool@2.4.7%qcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^m4@1.4.19%gcc@10.2.1+sigsegv build_system=autotools patches=9dc5fbd,bfdffa7 arch=linux-debian11-haswell ^diffutils@3.8%qcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^libsigsegv@2.13%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^openssh@9.1p1%gcc@10.2.1+gssapi build_system=autotools arch=linux-debian11-haswell ^krb5@1.20.1%gcc@10.2.1+shared build_system=autotools arch=linux-debian11-haswell ^bison@3.8.2%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^gettext@0.21.1%gcc@10.2.1+bzip2+curses+git~libunistring+libxml2+tar+xz build_system=autotools arch=linux-debian11-haswell ^tar@1.34%gcc@10.2.1 build_system=autotools zip=pigz arch=linux-debian11-haswell ^pigz@2.7%gcc@10.2.1 build_system=makefile arch=linux-debian11-haswell ^zstd@1.5.2%gcc@10.2.1+programs build_system=makefile compression=none libs=shared,static arch=linux-debian11-haswell ^libedit@3.1-20210216%qcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^libxcrypt@4.4.33%gcc@10.2.1~obsolete_api build_system=autotools arch=linux-debian11-haswell ^perl@5.36.0%gcc@10.2.1+cpanm+open+shared+threads build_system=generic arch=linux-debian11-haswell ^berkeley-db@18.1.40%qcc@10.2.1+cxx~docs+stl build_system=autotools patches=26090f4,b231fcc arch=linux-debian11-haswell ^bzip2@1.0.8%qcc@10.2.1~debug~pic+shared build_system=generic arch=linux-debian11-haswell ^qdbm@1.23%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^readline@8.2%gcc@10.2.1 build_system=autotools patches=bbf97f1 arch=linux-debian11-haswell ^pmix@4.1.2%gcc@10.2.1~docs+pmi_backwards_compatibility~python~restful build_system=autotools arch=linux-debian11-haswell ^libevent@2.1.12%gcc@10.2.1+openssl build_system=autotools arch=linux-debian11-haswell ^pkgconf@1.8.0%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^zlib@1.2.13%gcc@10.2.1+optimize+pic+shared build_system=makefile arch=linux-debian11-haswell

A spec defines a package, it is generally not referring to a single exact configuration (leaving a lot of defaults). It covers the package and its dependencies





🥑 @admire_eurohpc

Transforming a « spec » into a package configuration with defined constraints is where the true power of spack lies. Saving you a lot of complexity in your deployment. Moreover, it is possible to write sufficiently constrained specs to achieve reproducible build. This process is called concretization.







spack info <package>

List installable packages (with an optional search pattern)

For example:

spack info hdf5

Show versions, parameters and options for HDF5.





@admire_eurohpc

| | Variants: Name [Default] | When | Allowed values | Description |
|---|-----------------------------|------|--|--|
| \$ spack info hdf5 CMakePackage: hdf5 | api [default] | | default, v114, v112, v110, v18, v16 | Choose api compatibility for |
| Description: HDF5 is a data model, library, and file format for storing and managing data. It supports an unlimited variety of datatypes, and is designed for flexible and efficient I/O and for high volume and complex data. | build_type [RelWithDebInfo] | | Debug, Release, RelWithDebInfo, MinSizeRel | earlier version CMake build type |
| Homepage: https://portal.hdfgroup.org | cxx [off] | | on, off | Enable C++ support |
| Maintainers: @lrknox @brtnfld @byrnHDF @ChristopherHogan @epourmal @gheber @hyoklee @lkurz @soumagne | fortran [off] | | on, off | Enable Fortran support |
| Externally Detectable: False | hl [off] | | on, off | Enable the high- level library |
| Tags: e4s | ipo [off] | | on, off | CMake interprocedural optimization |
| Profement vencion: | java [off] | | on, off | Enable Java support |
| 1.12.1 https://support.hdfaroup.org/ftp/HDF5/releases/hdf5-1.12/hdf5-1.12.1/src/hdf5-1.12.1.tar.gz | mpi [on] | | on, off | Enable MPI support |
| Safe versions: develop-1.13 [git] https://github.com/HDFGroup/hdf5.git on branch develop | shared [on] | | on, off | Builds a shared version of the library |
| develop-1.12 [glt] https://glthub.com/HDFGroup/hdf5.glt on branch hdf5_1_12 | szip [off] | | on, off | Enable szip support |
| develop-1.8[git] https://github.com/HDFGroup/hdf5.git on branch hdf5_1_81.13.0https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.13/hdf5-1.13.0/src/hdf5-1.13.0.tar.gz | threadsafe [off] | | on, off | Enable thread-safe capabilities |
| 1.12.1https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.12.hdf5-1.12.1/src/hdf5-1.12.1.tar.gz1.12.0https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.12.hdf5-1.12.0/src/hdf5-1.12.0.tar.gz1.10.8https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.10/hdf5-1.10.8/src/hdf5-1.10.8.tar.gz | tools [on] | | on, off | Enable building tools |

Installation Phases:

cmake build install

Show versions, paran Build Dependencies: cmake java mp

cmake java mpi numactl szip zlib

Link Dependencies:

mpi numactl szip zlib





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spack info hdf5 CMakePackage: hdf5 Description: HDF5 is a data model, library, and file format for storing and managing data. It supports an unlimited variety of datatypes, and is designed for flexible and efficien and for high volume and complex do lfa omepage: https://portal. org Maintainers: @lrknox @brtnfld @byrnHDF @ChristopherHogan @epourmal @gheber @hyoklee @lkurz @soumagne Externally Detectable: False Preferred version: 1.12.1 https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.12/hdf5-1.12.1/src/hdf5-1.12. Safe versions: [git] https://_ithu com/HDFGroup/hdf_git on branch develop [git] https://g tł **__1_12** on Jf. 402 develop-1.10 1_10 [git] https://g : 0 develop-1.8 18 [git] https://gi 1.13.0 https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.13/hdf5-1.13.0/src/hdf5-1.13. https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.12/hdf5-1.12.1/src/hdf5-1.12 1.12.0 https://support.hdfgroup.org/ftp/HDF5/releases/hdf5-1.12/hdf5-1.12.0/src/hdf5-1.12. https://support.hdfaroup.ora/ftp/HDE5/releases/hdf5-1_10/hdf5-1_10_8/src/hdf5-1_10 1 10 8

| lame [Default] | When | Allowed values | Description |
|----------------------------|---|---|---|
| ni [defau]+] | | default v114 v112 | Choose ani |
| pr [derdurt] | | v110, v18, v16 | compatibility for |
| uild_type [RelWithDebInfo] | | Debug, Release, RelWithDebInfo, MinSizeRel | earlier version CMake build type |
| xx [off] | | on, off | Enable C++ support |
| fortran [off] | | on, off | Enable Fortran |
| | | | support |
| il [off] | | or of C I U | Fnable the high- |
| po [off] | | on, off | CMake |
| | | | interprocedural |
| | | on off | optimization Engble lava support |
| | | on, off | Enable Juva Support |
| bared [on] | | on off | Builds a shared |
| | | | version of the |
| zin [off] | | on, off | Enable szip support |
| hreadsafe [off] | | on, off | Enable thread-safe |
| | | 0.1., 0.1. | capabilities |
| cools [on] | | on. off | Enable buildina |
| | | | toolo |
| | <pre>pi [default] uild_type [RelWithDebInfo] exx [off] fortran [off] ul [off] po [off] ava [off] pi [on] hared [on] exip [off] hreadsafe [off] cools [on]</pre> | ava [off] ava [off] ava [off] ava [off] ava [off] ava [off] bi [on] ava [off] ava [off] | pi [default] default, v114, v112, v110, v18, v16 uuild_type [RelWithDebInfo] Debug, Release, RelWithDebInfo, MinSizeRel exx [off] on, off fortran [off] on, off ul [off] on, off po [off] on, off ava [off] on, off pi [on] on, off hared [on] on, off exip [off] on, off |

Show versions, paran

Link Dependencies: mpi numactl szip zlib

EuroHPC



\$ spack spec bzip2

Input spec

bzip2

Concretized

\$ spack spec bzip2@1.0.6

Input spec

bzip2@1.0.6

Concretized

From « spack info bzip2 »

eferred version:

1.0.8 https://sourceware.org/pub/bzip2/bzip2-1.0.8.tar.gz

Safe versions:

1.0.8 https://sourceware.org/pub/bzip2/bzip2-1.0.8.tar.gz

- 1.0.7 https://sourceware.org/pub/bzip2/bzip2-1.0.7.tar.gz
- 1.0.6 https://sourceware.org/pub/bzip2/bzip2-1.0.6.tar.gz

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| Version Specifier | Matching Versions |
|-------------------|---|
| @3.2 | single 3.2 version |
| @1.0:1.2 | all versions from 1.0 to 1.2, inclusive |
| @:3 | all versions before 3 (3 included) |
| @3.2: | all versions after 3.2 (3.2 included) |
| @3.4,1.4,2.2 | Specific versions list, 3.4, 1.4, 2.2 |





\$ spack install hdf5

- \$ spack install hdf5^mpich
- \$ spack install hdf5^openmpi

\$ spack install hdf5^intel-mpi





@admire_eurohpc

\$ spack info openmpi

| pmi [off] romio [on] rsh [on] | [@1.5.5:4 schedulers=slurm] | on, off on, off | Enable PMI support Enable ROMIO support Enable not (aponoch) process lifesuele management |
|--|---------------------------------|-----------------------------------|---|
| rsn [on] schedulers [non <u>e</u>] | | on, off none, auto, sge, | List of schedulers for which support is enabled; 'auto' lets openmpi determine |
| | | alps, lsf, loadleveler, slurm, | |

Default values are shown in the brackets.

Variant types are:

- Enumerations (can be comma separated lists):
 - schedulers=slurm
- Booleans / on, off :
 - +pmi enable PMI
 - -pmi or ~pmi disable PMI
- Compiler flags **applies to all pkgs** (cflags, cxxflags, fflags, cppflags, ldflags, and ldlibs):
 - cflags=-g cxxflags=-g
- Since spack 0.19 it is possible to double +, and = to impact all dependencies



🥑 @admire_eurohpc

Variants are generally analogous to configure flags passed to the package. They may change feature support and dependencies.

Spack hashes everything, you can install the same package with different variants and end-up with multiple times this package.

\$ spack install bzip2
\$ spack install bzip2 +debug
\$ spack install bzip2 +debug cflags=-g

This can lead to up to 3 installations of bzip2.





spack find <package>

List packages matching the « spec »

For example:

spack find bzip2

Lists the bzip2 package

-- linux-debian11-haswell / gcc@10.2.1
bzip2@1.0.8 bzip2@1.0.8 bzip2@1.0.8





spack find -lfvp bzip2

- « -l » show package hash
- « -f » show package flags
- « -v » show package variants
- « -p » show install path





spack find -lfvp bzip2

« -l » show package hash
« -f » show package flags
« -v » show package variants
« -p » show install path

/home/jbbesnard/repo/s /home/jbbesnard/repo/s /home/jbbesnard/repo/s

We can see the three different install of bzip2 and their params.





\$ spack spec bzip2

bzip2@1.0.8%gcc@10.2.1~debug~pic+shared build_system=generic arch=linux-debian11-haswell
 ^diffutils@3.8%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell
 ^libiconv@1.16%gcc@10.2.1 build_system=autotools libs=shared,static arch=linux-debian11-haswell

\$ spack spec bzip2^diffutils@3.6

bzip2@1.0.8%gcc@10.2.1~debug~pic+shared build_system=generic arch=linux-debian11-haswell ^diffutils@3.6%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^libiconv@1.16%gcc@10.2.1 build_system=autotools libs=shared,static arch=linux-debian11-haswell

\$ spack spec bzip2^diffutils@3.6^libiconv@1.14





\$ spack spec bzip2

bzip2@1.0.8%gcc@10.2.1~debug~pic+shared build_system=generic arch=linux-debian11-haswell
 ^diffutils@3.8%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell
 ^libiconv@1.16%gcc@10.2.1 build_system=autotools libs=shared,static arch=linux-debian11-haswell

\$ spack spec bzip2^diffutils@3.6

bzip2@1.0.8%gcc@10.2.1~debug~pic+shared build_system=generic arch=linux-debian11-haswell ^diffutils@3.69gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell ^libiconv@1.16%gcc@10.2.1 build_system=autotools libs=shared,static arch=linux-debian11-haswell

\$ spack spec bzip2^diffutils@3.6^libiconv@1.14







bzip2@1.0.8%gcc@10.2.1~debug~pic+ hared build_system=generic arch=linux-debian11-haswell
 ^diffutils@3.8%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell
 ^l biconv@1.16%gcc@10.2.1 build_system=autotools libs=shared,static arch=linux-debian11-haswell

\$ spack spec bzip2^diffutilc@2 6

But wait, why switching to clang as compiler?

bzip2@1.0.8%gcc@10.2.1~debug~pic+s ared bu ^diffutils@3.6%gcc@10.2.1 buil_system ^l_biconv@1.16%gcc@10.2.1 uild_system

uild_system=autotools libs=shared,static arch=linux-debian11-haswell

\$ spack spec bzip2^diffutils@3.6^libiconv@1.14





\$ spack spec bzip2^diffutils@3.6^libiconv@1.14 % gcc

=> Error: libiconv '@1.14' conflicts with '%gcc@5:'

Spack mitigated the issue by moving to clang at concretization time !







@admire_eurohpc

Ok let's mix both compilers (but do not do it ;-)) Warning: gray areas don't do it with Fortran/C++ but the C ABI should allow this. Use the same compiler everywhere.

\$ spack spec bzip2^diffutils@3.6%gcc^libiconv@1.14%clang

bzip2@1.0.8%gcc@10.2.1~debug~pic+shared build_system=generic arch=linux-debian11-haswell
 ^diffutils@3.6%gcc@10.2.1 build_system=autotools arch=linux-debian11-haswell
 ^libiconv@1.14%clang@11.0.1 build_system=autotools libs=shared,static patches=8867b9a arch=linux-debian11-haswel

\$ spack find -ldvf bzip2 -d for dependencies

g6uthxm bzip2@1.0.8%gcc ~debug~pic+shared build_system=generic 5k4mzlj diffutils@3.6%gcc build_system=autotools bitukof libiconv@1.14%clang build_system=autotools libs=shared,static patches=8867b9a

Easier to use the hash passed with **/XXX** than the spec in this case.

\$ spack load /g6uthxm && which bunzip2

/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/bzip2-1.0.8-g6uthxm6xfoprghxd64wuupl5o43vf2h/bin/bunzip2



```
$ spack find -l openmpi
```

Spack find will list per compiler and target architecture/os (variant target=XXX)

```
-- linux-centos7-cascadelake / gcc@10.3.0 ------
2owvgwy openmpi@4.1.3
```

```
-- linux-ubuntu20.04-broadwell / gcc@9.4.0 ------
t2xwh73 openmpi@4.1.3
```

> Protip: get used to the « -l » option to get hashes when there are multiple specs for a given package.



spack list [<pattern>]

List installable packages (with an optional search pattern)

For example:

spack list mpi

Find all spack packages matching « mpi »





snack list [rnattorn]

| \$ | spack list mpi | | | |
|---------------|----------------------|------------------------|-------------------|--------------|
| co | mpiz | intel-oneapi-mpi | mpip | py-mpi4py |
| ex | ay-mpich | mpc-compiler-additions | mpir | r-rmpi |
| | cempi | mpi-bash | mpitrampoline | rempi |
| fu | ijitsu-mpi | mpibind | mpix-launch-swift | spectrum-mpi |
| hp | ocx-mpi | mpich | openmpi | sst-dumpi |
| in | ıtel-mpi | mpifileutils | pbmpi | umpire |
| in | ıtel-mpi-benchmarks | mpilander | phylobayesmpi | vampirtrace |
| For exampling | tel-oneapi-compilers | mpileaks | pnmpi | wi4mpi |

spack list mpi

Find all spack packages matching « mpi »





To get new recipes, simply git pull the repository.





Installs the specified spec and its dependencies.

Remove the specified spec.

Remove the specified spec and packages depending upon it.

spack uninstall --dependents <spec>

Remove all packages matching the spec

spack uninstall-a <spec>





Installs the specified spec and its dependencies.

\$ spack install <spec>

Remove the specified spec.

spack uninstall <spec>

Remove the specified spec and packages depending upon it.

spack uninstall --dependents <spec>

Remove all packages matching the spec

spack uninstall-a <spec>

Quite straightforward once you master specs







Now let's use these packages...





Load a given package spec

\$ spack load <spec>

This requires spack to be sourced in your current shell (. \$SPACKROOT/share/spack/setup-env.sh)

We will not cover «environments » which are a powerful way to manage packages load.

Spack also has a « module » integration that we will not cover here.

\$ spack load wget

\$ which wget

/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/
wget-1.21.3-dwt2inqs536nrtw7m4bezxxewoekzzn6/bin/wget





Spack will alter you shell environment to load the package changing common variables (PATH, MANPATH, PKG_CONFIG_PATH)

\$ spack load --sh wget

export ACLOCAL_PATH=/home/jbbesnard/...; export CMAKE_PREFIX_PATH=/home/jbbesnard/...; export MANPATH=/home/jbbesnard/...; export PATH=/home/jbbesnard/...; export PKG_CONFIG_PATH=/home/jbbesnard/...; export SPACK_LOADED_HASHES=...;

You may then load manually by doing:

Note: This does not requires spack to be sourced (only in PATH).





- When mixing multiple versions of packages:
 - it is very easy to end-up substituting a library with one of the system if library search paths are not correctly set.
 - This can make your environment over-sensitive to changes.
- Spack ensures your binaries find the right libraries
 - It uses compiler wrappers to alter RPATHs
 - It passes the correct parameters to the build systems
- Overall it makes library resolution much more robust and self-descriptive





@admire_eurohpc

\$ spack find -p python

python@3.10.8 /home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/ python-3.10.8-qox3bf6trwl2bsiwvvxn4dvmy4xsifre

\$ ldd /home/jbbesnard/repo/spack/(...)/bin/python

Libraries are resolved in the spack realm thanks to rpaths.

linux-vdso.so.1 (0x00007ffd169d0000)

libpython3.10.so.1.0 => /home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/pythor

libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007fec8a520000)

libintl.so.8 => /home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/gettext-0.21.1

libpthread.so.0 => /lib/x86_64-linux-gnu/libpthread.so.0 (0x00007fec8a4ef000)

libdl.so.2 => /lib/x86_64-linux-gnu/libdl.so.2 (0x00007fec8a4e9000)

libutil.so.1 => /lib/x86_64-linux-gnu/libutil.so.1 (0x00007fec8a4e4000)

libm.so.6 => /lib/x86_64-linux-gnu/libm.so.6 (0x00007fec8a3a0000)

/lib64/ld-linux-x86-64.so.2 (0x00007fec8aae7000)

libiconv.so.2 => /home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/libiconv-1.16

\$ objdump -x /home/jbbesnard/repo/spack/(...)/python lgrep 'R.*PATH'

RPATH/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/python-3.10.8-qox3bf6trwl2bsiwvvxn4dvmy4xsifre/lib64:/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/utilpython-3.10.8-qox3bf6trwl2bsiwvvxn4dvmy4xsifre/lib64:/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/utilpack/linux-debian11-haswell/gcc-10.2.1/sqlite-3.40.0-zosvjs4b7ygdntsq2xabixsvmdorp6d3/lib:/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/libxcrypt-4.4.33-smz7usr46f3w5mlilx64yv4mwgrjgbu6/lib:/home/x2fvfbh4z3qqnqtelcwzvm/lib:/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/gettext-0.21.1-wvxt5srkobz5p77.2.1/libxml2-2.10.3-mfie3bzeeyj7gujvq2prjzjpvvs7l23i/lib:/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/nux-debian11-haswell/gcc-10.2.1/xz-5.2.7-bqfcolikyiqygnkkrixckemve2dkhfkb/lib:/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/rext5fcolikyiqygnkkrixckemve2dkhfkb/lib:/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/expack/lib:/home/jbbesnard/repo/spack/linux-debian11-haswell/gcc-10.2.1/expack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/lib:/home/jbbesnard/repo/spack/linux-debian11-haswell/gcc-10.2.1/lib:/home/jbbesnard/repo/spack/linux-debian11-haswell/gcc-10.2.1/lib:/home/jbbesnard/repo/spack/linux-debian11-haswell/gcc-10.2.1/lib:/home/jbbesnard/repo/spack/linux-debian11-haswell/gcc-10.2.1/lib:/home/jbbesnard/repo/spack/linux-debian11-haswell/gcc-

Less chances for clashes.











ADMIRE Spack Repository



A repo is a source for package recipes.

\$ spack repo --help

usage: spack repo [-h] SUBCOMMAND ...

manage package source repositories

positional arguments:

SUBCOMMAND

Create a new package repository. create

Show registered repositories and their namespaces. list Add a package source to Spack's configuration. add

remove (rm)

Remove a repository from Spack's configuration.

optional arguments:

-h, --help show this help message and exit

Repository == Recipes

You can add several external repos synced with packages outside of the main spack repository.







Create a new « repository » in your home

- \$ spack repo create \$HOME/mypkg
 ==> Created repo with namespace 'mypkg'.
 ==> To register it with spack, run this command:
- spack repo add /home/jbbesnard/mypkg

Add it to your spack sources

\$ spack repo add /home/jbbesnard/mypkg

==> Added repo with namespace 'mypkg'.

\$ tree /home/jbbesnard/mypkg





More on how to make packages recipes in a few slides!







A mirror stores the package sources (tarball)

\$ spack mirror --help

Mirror == Tarballs / Sources

manage mirrors (source and binary)

positional arguments:

SUBCOMMAND

| create | Create a directory to be used as a spack mirror, and fill it with |
|-------------|---|
| | package archives. |
| destroy | Given a url, recursively delete everything under it. |
| add | Add a mirror to Spack. |
| remove (rm) | Remove a mirror by name. |
| set-url | Change the URL of a mirror. |
| list | Print out available mirrors to the console. |





ADMIRE Spack Mirror Howto



https://www.admire-eurohpc.eu/ @admire_eurohpc

$spack mirror create \setminus$ --dependencies -d \$HOME/mymirror hwloc

- Adding package hwloc@2.4.1 to mirror
- Adding package libiconv@1.16 to mirror
- Adding package libxml2@2.9.10 to mirror
- Adding package ncurses@6.2 to mirror
- Adding package pkgconf@1.7.4 to mirror
- Adding package xz@5.2.5 to mirror
- Adding package zlib@1.2.11 to mirror
- Successfully updated mirror in file:///Users/jbbesnard/mymirror Archive stats:
 - already present
 - added 0

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failed to fetch. 0



ADMIRE Spack Mirror Howto



https://www.admire-eurohpc.eu/ @admire eurohpc

$spack mirror create -n all \setminus$ --dependencies -d \$HOME/mymirror hwloc

You can mirror all versions (or a number of versions) if needed !

- ⇒ Adding package pkgconf@1.6.3 to mirror
- => Adding package pkgconf@1.7.3 to mirror
- ==> Adding package pkgconf@1.7.4 to mirror
- ==> Adding package xz@5.2.0 to mirror
- ==> Adding package xz@5.2.2 to mirror
- ==> Adding package xz@5.2.3 to mirror
- ==> Adding package xz@5.2.4 to mirror
- ==> Adding package xz@5.2.5 to mirror
- => Adding package zlib@1.2.3 to mirror
- --> Adding package zlib@1.2.8 to mirror
- Adding package zlib@1.2.11 to mirror
- Successfully updated mirror in file:///Users/jbbesnard/mymirror Archive stats:
 - already present 54
 - added 0
 - failed to fetch. 0







\$ spack mirror add local \$HOME/mymirror
\$ spack mirror list

local file:///Users/jbbesnard/mymirror
spack-public https://spack-llnl-mirror.s3-us-west-2.amazonaws.com/

- Spack will then look in this directory before trying to dowload the sources;
- It is also a way to use spack on systems not connected to the internet;
- In conjunction with Spack environments it is possible to download many packages at once before moving them to a given system.

=> Installing ncurses-6.2-djygwta7byhqs5dtftsh6q2w3u24h2oo

- No binary for ncurses-6.2-djygwta7byhqs5dtftsh6q2w3u24h2oo found: installing from source
- =>> Fetching file:///Users/jbbesnard/mymirror/_source-cache/archive/30/30306e0c76e0f9f1f0de987cf1c82a5c21e1ce6568b9227f7da5b71cbea86c9d.tar.gz





Time to create our own packages !









ADMIRE A Look at a Package Recipe

♥ @admire_eurohpc

\$ spack info tig

It all comes from the recipe

| AutotoolsPackage: tig | | | | | | | |
|---|--|---------------------|--|--|--|--|--|
| Description: Text-mode interface for git | | | | | | | |
| Homepage: https://jonas.githu | Homepage: https://jonas.github.io/tig/ | | | | | | |
| Preferred version: 2.2.2 https://github.com/jonas/tig/releases/download/tig-2.2.2/tig-2.2.2.tar.gz | | | | | | | |
| Safe versions: 2.2.2 https://github.c | :om/jonas/ | /tig/releases/downl | .oad/tig-2.2.2/tig-2.2.2.tar.gz | | | | |
| Deprecated versions: None | | | | | | | |
| Variants: | | | | | | | |
| Name [Default] | When | Allowed values | Description | | | | |
| <pre>build_system [autotools]</pre> | | autotools | Build systems supported by the package | | | | |
| Build Dependencies: gnuconfig ncurses | | | | | | | |
| Link Dependencies: ncurses | | | | | | | |
| Run Dependencies: | | | | | | | |





\$ spack create URL_TO_TARBALL

We add some simple option to this command (which would work as is):

- -r \$HOME/mypkg to store the new package in our own repository
- --name mytig As tig is already in spack we do not want to clash
- $spack create -r HOME/mypkg \setminus$
- --name mytig\

http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.5.1.orig.tar.gz

=> Using specified package name: 'mytig' Found 16 versions of mytig: http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.5.1.orig.tar.gz 2.5.1 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.4.1.orig.tar.gz 2.4.1 2.3.0 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.3.0.orig.tar.gz http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.2.orig.tar.gz 2.2 2.0.2 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.0.2.orig.tar.gz 1.1 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_1.1.orig.tar.gz 1.0 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_1.0.orig.tar.gz 0.17 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_0.17.orig.tar.gz 0.16 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_0.16.orig.tar.gz 0.5 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_0.5.orig.tar.gz → How many would you like to checksum? (default is 1, q to abort)



Spack will detect all versions in the same prefix



Just answer how many you want to hash.



Euro**HPC**

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ADMIRE Use of Spack Create to redo TIG

9 @admire_eurohpc

| Then the recipe opens | <pre>class Mytig(AutotoolsPackage): Spack found it looked like Autotools. """FIXME: Put a proper description of your package here."""</pre> |
|--|--|
| | <pre># FIXME: Add a proper url for your package's homepage here. homepage = "https://www.example.com" url = "http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.5.1.orig.tar.gz"</pre> |
| | <pre># FIXME: Add a list of GitHub accounts to # notify when the package is updated. # maintainers = ["github_user1", "github_user2"]</pre> |
| Spack hashed the various tarballs for us | <pre>version("2.5.1", sha256="500d5d34524f6b856edd5cae01f1404d14f3b51a9a53fd7357f4cebb3d4c9e64") version("2.4.1", sha256="b6b6aa183e571224d0e1fab3ec482542c1a97fa7a85b26352dc31dbafe8558b8") version("2.3.0", sha256="686f0386927904dc6410f0b1a712cb8bd7fff3303f688d7dc43162f4ad16c0ed")</pre> |
| We may say we depend on ncurses here as it is a | <pre># FIXME: Add dependencies if required. # depends_on("foo")</pre> |
| required dep. | <pre>def configure_args(self): # FIXME: Add arguments other thanprefix # FIXME: If not needed delete this function args = [] return args</pre> |



uro**HPC**

ADMIRE Use of Spack Create to redo TIG

9 @admire_eurohpc

| Then the recipe opens | class Mytig(AutotoolsPackage): Spack found it looked like Autotools. """FIXME: Put a proper description of your package here.""" | | | | | |
|--|--|--|--|--|--|--|
| | <pre># FIXME: Add a proper url for your package's homepage here. homepage = "https://www.example.com" url = "http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.5.1.orig.tar.gz"</pre> | | | | | |
| | <pre># FIXME: Add a list of GitHub accounts to # notify when the package is updated. # maintainers = ["github_user1", "github_user2"]</pre> | | | | | |
| Spack hashed the various tarballs for us | <pre>version("2.5.1", sha256="500d5d34524f6b856edd5cae01f1404d14f3b51a9a53fd7357f4cebb3d4c9e64") version("2.4.1", sha256="b6b6aa183e571224d0e1fab3ec482542c1a97fa7a85b26352dc31dbafe8558b8") version("2.3.0", sha256="686f0386927904dc6410f0b1a712cb8bd7fff3303f688d7dc43162f4ad16c0ed")</pre> | | | | | |
| We know TIG needs ncurses | # FIXME. Add dependence if required. depends_on("ncurses") | | | | | |
| | <pre>def configure_args(self): # FIXME: Add arguments other thanprefix # FIXME: If not needed delete this function args = [] return args</pre> | | | | | |



\$ spack install mytig

- [+] /home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/pkgconf-1.8.0-biltfbhkws6qw5eipljq6tqx6o4e3bqc
- [+] /home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/ncurses-6.3-53tai6gvahjeukesc5k5gxy5mihpxguj

Installing mytig-2.5.1-q2bg25rhlsde324ow6i7d3u3x774dtbp

- mytig exists in binary cache but with different hash
- > No binary for mytig-2.5.1-q2bg25rhlsde324ow6i7d3u3x774dtbp found: installing from source
- ==> Using cached archive: /home/jbbesnard/repo/spack/var/spack/cache/_source-cache/archive/50/500d5d34524f6b856edd5cae01f 4cebb3d4c9e64.tar.gz
- No patches needed for mytig
- => mytig: Executing phase: 'autoreconf'
- => mytig: Executing phase: 'configure'
- mytig: Executing phase: 'build'
- mytig: Executing phase: 'install'
- mytig: Successfully installed mytig-2.5.1-q2bg25rhlsde324ow6i7d3u3x774dtbp
- Stage: 0.03s. Autoreconf: 0.00s. Configure: 1.45s. Build: 1.67s. Install: 0.03s. Total: 3.21s
- [+] /home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/mytig-2.5.1-q2bg25rhlsde324ow6i7d3u3x774dtbp

It already builds !



ADMRE Use of Spack Create to redo TIG

🥑 @admire_eurohpc

\$ spack load mytig \$ which tig

/home/jbbesnard/repo/spack/opt/spack/linux-debian11-haswell/gcc-10.2.1/mytig-2.5.1-q2bg25rhlsde324ow6i7d3u3x774dtbp/bin/tig

\$ tig

| 2023-01-17 | 20:47 | -0700 | Adam J. Stewart | o [d | levelop] {origin/develop} {origin/HEAD} Subclass |
|------------|---------|--------|--------------------------------------|-------------------|---|
| 2023-01-17 | | | Glenn Johnson | о ру | /-itk: add version 5.3.0 (#34968) |
| 2023-01-17 | | | eugeneswalker | о ру | /-h5py %oneapi@2023.0.0: -Wno-error=incompatible |
| 2023-01-17 | | | Todd Gamblin | о ру | -sphinx-immaterial: new package (#34948) |
| 2023-01-17 | | | eugeneswalker | o re | empi: patch rempi_message_manager.h: include str |
| 2023-01-17 | | | Massimiliano Culpo | o CD | DashReporter: remove unused argument (#34869) |
| 2023-01-17 | | | Massimiliano Culpo | o Fo | prward lookup of "test_log_file" and "test_failu |
| 2023-01-17 | | | Annop Wongwathanarat | о ср | o2k: enable linking with armpl-gcc for BLAS and |
| 2023-01-17 | | | Harmen Stoppels | о ру | /thon: 3.11.1, use -flto=thin when clang (#34951 |
| 2023-01-17 | | | Harmen Stoppels | o Bu | ımp gnupg & libksba, (CVE) (#34976) |
| 2023-01-17 | | | roottreej | o Re | educe verbosity in mirrors.yaml (#34210) |
| 2023-01-17 | | | Loïc Pottier | <mark>o</mark> fa | aiss: fixed error when importing faiss python pa |
| 2023-01-17 | | | Harmen Stoppels | o bu | ıbblewrap: 0.7.0 (#34975) |
| 2023-01-17 | | | Christopher Christofi | o pe | erl-file-temp: add 0.2311 (#34866) |
| 2023-01-17 | | | Glenn Johnson | o li | bcroco: Get the `doc` variant working (#34735) |
| 2023-01-17 | | | MatthewLieber | o mv | vapich: add new package in preparation for v3.0 |
| 2023-01-17 | | | Ashwin Kumar | <mark>o</mark> fl | exiblas: add versions up to v3.3.0 (#34874) |
| 2023-01-17 | | | Marie Houillon | o Ne | ew version for openCARP packages, v12.0 (#34710) |
| 2023-01-17 | | | Axel Huebl | o Do | oc: config.yaml mention \$env (#34905) |
| 2023-01-17 | | | dependabot[bot] | o bu | <pre>uild(deps): bump actions/checkout from 3.2.0 to</pre> |
| 2023-01-17 | | | Cameron Smith | o mf | em: support pumi w/zoltan and parmetis (#34864) |
| 2023-01-17 | | | Dom Heinzeller | o cr | rtm: overhaul package, add crtm-fix (#34715) |
| 2023-01-17 | | | dependabot[bot] | o bu | <pre>uild(deps): bump docker/build-push-action from 3</pre> |
| [main] 205 | 75ca96a | aaa434 | 40d3583f68266133fa3e65dfc - commit 1 | of 29184 | 0% |





@admire_eurohpc

| \$ spack | info | mytig | AutotoolsPackage: mytig Description: FIXME: Put a proper descri | ption of | your package here | 2. |
|-------------------|------|-------|---|----------------------------------|--|---|
| | | | Homepage: https://www.example. | com | | |
| | | | Preferred version: 2.5.1 http://old-releas | es.ubunt | u.com/ubuntu/pool/ | ′universe/t/tig/tig_2.5.1.orig.tar.gz |
| | | | Safe versions: 2.5.1 http://old-releas 2.4.1 http://old-releas 2.3.0 http://old-releas | es.ubunt es.ubunt es.ubunt | u.com/ubuntu/pool/ u.com/ubuntu/pool/ u.com/ubuntu/pool/ | ′universe/t/tig/tig_2.5.1.orig.tar.gz ′universe/t/tig/tig_2.4.1.orig.tar.gz ′universe/t/tig/tig_2.3.0.orig.tar.gz |
| | | | Deprecated versions: None | | | |
| | | | Variants: Name [Default] | When | Allowed values | Description |
| | | | build_system [autotools] | | autotools | Build systems supported by the package |
| | | | Build Dependencies: gnuconfig ncurses | | | |
| | | | Link Dependencies: ncurses | | | |
| * * * * * EuroHPC | | | Run Dependencies: None | | | |





ADMIRE Closer Look on depends_on

| depends_on | Description |
|--|---|
| <pre>depends_on("hwloc")</pre> | Depend on the default version of hwloc. |
| depends_on(" <u>hwloc@2.1.0</u> ") | Depend on hwloc 2.2.1. |
| <pre>depends_on("hwloc@2:")</pre> | Depend on hwloc higher than 2x |
| <pre>depends_on("hwloc", when="+hwloc")</pre> | Conditionnal dependency with spec |
| <pre>depends_on("hwloc +cairo")</pre> | You can use variants ! |
| <pre>depends_on("hwloc", patches="my.patch")</pre> | You can customize the dependency w. patch |

There is also a **type=** argument:

- **build**: only needed to build the package, can be removed why leaving the package
- **link**: used at runtime by the package (libraries)
- run: the "bindir" of the prefix must be loaded when the package is loaded (PATH, PYTHONPATH)
- **test**: this dependency is used when running spack tests

Default dependency type is a set : ("build", "link")





| Variant Syntax | Description |
|---|---|
| <pre>variant('myvar', default=True, description='Myvar desc')</pre> | A boolean variant 'myvar' (+/-) |
| <pre>variant('mychoice', default='a', description='Choose in hoice', values=('a', 'b', 'c'), multi=False)</pre> | Choose a value in (a,b,c) |
| <pre>variant('condvar', default=False, when='@1.0:',</pre> | Condvar can only be used after the |
| description='Only valid after 1.0') | 1.0 version. |
| if 'mychoice=a options.app | a' in self.spec: pend('enable-choice-a') |
| extra_args.append('enable-myvar') | |
| extra_args.append('disable-myvar') if self.spec.var options.appe | iants['mychoice'].value == 'a': end('enable-choice-a') |
| depends_on('hwloc', when='+var') | |

Note: there are much more convoluted examples see: <u>https://spack.readthedocs.io/en/latest/packaging_guide.html#variants</u>







| Variant Syntax | Description |
|---|-------------------------------------|
| <pre>conflicts('%clang', when='@:1.9', msg='Cannot build prior to 1.9 with</pre> | Prevent building with clang before |
| clang') | 1.5 |
| conflicts('+myvar', when='@:1.9', msg='Myvar is not supported before 1.9') | Prevent a variant on a specific |
| | version |
| <pre>conflicts('mychoice=a', when='@1.3', msg='Cannot set mychoice=a in 1.3')</pre> | Do not allow mychoice=a in version |
| | 1.3 |
| conflicts('+cuda', when='+nogpu', msg='Cannot set both +cuda and +nogpu') | Define incompatible variants |
| conflicts('+nogpu') | Can be used programmatively in "if" |





• Use of Spack Create to redo TIG

🥑 @admire_eurohpc

\$ spack info mytig

Protip: a good way to find how to do packages is to look at how other did ! Just do **spack edit** a similar package, for example a Python one if you are in Python and see.



AutotoolsPackage: mytig

Description:

FIXME: Put a proper description of your package here.

Homepage: https://www.example.com

Preferred version:

2.5.1 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.5.1.orig.tar.gz

Safe versions:

- 2.5.1 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.5.1.orig.tar.gz
- 2.4.1 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.4.1.orig.tar.gz
- 2.3.0 http://old-releases.ubuntu.com/ubuntu/pool/universe/t/tig/tig_2.3.0.orig.tar.gz

Deprecated versions:

None

| iants: Name [Default] ========= | When | Allowed values | Description | |
|---|------|---------------------------------|---|--|
| build_system [autotools] iconv [on] readline [on] | | autotools on, off on, off | Build systems supported by the package Build iconv support Build readline support | |
| ld Dependencies: gnuconfig libicon∨ ncurses readline | | | | |
| k Dependencies: libicon∨ ncurses readline | | | | |

Run Dependencies:

None



\$ spack graph mytig

o mytig@2.5.1/jzizfb7

o | | readline@8.2/3lursdp |/ /

o | ncurses@6.3/53tai6g
o | pkgconf@1.8.0/biltfbh

o libiconv@1.16/rijolwa

\$ spack graph mytig \ -readline -iconv

o mytig@2.5.1/y3raqkm o ncurses@6.3/53tai6g o pkgconf@1.8.0/biltfbh





E Use of Spack Create to redo TIG

https://www.admire-eurohpc.eu/

🥑 @admire_eurohpc

\$ tree \$HOME/mypkg

```
/home/jbbesnard/mypkg

packages

mytig

package.py

repo.yaml
```

This repository can then be shared as a git repository to serve as a base for software exchange. Including prior to a later addition in Spack.

As directed by the -r \$HOME/mypkg argument at spack create, the package is located in our own repository.

Spack built-in repository is at: **\$SPACK_ROOT/var/spack/repos/builtin**





Spack Packaging Documentation

https://www.admire-eurohpc.eu/

https://spack.readthedocs.io/en/latest/packaging_guide.html







We have seen;

- Context of Spack and its use in ECP + E4S, Pr. Shende
- Then we learned how to install Spack
- After we looked at specs and made some experiments
- We made a simple recipe and learned the base syntax arround spack's scaffolding capabilities

We made just a small introduction to Spack and did not cover specific cases, feel free to connect to us in point to point to ask us questions on your particular case. jbbesnard@paratools.fr











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