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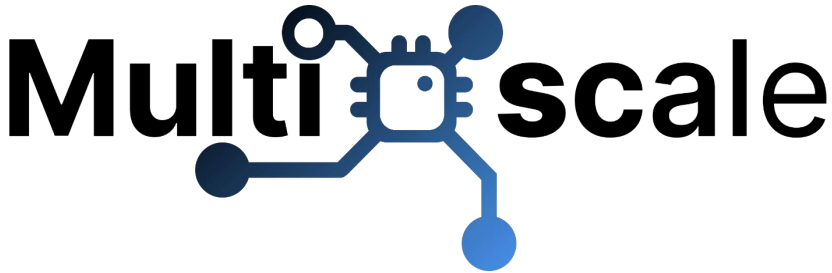

EuroHPC Joint Undertaking

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Preparing to Hit the Ground Running: Adding RISC-V support to EESSI

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Outline

- Introduction
- A shared stack of optimized software installations (EESSI)
- File system layer
- Compatibility layer
- Software layer
- Lessons learned
- Conclusions

This project has received funding from the European High Performance Computing Joint Undertaking under grant agreement No. 101093169

1.

Introduction

Towards a scientific software stack for RISC-V

[1]

RISC-V architecture expected to be one of the key elements in the European HPC community

RISC-V software stack and system platform is much more mature than one could expect

Adding support to EESSI will facilitate the development, testing, and use of RISC-V-based systems

[1] https://www.european-processor-initiative.eu/

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2.

A shared stack of optimized software installations

EESSI (http://www.eessi.io/)

EESSI main goal (https://www.eessi.io/docs/)

- To provide a collection of scientific software installations on a wide range of different platforms
  - HPC clusters
  - Cloud infrastructure
  - Personal workstations and laptops
- without compromising performance

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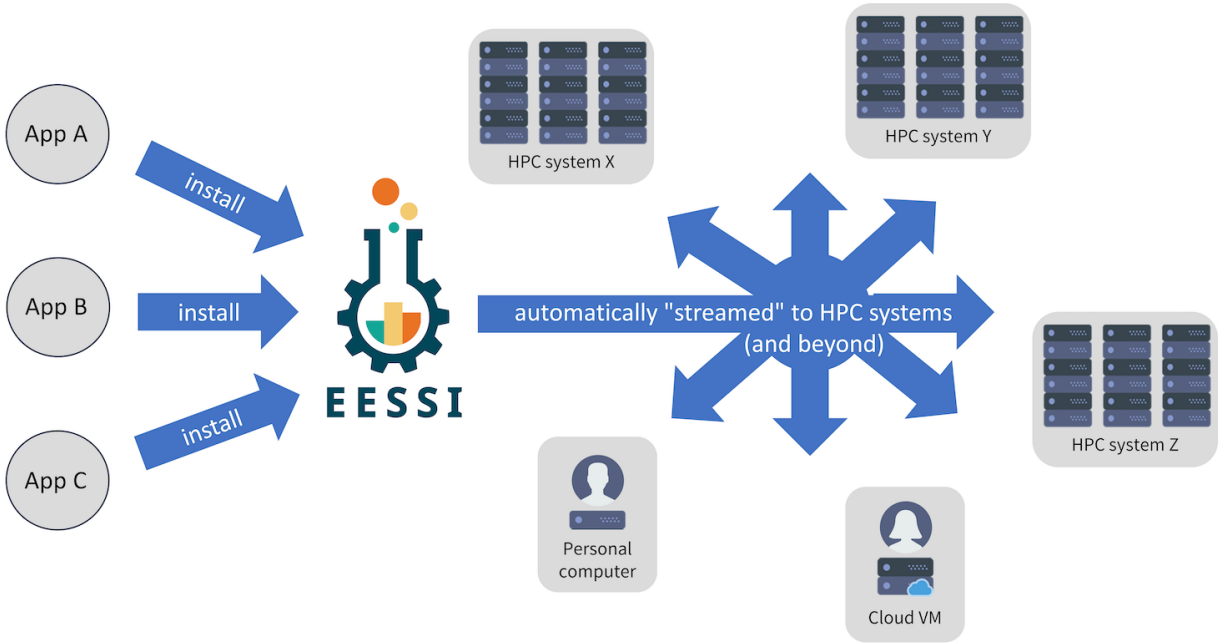
European Environment for Scientific Software Installations (EESSI)



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EESSI benefits

- Allows HPC support teams to more closely collaborate on building optimized software installations
- Scientists benefit from having a uniform software stack available regardless of where they want to work, and…
- …get this environment without worrying about architecture-specific optimization
- Publicly accessible / free

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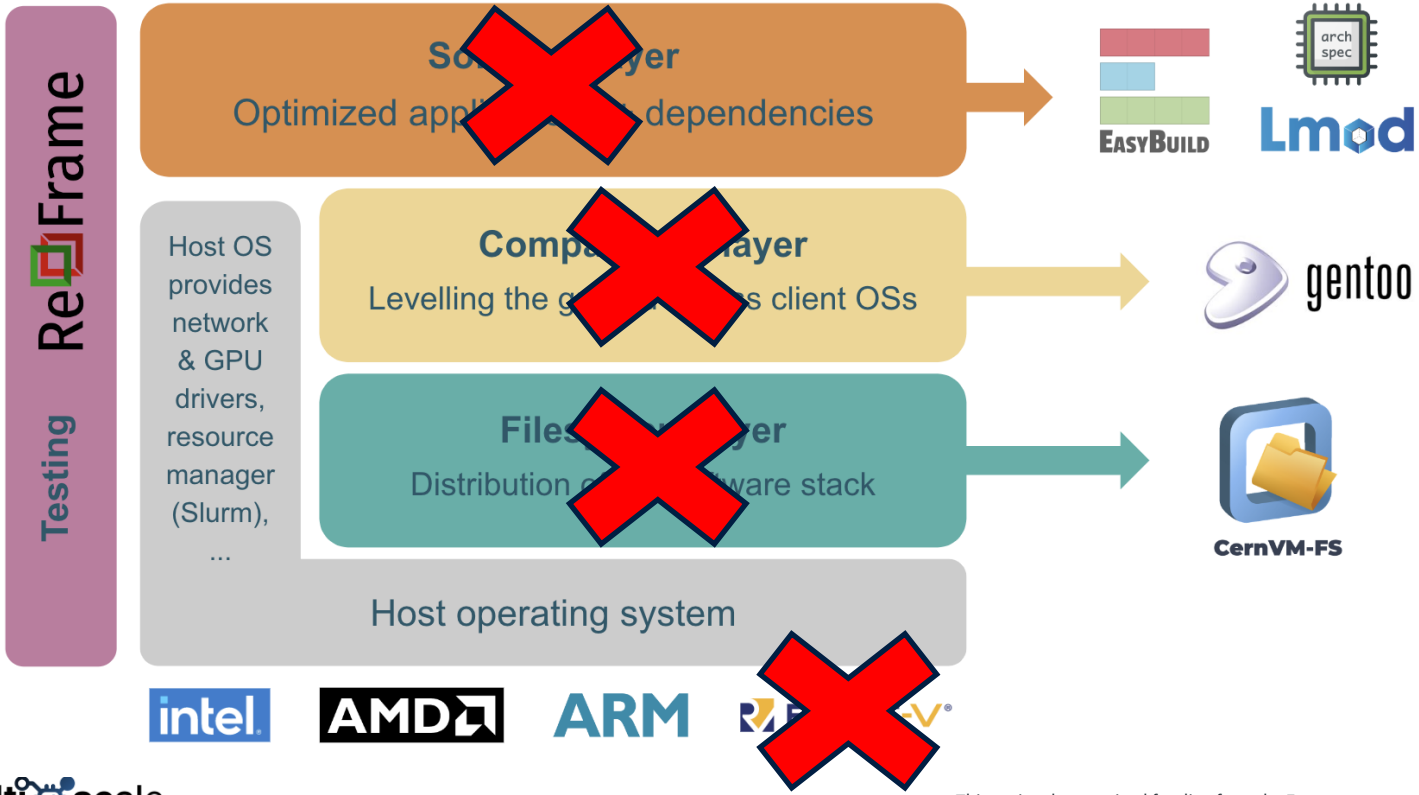
High-level design of EESSI (https://www.eessi.io/)



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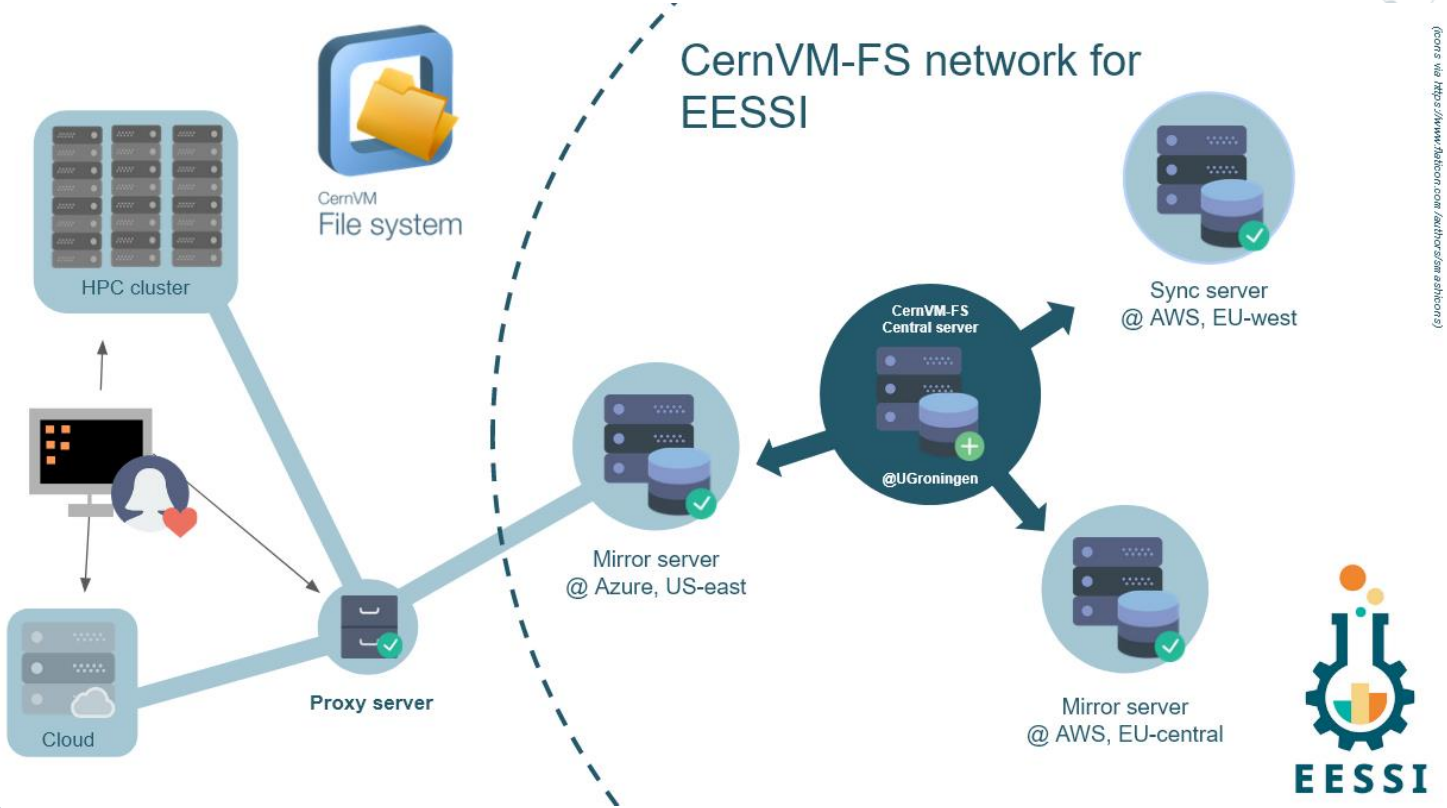
3.
File system layer

CernVM-FS

CernVM-FS overview



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CernVM-FS client for RISC-V

- No pre-built package for RISC-V
- Built CernVM-FS from source in a SiFive Hifive Unmatched running Ubuntu 21.04
- Issue with old `config.guess` files in two of the dependencies packed into the source code:
  - libressl-3.5.3
  - protobuf-2.6.1
- PR (https://github.com/cvmfs/cvmfs/pull/3446) already merged into main development branch of CernVM-FS:
  - Basically, running `autoreconf –vfi` to have a fresh `config.guess`

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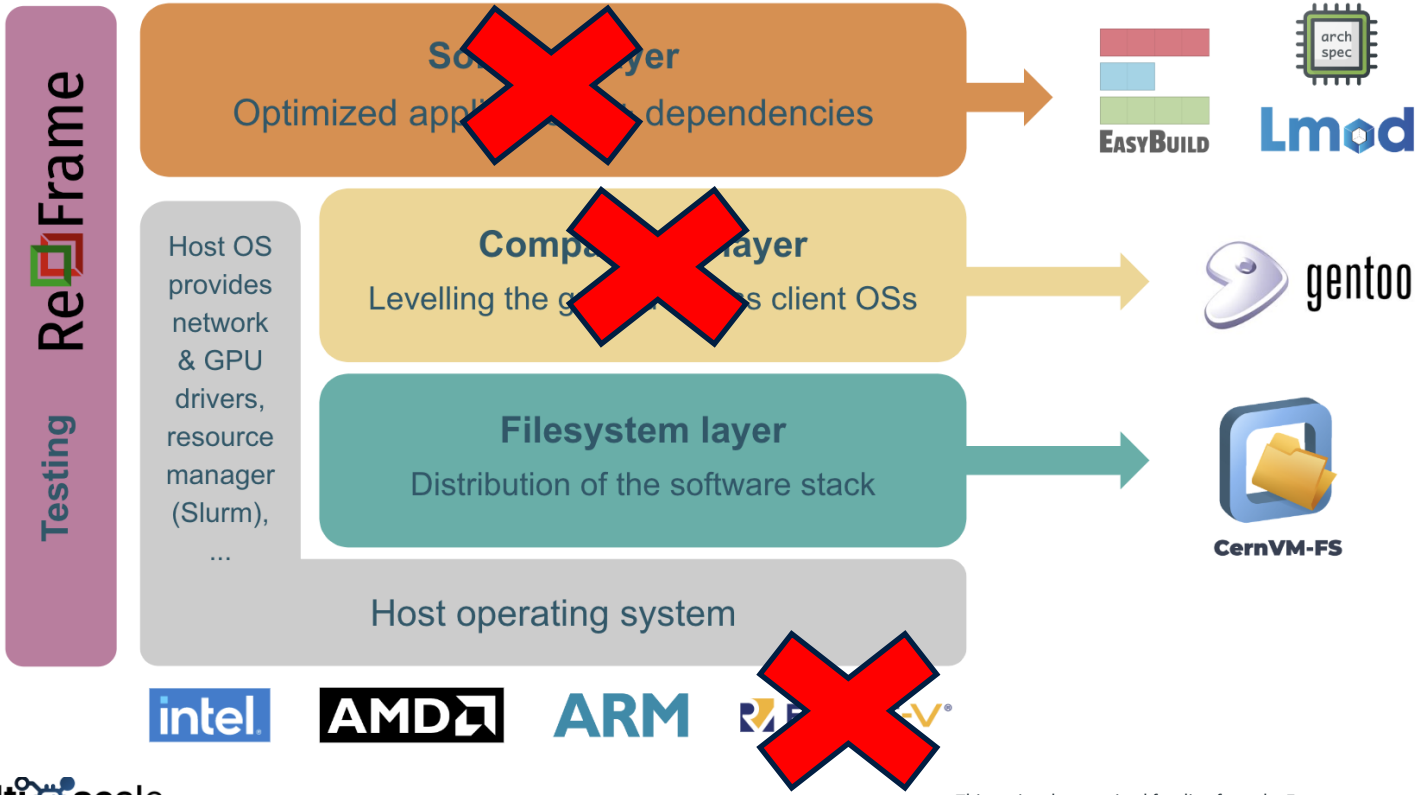
riscv.eessi.io

Dedicated CernVM-FS repository for RISC-V
(https://eessi.io/docs/repositories/riscv.eessi.io)

High-level design of EESSI



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4.

Compatibility layer

Ensures that the scientific software stack is compatible with different operating systems

Components

- Gentoo Prefix (main component)
- EESSI package set
- Container with Ansible
- ReFrame

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Bootstrapping Gentoo Prefix in RISC-V

- https://wiki.gentoo.org/wiki/Project:Prefix/Bootstrap

- bootstrap-prefix.sh failed to detect architecture identifier riscv64-unknown-linux-gnu
  - Submitted patch to Gentoo developers already applied (https://gitweb.gentoo.org/repo/proj/prefix.git/commit/?id=e66a8e81b12473d92c7fadb361feffb2aa127d9e)

- Compilation of GCC (during *Stage 2*) failed with finding some header files
  - Previously reported *GCC bug* (https://gcc.gnu.org/bugzilla/show_bug.cgi?id=106271)
  - Error and solution were reported to Gentoo's bug tracking system (https://bugs.gentoo.org/890636)
    → 4 commits already merged into main development branch:
    - https://gitweb.gentoo.org/proj/gcc-patches.git/commit/?id=f373ff919da62443ca59681f219b4899e72a6f2f
    - https://gitweb.gentoo.org/proj/gcc-patches.git/commit/?id=d5e5f9b252f00c9485c34446efc01bdd2eaaa9b1
    - https://gitweb.gentoo.org/repo/gentoo.git/commit/?id=1849c746cd35fb74c6014d1bfd2b1e287bad0a0f
    - https://gitweb.gentoo.org/repo/gentoo.git/commit/?id=7d55c7c1d2d179894998a18dc311714e05f0d913

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EESSI package set

- Additional packages installed on top of Gentoo Prefix:
  - Communication libraries required by OpenMPI
  - Lmod
  - pip
  - bash-completion
  - …
- We cloned the package set for the Arm CPU architecture
  - Worked out of the box ☺
- https://github.com/EESSI/gentoo-overlay/blob/main/etc/portage/sets/eessi-2023.06-linux-riscv64

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Container with Ansible

- Container images based on Debian 11 for CPUs already supported in EESSI, but Debian 11 does not support RISC-V → We created a new build container recipe based on Debian Sid.
- Kernel of the Debian provided by StarFive in the VisionFive 2 system (5.15.0-starfive) does not (yet) support SquashFS:
  - Workaround: `singularity build --sandbox`
- Ansible worked just fine on RISC-V ☺

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ReFrame (https://reframe-hpc.readthedocs.org/)

- Ansible role includes a test suite using ReFrame
  - https://github.com/EESSI/compatibility-layer/blob/main/test/compat_layer.py
- Installation of ReFrame worked fine ☺
- Test step revealed only one minor issue entirely unrelated to RISC-V, but due to a renamed Gentoo package.
  - Easily fixed
  - Full test suite then passed without problems ☺

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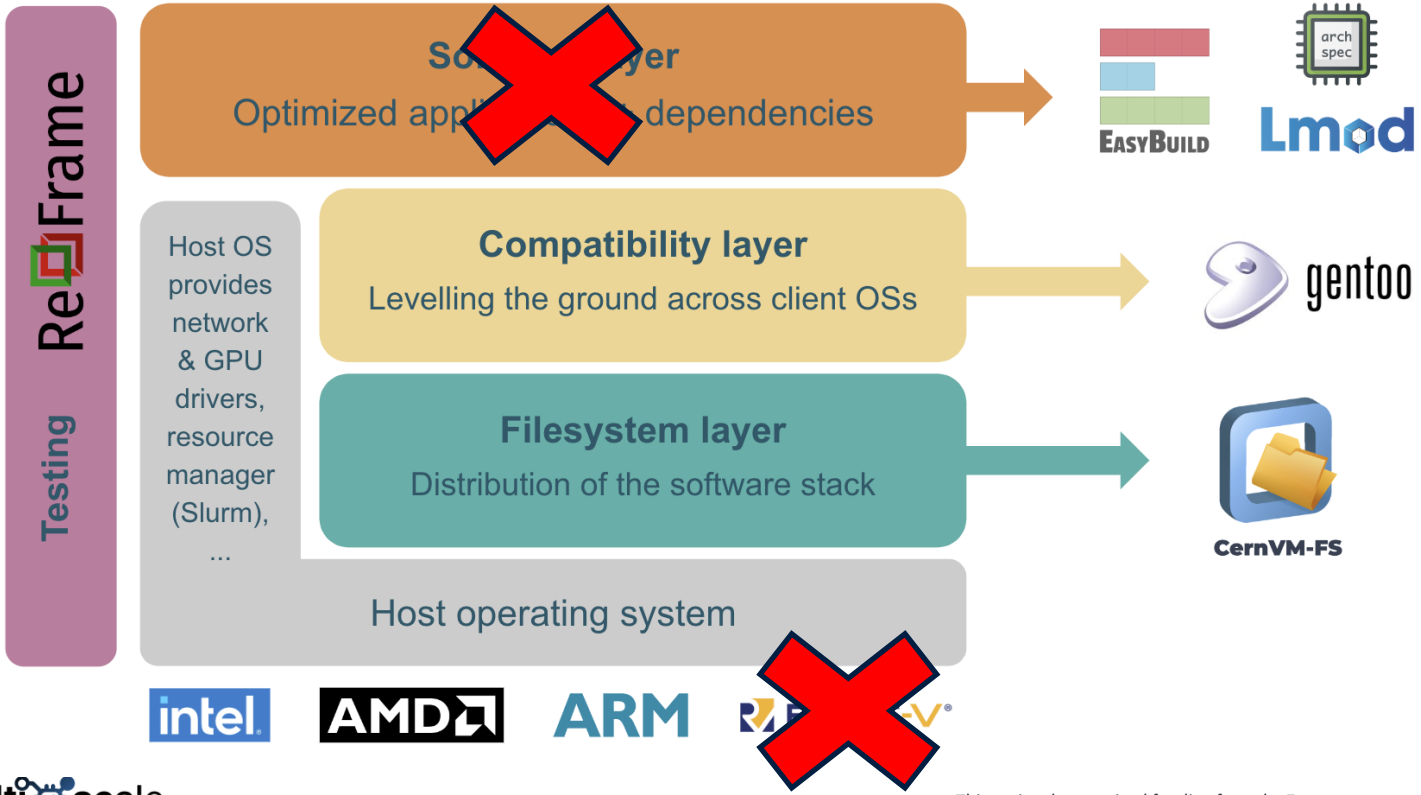
High-level design of EESSI



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5.

Software layer

The actual shared stack of (scientific) software

Initial step: building GCC for RISC-V with EasyBuild

- We ran into the same problem encountered when bootstrapping Gentoo Prefix
  - Patch mentioned there not included yet with GCC 13.2
  - PR to EasyBuild to include this patch for GCC versions 12.x and 13.x (https://github.com/easybuilders/easybuild-easyconfigs/pull/20035)
- Two additional changes:
  - Add to **$LIBRARY_PATH** the lib and lib64 subdirectories of the GCC installation in the Python script used by EasyBuild
  - NVPTX feature of GCC had to be disabled
- GCC 14.1 is first official release that will build from source in Debian-based systems out-of the-box

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Towards a complete toolchain and software applications

- Plan to install the **foss toolchain**:
  - GCC, OpenMPI, FlexiBLAS + OpenBLAS, FFTW
  - Most (if not all) of these components should already support RISC-V
- Then, actual scientific software:
  - GROMACS, HPL, OSU Micro Benchmarks, OpenFOAM, BLIS, ESPResSo, HDF5, LAMMPS, LLVM, netCDF, netCDF-Fortran, Perl, Python, PyTorch, QuantumESPRESSO, Rust, ScaLAPACK, TensorFlow, walBerla…
  - Many are known to be already working for RISC-V, so we do not expect many troubles in such cases.

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Expectations and approach for collaboration

- When adding more software installations we expect to run into various problems
  - Probably a significant part of the software projects are not compatible with RISC-V yet
  - We will engage with developers to jointly resolve issues
- Based on Arm CPU experience, we expect that problems will arise on RISC-V with the test suites provided by some software projects

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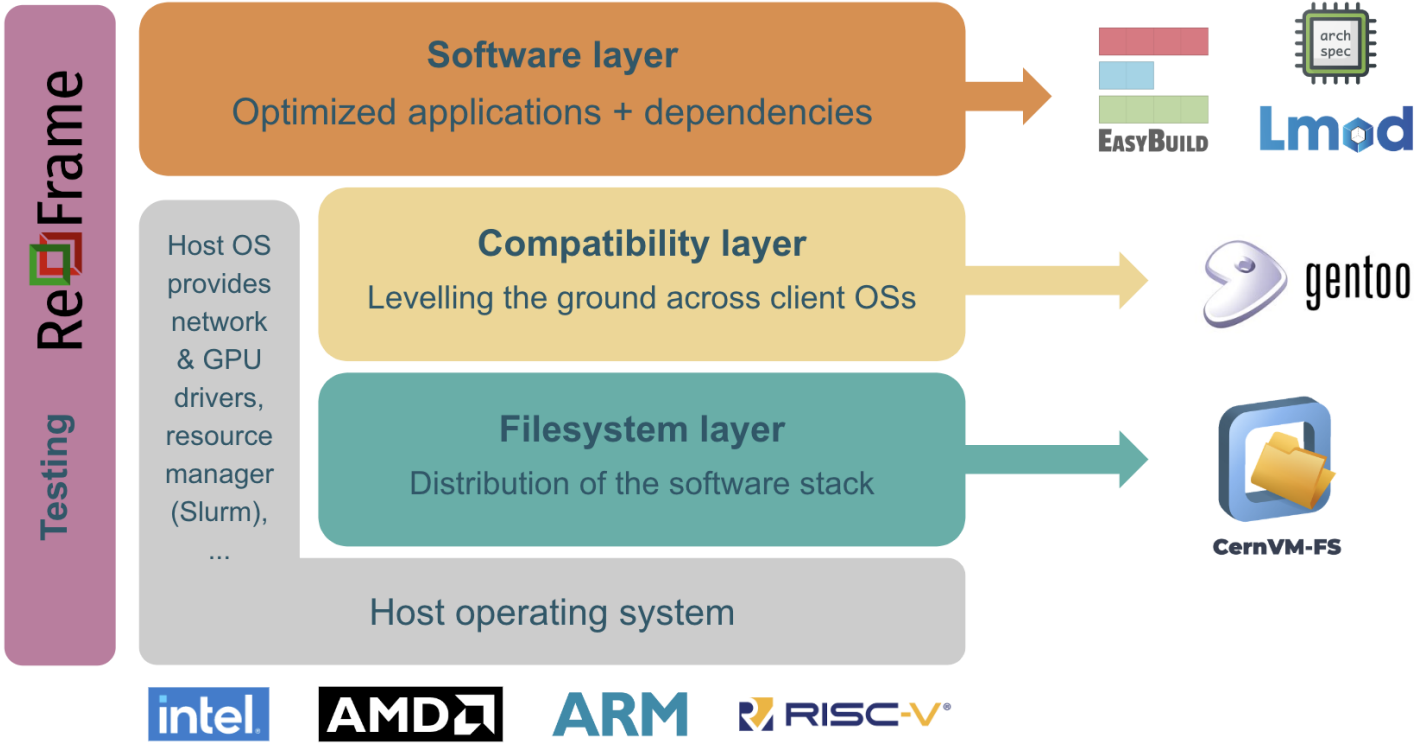
High-level design of EESSI



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6.

Lessons learned

Experiences and insights gained from implementing support for RISC-V in EESSI

Lessons learned

- In projects that support multiple CPU families (**x86_64**, **aarch64**, **ppc64le**) it should be relatively *easy* to add **riscv64** support
  - Blueprint for needed changes (especially true for **aarch64**)
- RISC-V already has support in many OS, compilers, runtimes and tools
  - Important to work with latest versions of compilers/runtimes/tools
- Many software packages are closer to working on RISC-V than expected
- High interest from the open source software community for RISC-V

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7.
Conclusions

Paving the way to the first generation of RISC-V HPC systems that may not be so far away

Conclusions

- Remarkable level of software readiness and maturity
- Contribution to the RISC-V software ecosystem by enabling the use of EESSI
  - CernVM-FS
  - Gentoo Prefix
- Dedicated CernVM-FS repository for RISC-V in EESSI:
  - **riscv.eessi.io**
- No significant roadblocks along the way
  - Actually…

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```
jmorillo@arriesgado-10:~$ /cvmfs/riscv.eessi.io/versions/20240402/compat/linux/riscv64/startprefix
Entering Gentoo Prefix /cvmfs/riscv.eessi.io/versions/20240402/compat/linux/riscv64
jmorillo@arriesgado-10:~$ source /cvmfs/riscv.eessi.io/versions/20240402/init/bash
Found EESSI repo @ /cvmfs/riscv.eessi.io/versions/20240402!
archdetect says riscv64/generic
Using riscv64/generic as software subdirectory.
Found Lmod configuration file at /cvmfs/riscv.eessi.io/versions/20240402/software/linux/riscv64/generic/.lmod/lmodrc.lua
Found Lmod SitePackage.lua file at /cvmfs/riscv.eessi.io/versions/20240402/software/linux/riscv64/generic/.lmod/SitePackage.lua
Using /cvmfs/riscv.eessi.io/versions/20240402/software/linux/riscv64/generic/modules/all as the directory to be added to MODULEPATH.
Initializing Lmod...
Prepending /cvmfs/riscv.eessi.io/versions/20240402/software/linux/riscv64/generic/modules/all to $MODULEPATH...
Environment set up to use EESSI (20240402), have fun!
{EESSI 20240402} jmorillo@arriesgado-10:~$ module --nx avail

---------------------------------- /cvmfs/riscv.eessi.io/versions/20240402/software/linux/riscv64/generic/modules/all ----------------------------------
   Bison/3.8.2-GCCcore-13.2.0                    hwloc/2.9.2-GCCcore-13.2.0                    OpenBLAS/0.3.24-GCC-13.2.0
   BLIS/0.9.0-GCC-13.2.0                         hypothesis/6.90.0-GCCcore-13.2.0              OpenMPI/4.1.6-GCC-13.2.0
   Brotli/1.1.0-GCCcore-13.2.0                   ICU/74.1-GCCcore-13.2.0                       OpenSSL/1.1
   cairo/1.18.0-GCCcore-13.2.0                   Java/21.0.2                           (21)    patchelf/0.18.0-GCCcore-13.2.0
   Catch2/2.13.9-GCCcore-13.2.0                  jbigkit/2.1-GCCcore-13.2.0                    PCRE2/10.42-GCCcore-13.2.0
   cffi/1.15.1-GCCcore-13.2.0                    libarchive/3.7.2-GCCcore-13.2.0               Perl/5.38.0-GCCcore-13.2.0
   CMake/3.27.6-GCCcore-13.2.0                   libdeflate/1.19-GCCcore-13.2.0                pixman/0.42.2-GCCcore-13.2.0
   cryptography/41.0.5-GCCcore-13.2.0            libdrm/2.4.117-GCCcore-13.2.0                 pkgconf/1.8.0
   cURL/8.3.0-GCCcore-13.2.0                     libevent/2.1.12-GCCcore-13.2.0                pkgconf/2.0.3-GCCcore-13.2.0          (D)
   dlb/3.4-gompi-2023b                           libfabric/1.19.0-GCCcore-13.2.0               PMIx/4.2.6-GCCcore-13.2.0
   Doxygen/1.9.8-GCCcore-13.2.0                  libffi/3.4.4-GCCcore-13.2.0                   poetry/1.6.1-GCCcore-13.2.0
   EasyBuild/4.9.1                               libgit2/1.7.2-GCCcore-13.2.0                  pybind11/2.11.1-GCCcore-13.2.0
   Eigen/3.4.0-GCCcore-13.2.0                    libGLU/9.0.3-GCCcore-13.2.0                   Python-bundle-PyPI/2023.10-GCCcore-13.2.0
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   flit/3.9.0-GCCcore-13.2.0                     libpng/1.6.40-GCCcore-13.2.0                  scikit-build/0.17.6-GCCcore-13.2.0
   fontconfig/2.14.2-GCCcore-13.2.0              LibTIFF/4.6.0-GCCcore-13.2.0                  setuptools-rust/1.8.0-GCCcore-13.2.0
   foss/2023b                                    libunwind/1.6.2-GCCcore-13.2.0                SQLite/3.43.1-GCCcore-13.2.0
   freetype/2.13.2-GCCcore-13.2.0                libxml2/2.11.5-GCCcore-13.2.0                 Tcl/8.6.13-GCCcore-13.2.0
   FriBidi/1.0.13-GCCcore-13.2.0                 LLVM/16.0.6-GCCcore-13.2.0                    Tk/8.6.13-GCCcore-13.2.0
   GCC/13.2.0                                    lz4/1.9.4-GCCcore-13.2.0                      UCC/1.2.0-GCCcore-13.2.0
   GCCcore/13.2.0                                make/4.4.1-GCCcore-13.2.0                     UCX/1.15.0-GCCcore-13.2.0
   gfbf/2023b                                    Mako/1.2.4-GCCcore-13.2.0                     UnZip/6.0-GCCcore-13.2.0
   git/2.42.0-GCCcore-13.2.0                     Mesa/23.1.9-GCCcore-13.2.0                    virtualenv/20.24.6-GCCcore-13.2.0
   GLib/2.78.1-GCCcore-13.2.0                    meson-python/0.15.0-GCCcore-13.2.0            Wayland/1.22.0-GCCcore-13.2.0
   GObject-Introspection/1.78.1-GCCcore-13.2.0   Meson/1.2.3-GCCcore-13.2.0                    X11/20231019-GCCcore-13.2.0
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   hatchling/1.18.0-GCCcore-13.2.0               numactl/2.0.16-GCCcore-13.2.0
```

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