E4S: A Platform for HPC-AI Tool Interoperability

Scalable Tools Workshop 2025

3:30pm – 4pm PDT, July 7, 2025
Granlibakken Resort, Lake Tahoe, CA

Sameer Shende
Research Professor and Director,
Performance Research Laboratory, OACISS, University of Oregon
President and Director, ParaTools, Inc.
sameer@cs.uoregon.edu
https://oaciss.uoregon.edu/e4s/talks/E4S_Scalable_Tools25.pdf

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Motivation

- As our software gets more complex, it is getting harder and harder to install and operate our performance evaluation tools and libraries for HPC-AI workflows on GPUs correctly in an integrated and interoperable software stack!

Solutions

- E4S: An HPC-AI software platform for tool integration
- Frank@UO: A hardware platform for CI for performance tools
- ParaTools Pro for E4S™: A cloud image for tool integration

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Extreme-scale Scientific Software Stack (E4S)

https://e4s.io

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Motivation

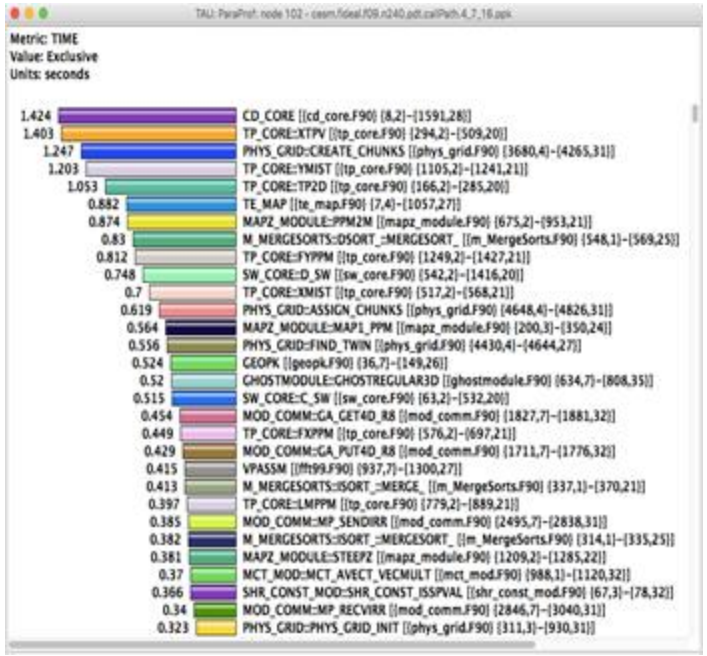
- What are the requirements for performance evaluation tools?

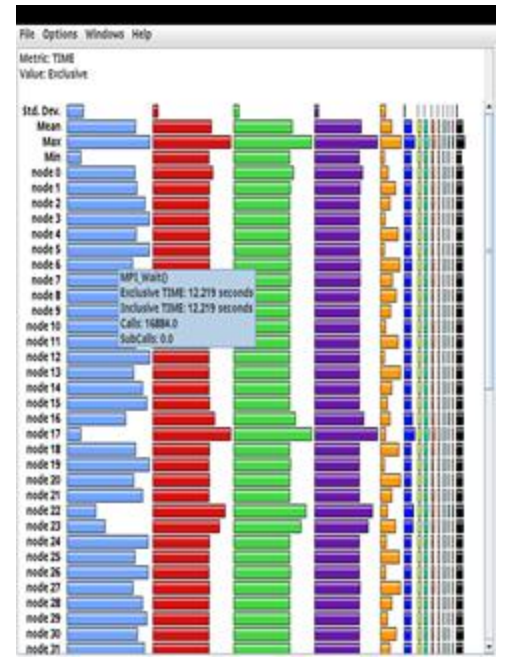
TAU Performance System®

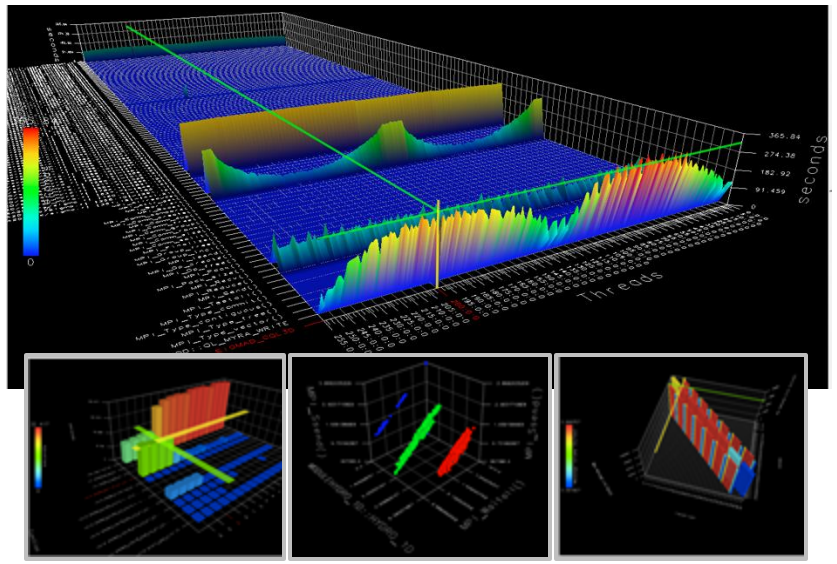
Portable profiling and tracing toolkit for performance analysis of HPC parallel programs

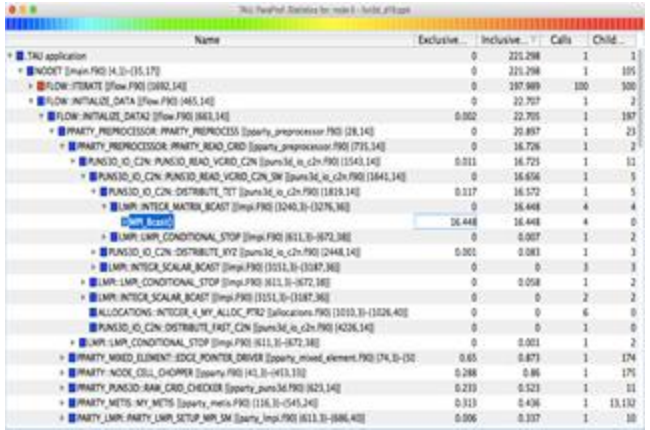
- Supports most parallel execution models
- Provides instrumentation and measurement
- Parallel profiling analysis and data mining
- Open source: http://tau.uoregon.edu

TAU runs on most HPC platforms









https://tau.uoregon.edu

Our performance evaluation tools are getting complex to install!

- GPU Runtimes: ROCm, CUDA/CUPTI, Intel® oneAPI
- Tool interfaces: ROCprofiler-sdk, CUPTI, Intel Level Zero, OpenCL, MPI_T, OMPT, Kokkos, RAJA, Caliper, CAMTimers, PerfStubs, GPTL, phiprof, ittnotify, …
- Tool dependencies:
  - DyninstAPI, binutils, libunwind, libdwarf installed just right (-fPIC used to compile .o files in DSOs)
  - Languages: C++/C/Fortran, Python, Rust, Chapel
  - Tools: Qt5, Java, perl, ruby, autotools, sed, awk, cmake…
  - PAPI, Likwid for hardware performance counter access
  - Compilers: LLVM, GNU, Intel, AMD, NVHPC, PrgEnv-{cray,amd,nvidia,intel,gnu-amd} on HPE CPE
  - MPI (MVAPICH with MPI_T, zfp compression, GDR, OFI/UCX/EFA)
  - Intel TBB
  - Boost
  - Other third-party libraries (e.g., AWS NeuronX SDK for AWS Trainium and Inferentia nodes) …
- Installing these tools and their dependencies by hand is hard!

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Tool dependencies: HPCToolkit, DyninstAPI, TAU, OpenFOAM

```
Singularity> spack find -d  hpctoolkit+rocm
-- linux-ubuntu22.04-x86_64_v3 / gcc@11.4.0 ----------------------
hpctoolkit@2024.01.1
    autoconf@2.72
        m4@1.4.19
            libsigsegv@2.14
        perl@5.40.0
            berkeley-db@18.1.40
            gdbm@1.23
                readline@8.2
    automake@1.16.5
    boost@1.86.0
    bzip2@1.0.8
        diffutils@3.10
    dyninst@13.0.0
        cmake@3.31.6
            ncurses@6.5
    elfutils@0.190
        libiconv@1.17
        pkgconf@2.3.0
        zstd@1.5.6
    gcc-runtime@11.4.0
    glibc@2.35
    gmake@4.4.1
    hip@6.3.2
    hpcviewer@2025.01
        openjdk@17.0.11_9
    hsa-rocr-dev@6.3.2
    intel-tbb@2022.0.0
        hwloc@2.11.1
            libpciaccess@0.17
                util-macros@1.20.1
            libxml2@2.13.5
    intel-xed@2024.05.20
        python@3.10.12
    libiberty@2.41
    libmonitor@2023.03.15
    libtool@2.4.7
        findutils@4.10.0
            gettext@0.23.1
                tar@1.35
                    pigz@2.8
    libunwind@1.8.1
    mpich@4.2.3
    papi@7.1.0
    rocprofiler-dev@6.3.2
    roctracer-dev@6.3.2
    xerces-c@3.3.0
        curl@8.11.1
            nghttp2@1.65.0
            openssl@3.4.1
                ca-certificates-mozilla@2025-02-25
    xz@5.6.3
    yaml-cpp@0.8.0
    zlib-ng@2.2.3
```

```
Singularity> spack find -d dyninst
-- linux-ubuntu22.04-x86_64_v3 / gcc@11.4.0 ----------
dyninst@13.0.0
    boost@1.86.0
        mpich@4.2.3
    cmake@3.31.6
        curl@8.11.1
            nghttp2@1.65.0
            openssl@3.4.1
                ca-certificates-mozilla@2025-02-25
                perl@5.40.0
                    berkeley-db@18.1.40
                    gdbm@1.23
                        readline@8.2
        ncurses@6.5
        zlib-ng@2.2.3
    elfutils@0.190
        bzip2@1.0.8
            diffutils@3.10
        libiconv@1.17
        m4@1.4.19
            libsigsegv@2.14
        pkgconf@2.3.0
        xz@5.6.3
        zstd@1.5.6
    gcc-runtime@11.4.0
    glibc@2.35
    gmake@4.4.1
    intel-tbb@2022.0.0
        hwloc@2.11.1
            libpciaccess@0.17
                util-macros@1.20.1
            libxml2@2.13.5
    libiberty@2.41
```

```
Singularity> spack find -d tau+rocm
-- linux-ubuntu22.04-x86_64_v3 / gcc@11.4.0 ----------
tau@2.34.1
    binutils@2.43.1
        diffutils@3.10
        pkgconf@2.3.0
        zstd@1.5.6
    comgr@6.3.2
    elfutils@0.192
        bzip2@1.0.8
        gettext@0.23.1
            tar@1.35
                pigz@2.8
        libiconv@1.17
        m4@1.4.19
            libsigsegv@2.14
        xz@5.6.3
    gcc-runtime@11.4.0
    glibc@2.35
    gmake@4.4.1
    hip@6.3.2
    hsa-rocr-dev@6.3.2
    hwloc@2.11.1
        libpciaccess@0.17
            util-macros@1.20.1
        libxml2@2.13.5
        ncurses@6.5
    libdwarf@0.11.0
        cmake@3.31.6
            curl@8.11.1
                nghttp2@1.65.0
                openssl@3.4.1
                    ca-certificates-mozilla@2025-02-25
                    perl@5.40.0
                        berkeley-db@18.1.40
                        gdbm@1.23
                            readline@8.2
    libunwind@1.8.1
    mpich@4.2.3
    openjdk@17.0.11_9
    otf2@3.0.3
        python@3.10.12
        python-venv@1.0
    papi@7.1.0
    pdt@3.25.2
    rocm-core@6.3.2
    rocm-smi-lib@6.3.2
    rocprofiler-sdk@6.3.2
    zlib-ng@2.2.3
```

```
Singularity> spack find -d openfoam
-- linux-ubuntu22.04-x86_64_v3 / gcc@11.4.0 ----------
openfoam@2412
    adios2@2.10.2
        bzip2@1.0.8
        c-blosc2@2.15.1
            lizard@2.0
            lz4@1.10.0
            snappy@1.2.1
        gmake@4.4.1
        libcatalyst@2.0.0
        libfabric@1.22.0
        libffi@3.4.6
        libpng@1.6.39
        mgard@2023-12-09
            libarchive@3.7.6
                lzo@2.10
            protobuf@3.28.2
                abseil-cpp@20240722.0
            python@3.10.12
            sed@4.9
            yaml-cpp@0.8.0
        pkgconf@2.3.0
        sz@2.1.12.5
        zfp@0.5.5
    boost@1.86.0
        icu4c@74.2
        xz@5.6.3
        zstd@1.5.6
    cgal@5.6
        eigen@3.4.0
        gmp@6.3.0
        mpfr@4.2.1
            autoconf-archive@2023.02.20
            texinfo@7.1
    cmake@3.31.6
        curl@8.11.1
            nghttp2@1.65.0
            openssl@3.4.1
                ca-certificates-mozilla@2025-02-25
        ncurses@6.5
    fftw@3.3.10
    flex@2.6.4
        autoconf@2.72
            perl@5.40.0
                berkeley-db@18.1.40
                gdbm@1.23
        automake@1.16.5
        bison@3.8.2
        diffutils@3.10
            libiconv@1.17
        findutils@4.10.0
        gettext@0.23.1
            libxml2@2.13.5
            tar@1.35
                pigz@2.8
        help2man@1.49.3
        libtool@2.4.7
    gcc-runtime@11.4.0
    glibc@2.35
    json-c@0.18
    libyaml@0.2.5
    m4@1.4.19
        libsigsegv@2.14
    mpich@4.2.3
    readline@8.2
    scotch@7.0.6
    zlib-ng@2.2.3
```

How can we build a productive software stack to help tool developers?

- Tool dependencies should be pre-installed
- A consistent environment that we can share with other tool developers to report bugs
- Can containers help here?
- Build your tools with the dependencies inside a container
  - Same kernel as the host OS
  - Can support a different OS
  - Docker/podman and Singularity/Apptainer are popular container runtimes
- Need a base container that can provide the dependencies
- E4S provides a rich set of containers with tools and libraries
- Spack is a versatile package manager for HPC-AI tools and libraries

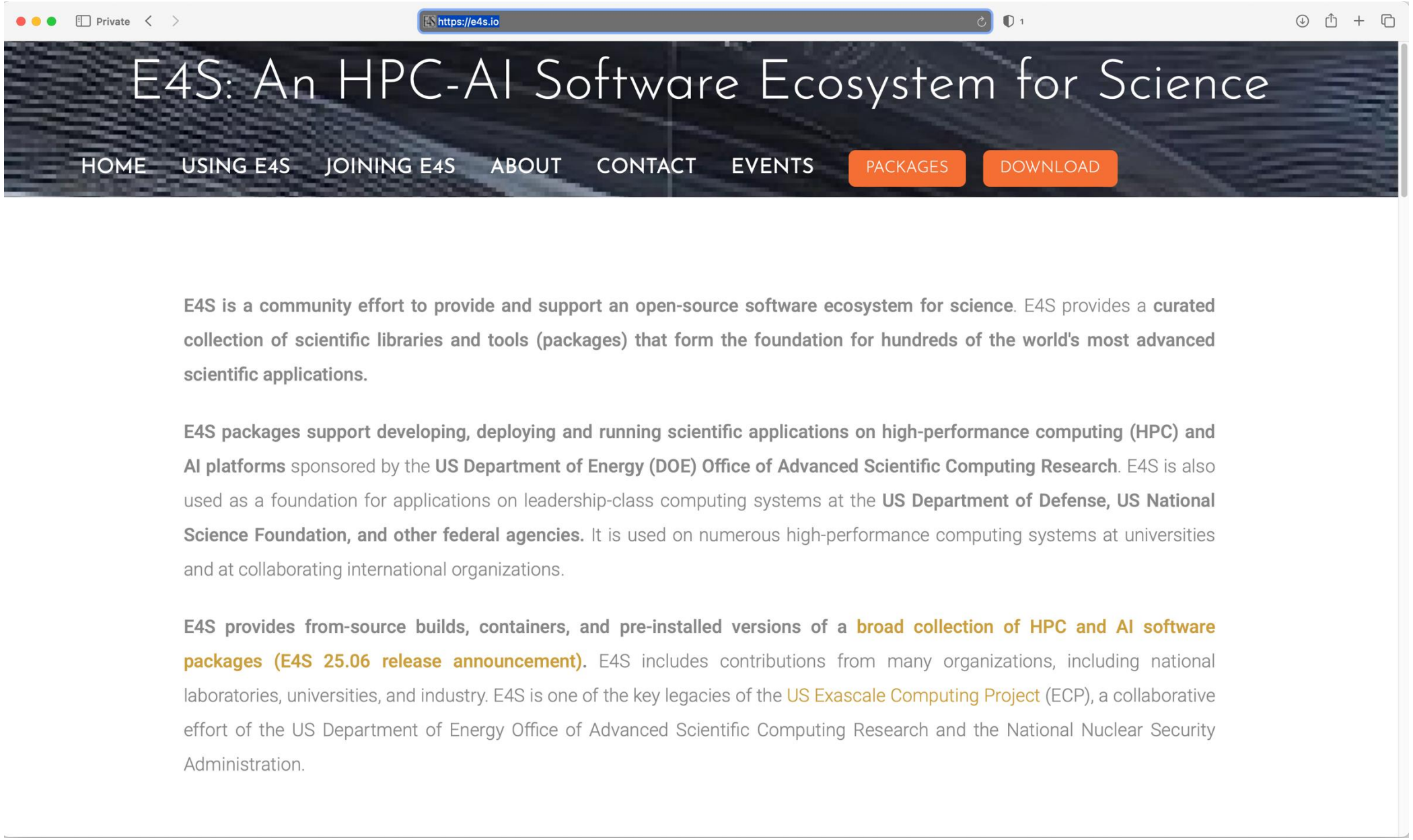
E4S: Extreme-scale Scientific Software Stack

https://e4s.io

About E4S

- E4S, an HPSF project, is an HPC-AI software **ecosystem for science** and a community effort to provide open-source software packages for developing, deploying and running scientific applications on HPC platforms.
- E4S has built a comprehensive, coherent software stack that enables application developers to productively develop highly parallel applications that effectively target diverse exascale architectures.
- E4S provides a curated, Spack based software distribution of 100+ HPC (OpenFOAM, Gromacs, Nek5000, LAMMPS), EDA (e.g., Xyce), and AI/ML packages (e.g., NVIDIA NeMo™, NVIDIA BioNeMo™, Vllm, HuggingFace CLI, TensorFlow, PyTorch, OpenCV, TorchBraid, Scikit-Learn, Pandas, JAX, LBANN with support for GPUs where available).
- Base images and full featured containers (with GPU support).
- Commercial support for E4S through ParaTools, Inc. for installation, maintaining an issue tracker, and application engagement.
- E4S for commercial clouds: Adaptive Computing's Heidi AI with ParaTools Pro for E4S™ image for **AWS, GCP, Azure, OCI.**
- With E4S Spack binary build caches, E4S supports both bare-metal and containerized deployment for GPU based platforms.
  - x86_64, ppc64le (IBM Power 10), aarch64 (ARM64) with support for CPUs and GPUs from NVIDIA, AMD, and Intel
  - Container images on DockerHub and E4S website of pre-built binaries of ECP ST products.
- e4s-chain-spack.sh to chain two Spack instances allows us to install new packages in home directory and use other tools.
- e4s-cl container launch tool allows binary distribution of applications by swapping MPI in the containerized app w/ system MPI.
- e4s-alc is an à la carte tool to customize container images by adding system and Spack packages to an existing image.
- E4S 25.06 released on June 6, 2025: https://e4s.io/talks/E4S_25.06.pdf

E4S Download from https://e4s.io



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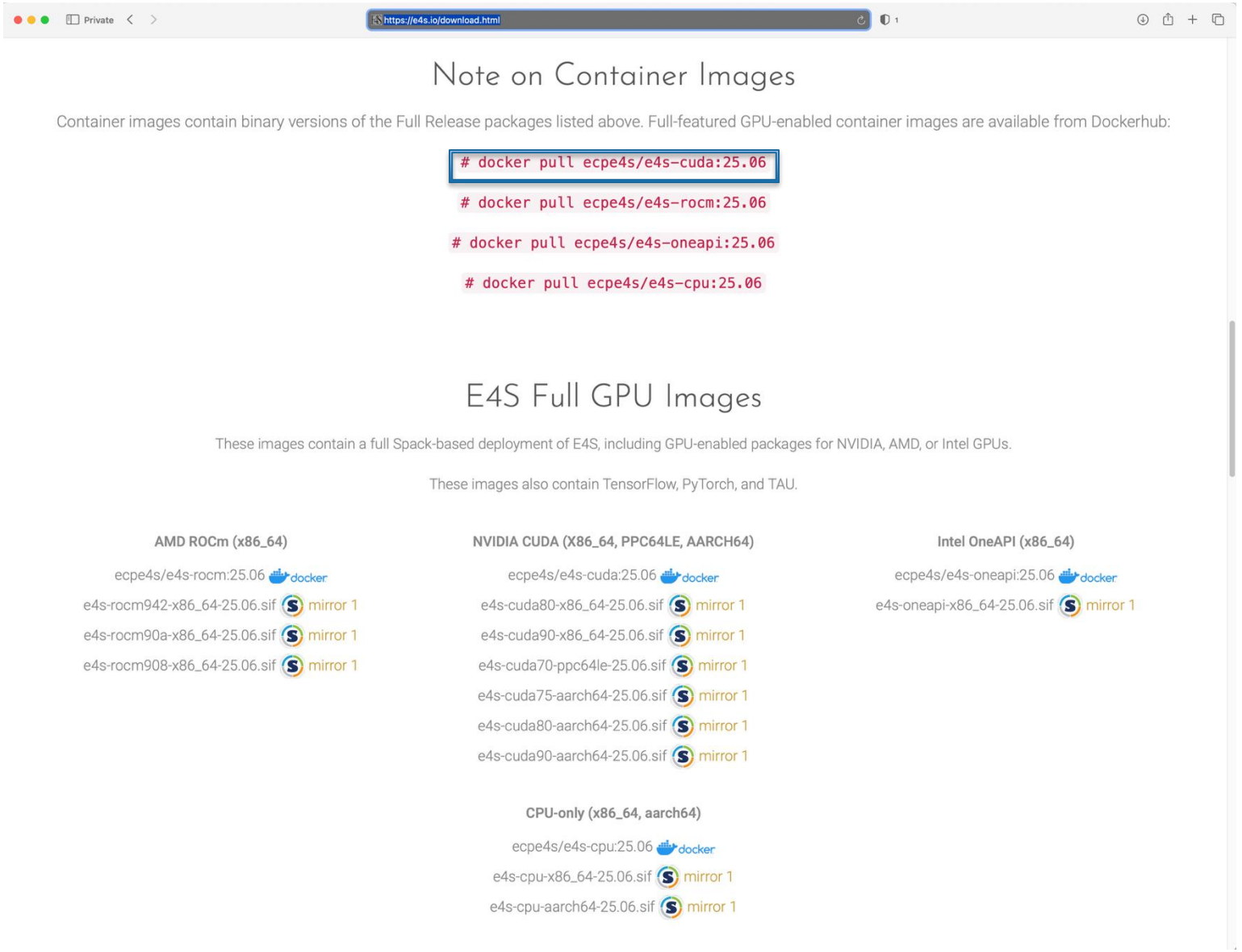
E4S Container Download from https://e4s.io

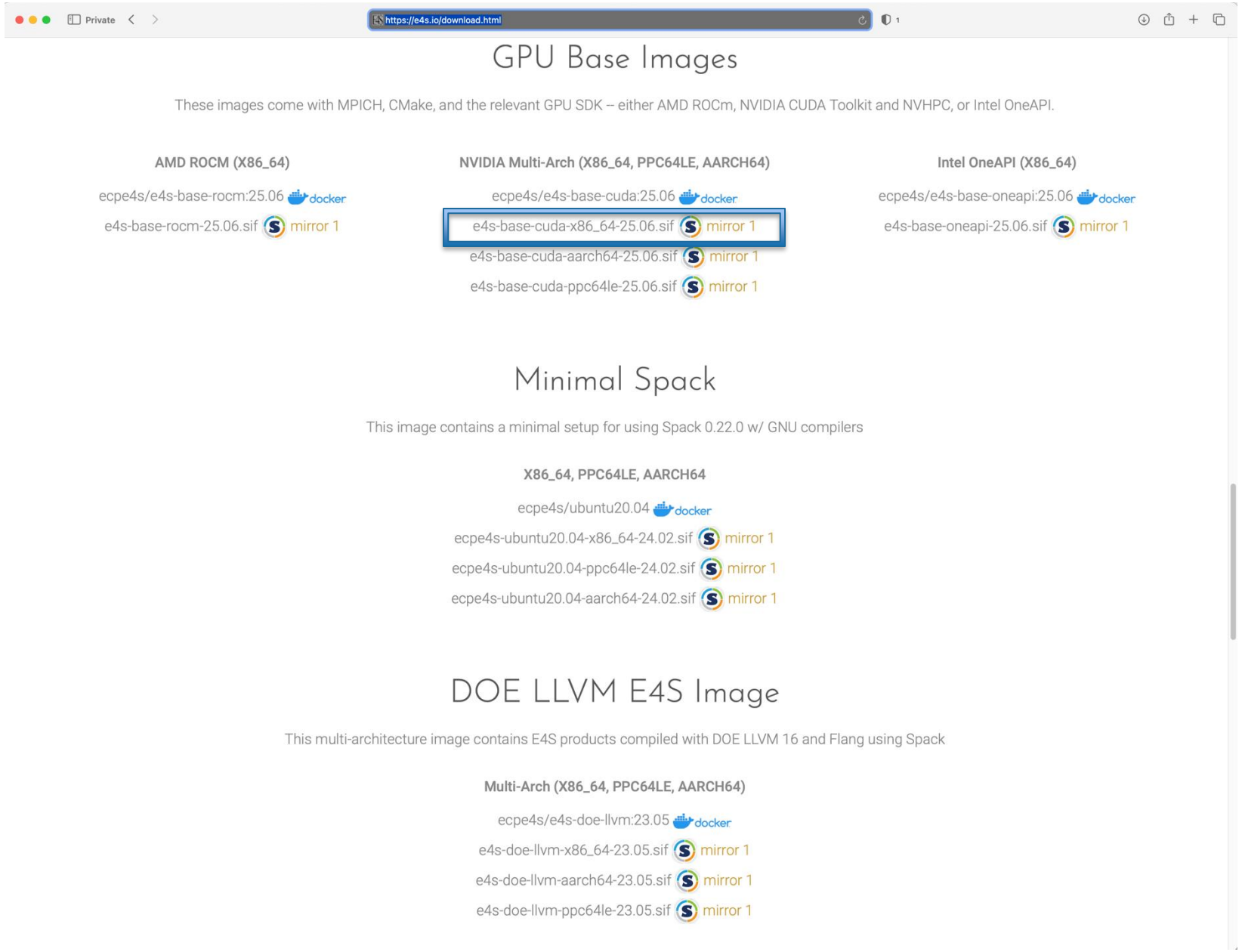
- Separate full featured Singularity images for 3 GPU architectures
- GPU full featured images for
  - x86_64 (Intel, AMD, NVIDIA)
  - ppc64le (NVIDIA)
  - aarch64 (NVIDIA)
- Full featured images available on Dockerhub
- 130+ products on 3 architectures

Download E4S 25.06 GPU Container Images: AMD, Intel, and NVIDIA



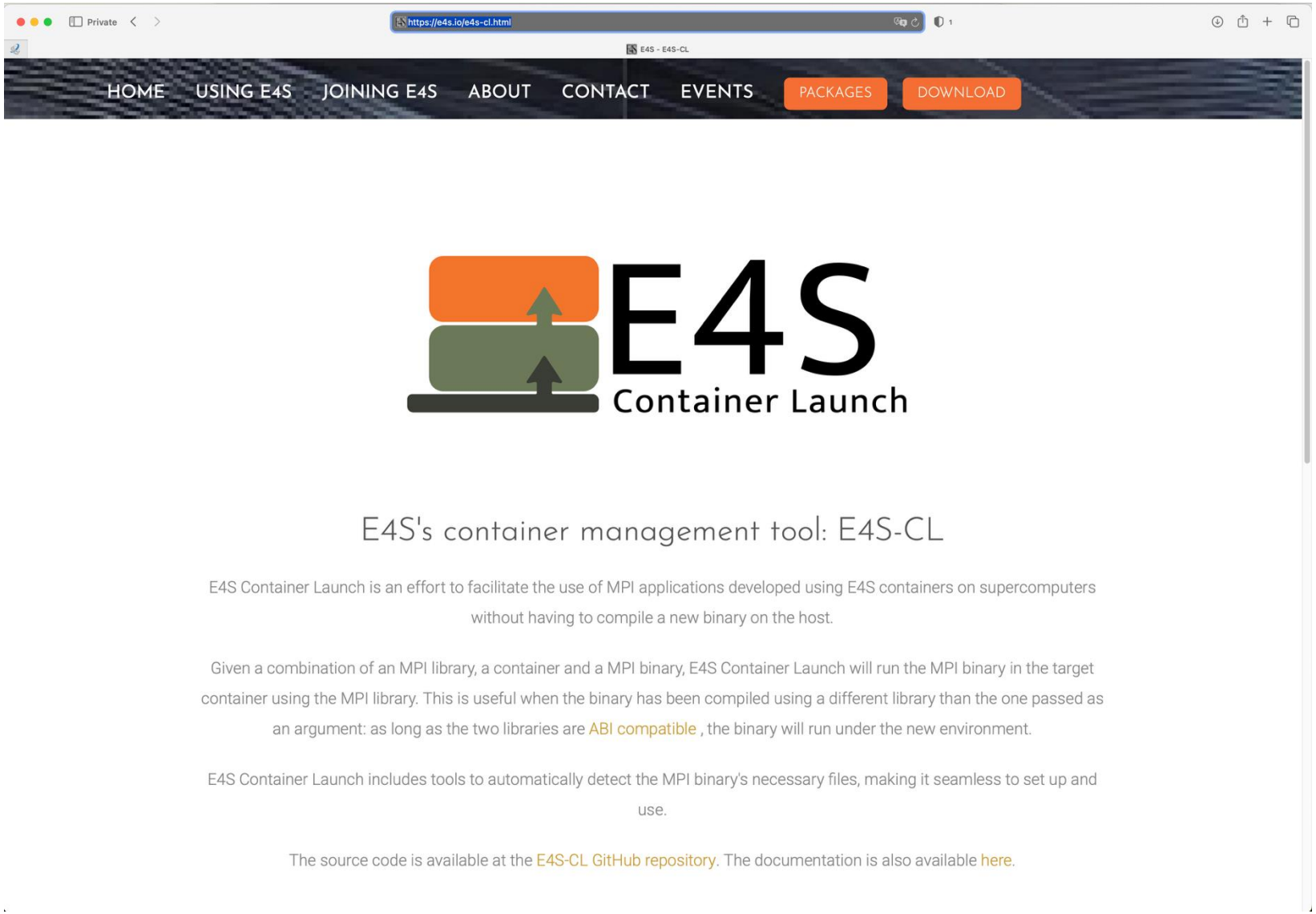
https://e4s.io

E4S base container images allow users to customize their containers



- Intel oneAPI
- AMD ROCm
- NVIDIA CUDA

E4S Tools: e4s-cl: Container Launch tool for MPI applications



- Distribute your MPI application as a binary with an E4S image
- While deploying on a system substitute the embedded containerized MPI in application with the system/vendor MPI
- Use inter-node network interfaces efficiently for near native performance!

https://e4s.io/e4s-cl.html

e4s-cl: A tool to simplify the launch of MPI jobs in E4S containers

- E4S containers support replacement of MPI libraries using MPICH ABI compatibility layer and Wi4MPI [CEA] for OpenMPI replacement.
- Applications binaries built using E4S can be launched with Singularity using MPI library substitution for efficient inter-node communications.
- e4s-cl is a new tool that simplifies the launch and MPI replacement.
  - e4s-cl init --backend [singularity|shifter|docker] --image <file> --source <startup_cmds.sh>
  - e4s-cl mpirun -np <N> <command>
- Usage:

```
% e4s-cl init --backend singularity --image ~/images/e4s-gpu-x86.sif --source ~/source.sh
% cat ~/source.sh
   . /spack/share/spack/setup-env.sh
   spack load trilinos+cuda cuda_arch=90
% e4s-cl mpirun -np 4 ./a.out
```

https://github.com/E4S-Project/e4s-cl

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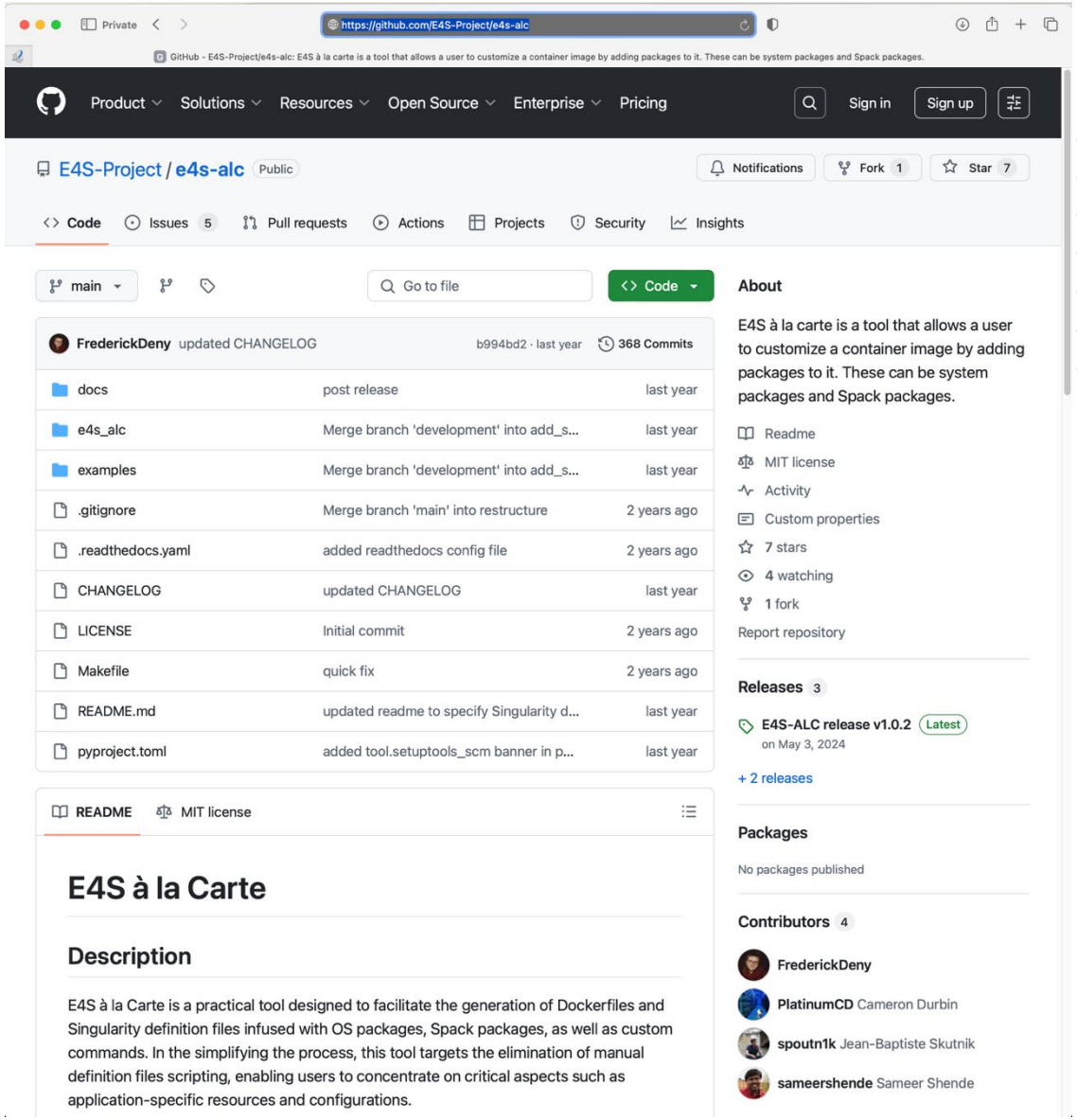
E4S Tools: E4S à la carte or e4s-alc: Customize container images



- Add new system packages
- Add new Spack packages
- Add new tarballs
- Customize the container image
- Start with a base image
- Add packages
- Create a new container image!

https://github.com/E4s-Project/e4s-alc

Spack

- E4S uses the Spack package manager for software delivery
- Spack provides the ability to specify versions of software packages that are and are not interoperable.
- Spack is a build layer for not only E4S software, but also a large collection of software tools and libraries outside of ECP ST.
- Spack supports achieving and maintaining interoperability between ST software packages.
- https://spack.io

Spack is a flexible package manager for HPC

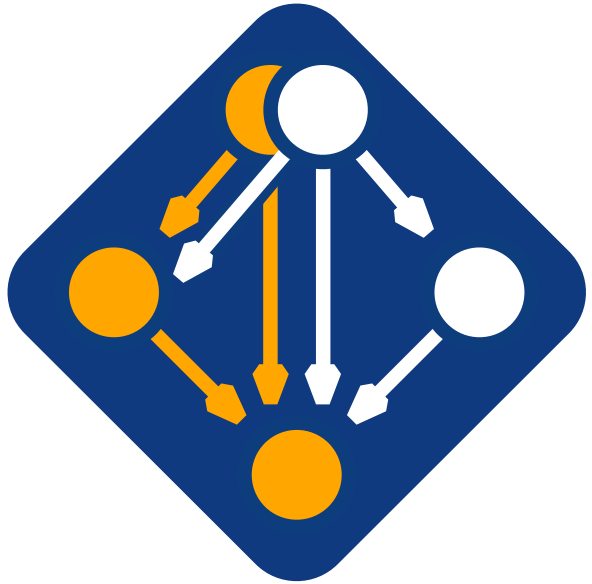
- How to install Spack (works out of the box):

```
$ git clone https://github.com/spack/spack
$ . spack/share/spack/setup-env.sh
```

- How to install a package:

```
$ spack install tau
```

- TAU and its dependencies are installed within the Spack directory.
- Unlike typical package managers, Spack can also install many variants of the same build.
  - Different compilers
  - Different MPI implementations
  - Different build options



Visit spack.io

github.com/spack/spack

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Spack provides the *spec* syntax to describe custom configurations

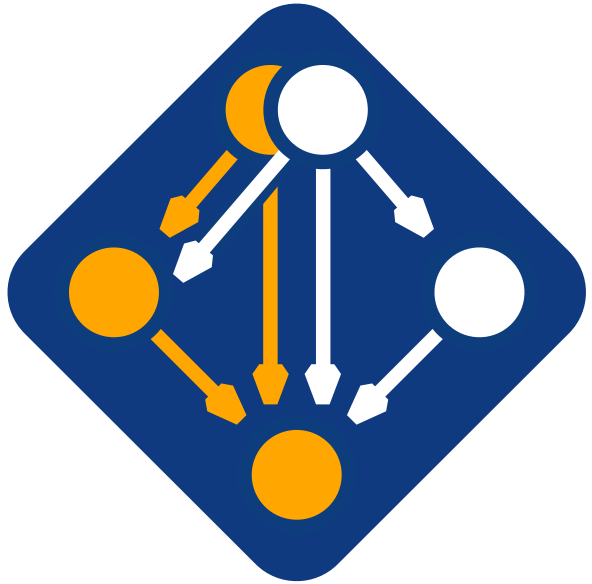
```
$ git clone https://github.com/spack/spack
$ . spack/share/spack/setup-env.sh
$ spack compiler find                    # set up compilers
$ spack external find                    # set up external packages
```

```
$ spack install tau                                          unconstrained
$ spack install tau@2.34.1                                   @ custom version
$ spack install tau@2.34.1 %gcc@12.4.0                       % custom compiler
$ spack install tau@2.34.1 %gcc@12.4.0 +rocm                 +/- build option
$ spack install tau@2.34.1 %gcc@12.4.0 +mpi ^mvapich2@4.0    ^ dependency information
```

- Each expression is a ***spec*** for a particular configuration
  - Each clause adds a constraint to the spec
  - Constraints are optional – specify only what you need.
  - Customize install on the command line!
- Spec syntax is recursive
  - Full control over the combinatorial build space

The Spack community is growing rapidly

- **Spack simplifies HPC software for:**
  - Users
  - Developers
  - Cluster installations
  - The largest HPC facilities
- **Spack is central to HPSF's software strategy**
  - Enable software reuse for developers and users
  - Allow the facilities to consume the entire E4S
- **The roadmap is packed with new features:**
  - Building the software distribution
  - Better workflows for building containers
  - Stacks for facilities
  - Chains for rapid dev workflow
  - Optimized binaries
  - Better dependency resolution



Visit spack.io
hpsf.io

github.com/spack/spack

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E4S Tools: e4s-chain-spack.sh to customize software stack

```
sameer@mothra:~$ ls ~/images
e4s-cuda80-x86_64-25.06.sif
sameer@mothra:~$ singularity run --nv ~/images/e4s-cuda80-x86_64-25.06.sif
Singularity> /etc/e4s/e4s-chain-spack.sh ~/spack
Cloning into '/home/sameer/spack'...
remote: Enumerating objects: 686113, done.
remote: Counting objects: 100% (976/976), done.
remote: Compressing objects: 100% (463/463), done.
remote: Total 686113 (delta 772), reused 518 (delta 510), pack-reused 685137 (from 3)
Receiving objects: 100% (686113/686113), 230.82 MiB | 37.06 MiB/s, done.
Resolving deltas: 100% (326280/326280), done.

------
Configuration SUCCESS!

Downstream: /home/sameer/spack
Upstream: /spack

To use the downstream Spack instance, run the following command in your shell:
. /home/sameer/spack/share/spack/setup-env.sh
------

Singularity> . /home/sameer/spack/share/spack/setup-env.sh
Singularity> spack find valgrind
==> Error: No package matches the query: valgrind
Singularity> spack install valgrind
[+] /usr/local/mpich/install/mpich (external mpich-4.2.3-47excoypwhfmhx57rfs6reouvninugcf)
[+] /usr (external glibc-2.35-a7drdl4tlx4bu3mzhor75pskvd3pdot6)
[+] /spack/opt/spack/linux-ubuntu22.04-x86_64_v3/gcc-11.4.0/gcc-runtime-11.4.0-f63c77kavzjtpmnhucd2oyfaxagwjzla
[+] /spack/opt/spack/linux-ubuntu22.04-x86_64_v3/gcc-11.4.0/boost-1.86.0-6qkv24gbidwxhllgah6jrkym5ev2cng5
[+] /spack/opt/spack/linux-ubuntu22.04-x86_64_v3/gcc-11.4.0/gmake-4.4.1-qp5blvcyuzgzhqsrp2ew6gq2nlos34b2
==> Installing valgrind-3.23.0-feuxx36lsqp7quzmhmo4opbiadwpsars [6/6]
==> No binary for valgrind-3.23.0-feuxx36lsqp7quzmhmo4opbiadwpsars found: installing from source
==> Fetching https://mirror.spack.io/_source-cache/archive/c5/c5c34a3380457b9b75606df890102e7df2c702b9420c2ebef9540f8b5d56264d.tar.bz2
==> Ran patch() for valgrind
==> valgrind: Executing phase: 'autoreconf'
==> valgrind: Executing phase: 'configure'
==> valgrind: Executing phase: 'build'
==> valgrind: Executing phase: 'install'
==> valgrind: Successfully installed valgrind-3.23.0-feuxx36lsqp7quzmhmo4opbiadwpsars
  Stage: 3.78s.  Autoreconf: 0.01s.  Configure: 48.56s.  Build: 37.71s.  Install: 2.97s.  Post-install: 0.60s.  Total: 1m 33.97s
[+] /home/sameer/spack/opt/spack/linux-ubuntu22.04-x86_64_v3/gcc-11.4.0/valgrind-3.23.0-feuxx36lsqp7quzmhmo4opbiadwpsars
Singularity> spack load valgrind
Singularity> which valgrind
/home/sameer/spack/opt/spack/linux-ubuntu22.04-x86_64_v3/gcc-11.4.0/valgrind-3.23.0-feuxx36lsqp7quzmhmo4opbiadwpsars/bin/valgrind
```

Specify location of downstream Spack installation directory

Source downstream Spack's setup-env.sh

Install a new Spack package in downstream Spack directory

Load new package (valgrind) using spack load

E4S Tools: e4s-chain-spack.sh to customize software stack

```
Singularity> which valgrind
/home/sameer/spack/opt/spack/linux-ubuntu22.04-x86_64_v3/gcc-11.4.0/valgrind-3.23.0-feuxx36lsqp7quzmhmo4opbiadwpsars/bin/valgrind
Singularity> valgrind --help
usage: valgrind [options] prog-and-args

  tool-selection option, with default in [ ]:
    --tool=<name>             use the Valgrind tool named <name> [memcheck]
                              available tools are:
                              memcheck cachegrind callgrind helgrind drd
                              massif dhat lackey none exp-bbv

  basic user options for all Valgrind tools, with defaults in [ ]:
    -h --help                 show this message
    --help-debug              show this message, plus debugging options
    --help-dyn-options        show the dynamically changeable options
    --version                 show version
    -q --quiet                run silently; only print error msgs
    -v --verbose              be more verbose -- show misc extra info
    --trace-children=no|yes   Valgrind-ise child processes (follow execve)? [no]
    --trace-children-skip=patt1,patt2,...    specifies a list of executables
                              that --trace-children=yes should not trace into
    --trace-children-skip-by-arg=patt1,patt2,...   same as --trace-children-skip=
                              but check the argv[] entries for children, rather
                              than the exe name, to make a follow/no-follow decision
    --child-silent-after-fork=no|yes omit child output between fork & exec? [no]
    --vgdb=no|yes|full        activate gdbserver? [yes]
                              full is slower but provides precise watchpoint/step
    --vgdb-error=<number>     invoke gdbserver after <number> errors [999999999]
                              to get started quickly, use --vgdb-error=0
                              and follow the on-screen directions
    --vgdb-stop-at=event1,event2,... invoke gdbserver for given events [none]
         where event is one of:
           startup exit abexit valgrindabexit all none
    --track-fds=no|yes|all    track open file descriptors? [no]
                              all includes reporting stdin, stdout and stderr
    --time-stamp=no|yes       add timestamps to log messages? [no]
    --log-fd=<number>         log messages to file descriptor [2=stderr]
    --log-file=<file>         log messages to <file>
    --log-socket=ipaddr:port  log messages to socket ipaddr:port
    --enable-debuginfod=no|yes query debuginfod servers for missing
                              debuginfo [yes]

  user options for Valgrind tools that report errors:
    --xml=yes                 emit error output in XML (some tools only)
    --xml-fd=<number>         XML output to file descriptor
    --xml-file=<file>         XML output to <file>
    --xml-socket=ipaddr:port  XML output to socket ipaddr:port
    --xml-user-comment=STR    copy STR verbatim into XML output
    --demangle=no|yes         automatically demangle C++ names? [yes]
    --num-callers=<number>    show <number> callers in stack traces [12]
    --error-limit=no|yes      stop showing new errors if too many? [yes]
    --exit-on-first-error=no|yes exit code on the first error found? [no]
    --error-exitcode=<number> exit code to return if errors found [0=disable]
    --error-markers=<begin>,<end> add lines with begin/end markers before/after
                              each error output in plain text mode [none]
    --show-error-list=no|yes|all  show detected errors list and
                              suppression counts at exit [no].
                              all means to also print suppressed errors.
    -s                        same as --show-error-list=yes
```

Downstream Spack's package is loaded in your environment

e4s-chain-spack.sh helps customize the software stack using upstream /spack (read-only in the container) for package dependencies while installing a new package in the downstream Spack in your writable home directory.

E4S 25.06 image for NVIDIA H100 GPU on x86_64

```
$ singularity run --nv e4s-cuda90-x86_64-25.06.sif
Singularity> ls /opt/demo/e4s-cloud-examples/
bionemo       cuda          julia-cuda       lammps            nalu                openfoam        pytorch                  superlu-dist-cpu  vllm
clean-all.sh  fetch-all.sh  julia-mpi        machine-learning  nemo                osu-benchmarks  pytorch-gpu              tau               xyce
CoMD          horovod       jupyter-notebook  matmult           nemo-speech_to_text  petsc-cpu       pytorch-image-classifier  tensorflow
containers    jax           laghos           mpi-procname      neuronx             petsc-cuda      qe                       visit
Singularity> ls /opt/demo/e4s-cloud-examples/machine-learning/
clean.sh  gemini  openai  perplexity  pytorch  tensorflow
Singularity> ls /opt/demo/e4s-cloud-examples/vllm
gradio_openai_chatbot_webserver.py  llama2_template.jinja  README.md  run.sh  run-smaller.sh
Singularity> python
Python 3.10.12 (main, Feb  4 2025, 14:57:36) [GCC 11.4.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> import nemo
>>> import bionemo
>>> import torch
>>> import openai
>>> import google.generativeai
>>> import huggingface_hub
>>> import jax
>>> import pandas
>>> import cv2
>>> import sklearn
>>> import mpi4py
>>> import matplotlib
>>> import seaborn
>>> import plotly
>>> import vllm
```

```
>>> vllm.__version__
'0.8.3.dev0+g25f560a62.d20250520'
>>> nemo.__version__
'2.3.0rc0'
>>> tensorflow.__version__
'2.19.0'
>>> torch.__version__
'2.6.0'
>>> torch.cuda.get_arch_list()
['sm_80', 'sm_90', 'sm_120']
>>>
```

https://e4s.io

E4S 25.06 image for NVIDIA GPUs (x86_64)

```
Singularity> spack find
-- linux-ubuntu22.04-x86_64_v3 / gcc@11.4.0 ---------------------
```

abseil-cpp@20240722.0	expat@2.7.0	libceed@0.12.0	openssl@3.4.1	py-urllib3@2.1.0
adiak@0.4.1	fftw@3.3.10	libdwarf@0.11.0	otf2@3.0.3	py-wheel@0.45.1
adios2@2.10.2	fftw@3.3.10	libedit@3.1-20240808	papi@7.1.0	python@3.10.12
amrex@25.03	fftx@1.2.0	libevent@2.1.12	papi@7.1.0	python-venv@1.0
arborx@1.5	findutils@4.10.0	libfabric@1.22.0	parmetis@4.0.3	raja@2024.07.0
arpack-ng@3.9.1	flecsi@2.3.2	libffi@3.4.6	parmetis@4.0.3	raja@2024.07.0
asio@1.32.0	flex@2.6.3	libiberty@2.41	parsec@3.0.2209	re2c@3.1
autoconf@2.72	flux-core@0.67.0	libiconv@1.17	pcre2@10.44	readline@8.2
automake@1.16.5	fmt@11.1.4	libidn2@2.3.7	pdt@3.25.2	sed@4.9
axom@0.10.1	fmt@11.1.4	libint@2.9.0	perl@5.40.0	slate@2024.10.29
bc@1.07.1	gasnet@2024.5.0	libmd@1.1.0	perl@5.40.0	slepc@3.22.2
berkeley-db@18.1.40	gcc-runtime@11.4.0	libmonitor@2023.03.15	perl-data-dumper@2.173	snappy@1.2.1
binutils@2.43.1	gdbm@1.23	libpciaccess@0.17	petsc@3.22.4	spiral-package-fftx@1.3.0
bison@3.8.2	gettext@0.23.1	libpng@1.6.39	petsc@3.22.4	spiral-package-jit@1.1.0
blaspp@2024.10.26	ginkgo@1.9.0	libsigsegv@2.14	pigz@2.8	spiral-package-mpi@1.1.0
blt@0.7.0	git@2.48.1	libsodium@1.0.20	pkgconf@2.3.0	spiral-package-simt@1.1.0
blt@0.7.0	glibc@2.35	libtool@2.4.7	protobuf@3.28.2	spiral-software@8.5.1
boost@1.86.0	gmake@4.4.1	libunistring@1.2	protobuf@3.29.3	sqlite@3.46.0
boost@1.86.0	gmp@6.3.0	libunwind@1.8.1	py-calver@2022.6.26	strumpack@8.0.0
boost@1.86.0	gperftools@2.15	libxc@7.0.0	py-certifi@2023.7.22	sundials@7.2.1
boost@1.86.0	gromacs@2024.4	libxcrypt@4.4.38	py-cffi@1.17.1	superlu-dist@9.1.0
boost@1.86.0	hdf5@1.8.23	libxml2@2.13.5	py-charset-normalizer@3.3.0	superlu-dist@9.1.0
bricks@2023.08.25	hdf5@1.14.5	libyaml@0.1.7	py-cython@3.0.11	sz@2.1.12.5
butterflypack@3.2.0	hdf5@1.14.5	libyaml@0.2.5	py-editables@0.5	tar@1.35
bzip2@1.0.8	heffte@2.4.1	libzmq@4.3.5	py-flit-core@3.10.1	tasmanian@8.1
c-blosc2@2.15.1	hpctoolkit@2024.01.1	lizard@2.0	py-fypp@3.1	tau@2.34.1
ca-certificates-mozilla@2025-02-25	hpcviewer@2025.01	llvm@19.1.7	py-hatchling@1.25.0	texinfo@7.1
cabana@0.7.0	hpx@1.10.0	lua@5.3.6	py-idna@3.4	trilinos@16.1.0
caliper@2.12.1	hwloc@2.11.1	lua@5.4.6	py-meson-python@0.16.0	umpire@2024.07.0
camp@2024.07.0	hwloc@2.11.1	lua-luaposix@36.1	py-numpy@2.2.4	umpire@2024.07.0
camp@2024.07.0	hypre@2.32.0	lz4@1.10.0	py-packaging@24.2	umpire@2024.07.0
chai@2024.07.0	hypre@2.32.0	lzo@2.10	py-pathspec@0.11.1	unzip@6.0
chapel@2.4.0	icu4c@74.2	m4@1.4.19	py-pip@24.3.1	upcxx@2023.9.0

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E4S 25.06 image for NVIDIA GPUs (x86_64)

```
Singularity> spack find +cuda
-- linux-ubuntu22.04-x86_64_v3 / gcc@11.4.0 ----------------------
adios2@2.10.2       camp@2024.07.0     gromacs@2024.4        kokkos@4.6.01          nvcomp@2.2.0       strumpack@8.0.0     upcxx@2023.9.0
amrex@25.03         chai@2024.07.0     heffte@2.4.1          kokkos-kernels@4.6.01  papi@7.1.0         sundials@7.2.1      vtk-m@2.2.0
arborx@1.5          chapel@2.4.0       hpctoolkit@2024.01.1  lammps@20240829.1      parsec@3.0.2209    superlu-dist@9.1.0  zfp@1.0.0
axom@0.10.1         cp2k@2025.1        hpx@1.10.0            lapackpp@2024.10.26    petsc@3.22.4       tasmanian@8.1
blaspp@2024.10.26   cusz@0.14.0        hwloc@2.11.1          legion@24.12.0         petsc@3.22.4       tau@2.34.1
bricks@2023.08.25   fftx@1.2.0         hypre@2.32.0          libceed@0.12.0         raja@2024.07.0     trilinos@16.1.0
cabana@0.7.0        flecsi@2.3.2       kokkos@4.5.01         magma@2.9.0            raja@2024.07.0     umpire@2024.07.0
caliper@2.12.1      flux-core@0.67.0   kokkos@4.6.01         mfem@4.7.0             slate@2024.10.29   umpire@2024.07.0
camp@2024.07.0      ginkgo@1.9.0       kokkos@4.6.01         mgard@2023-12-09       slepc@3.22.2       umpire@2024.07.0
==> 57 installed packages
Singularity> nvcc --version
nvcc: NVIDIA (R) Cuda compiler driver
Copyright (c) 2005-2025 NVIDIA Corporation
Built on Fri_Feb_21_20:23:50_PST_2025
Cuda compilation tools, release 12.8, V12.8.93
Build cuda_12.8.r12.8/compiler.35583870_0
Singularity> which huggingface-cli
/usr/local/bin/huggingface-cli
Singularity> which firefox
/usr/bin/firefox
Singularity> which codium
/usr/bin/codium
Singularity> which jupyter
/usr/local/bin/jupyter
Singularity> nvidia-smi
Sat Jun  7 22:02:16 2025
+-----------------------------------------------------------------------------------------+
| NVIDIA-SMI 570.124.06             Driver Version: 570.124.06     CUDA Version: 12.8     |
|-----------------------------------------+------------------------+----------------------+
| GPU  Name                 Persistence-M | Bus-Id          Disp.A | Volatile Uncorr. ECC |
| Fan  Temp   Perf          Pwr:Usage/Cap |           Memory-Usage | GPU-Util  Compute M. |
|                                         |                        |               MIG M. |
|=========================================+========================+======================|
|   0  NVIDIA H100 PCIe               On  |   00000000:E1:00.0 Off |                    0 |
```

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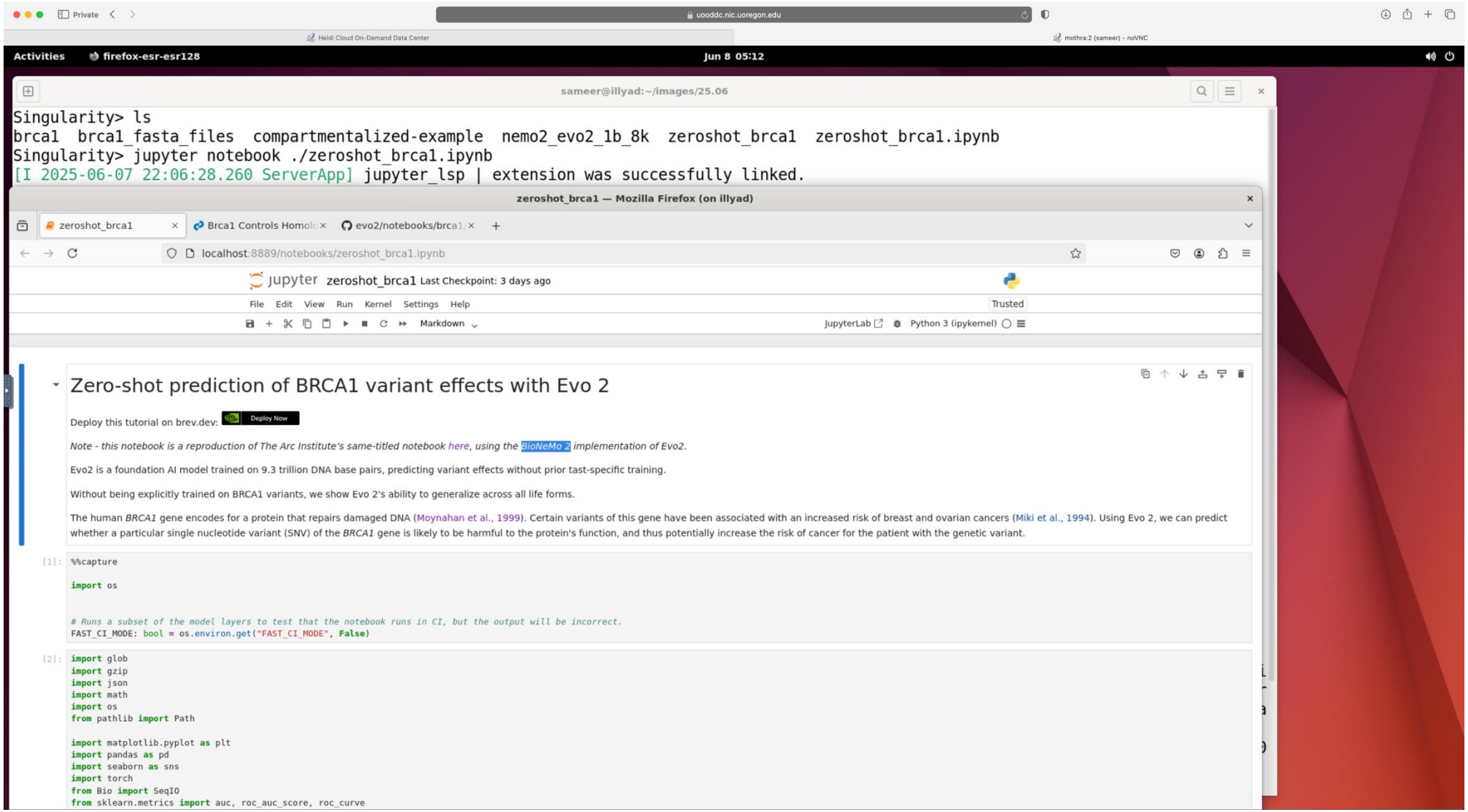
NVIDIA® BioNeMo™ Framework on E4S 25.06 CUDA x86_64



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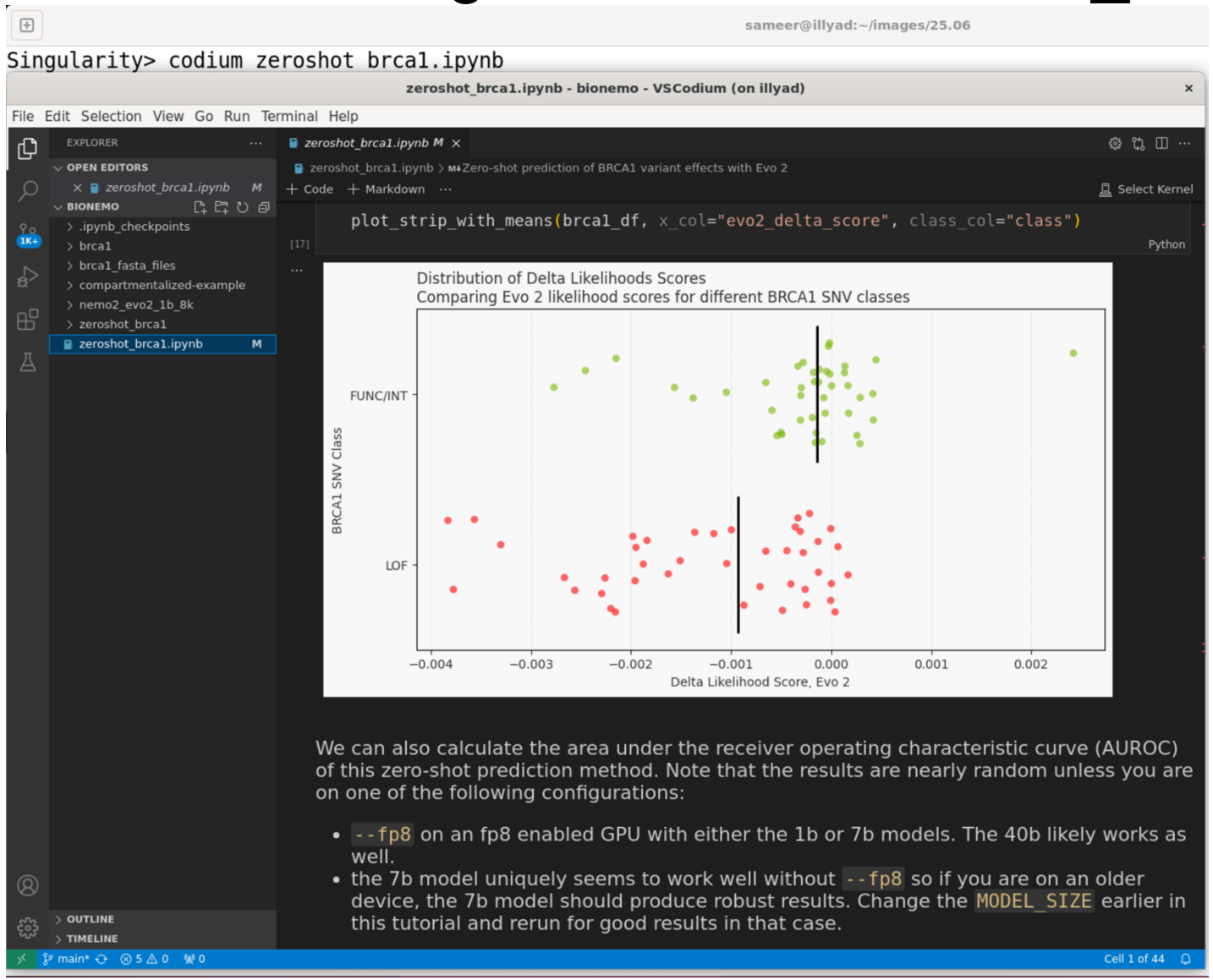
E4S 25.06 image for CUDA and x86_64 with VSCodium IDE



- NVIDIA H100 (cuda90) GPU on x86_64
- Jupyter Notebook in VSCodium IDE
- Running NVIDIA® BioNeMo™ Framework for biopharma workflows

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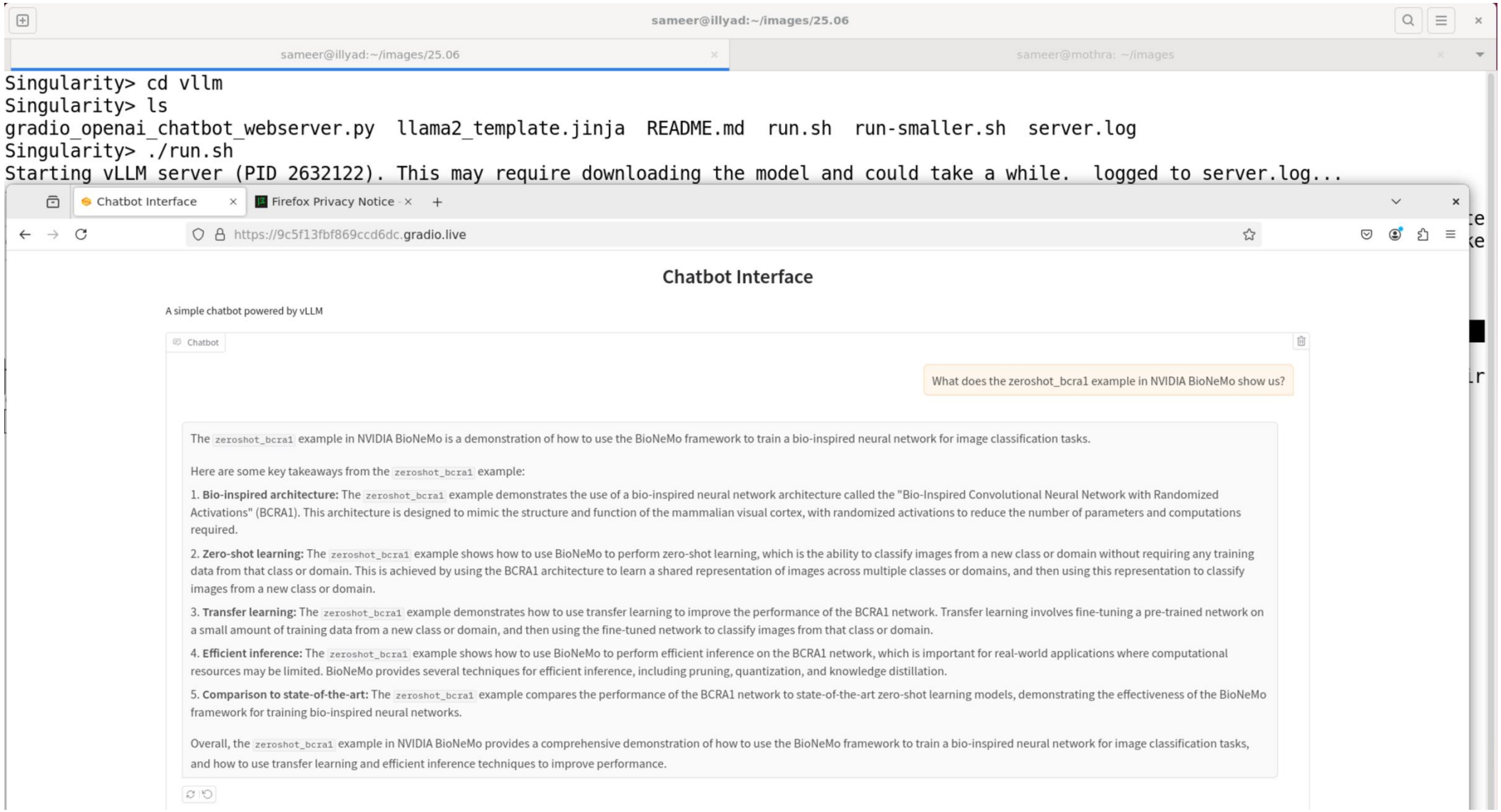
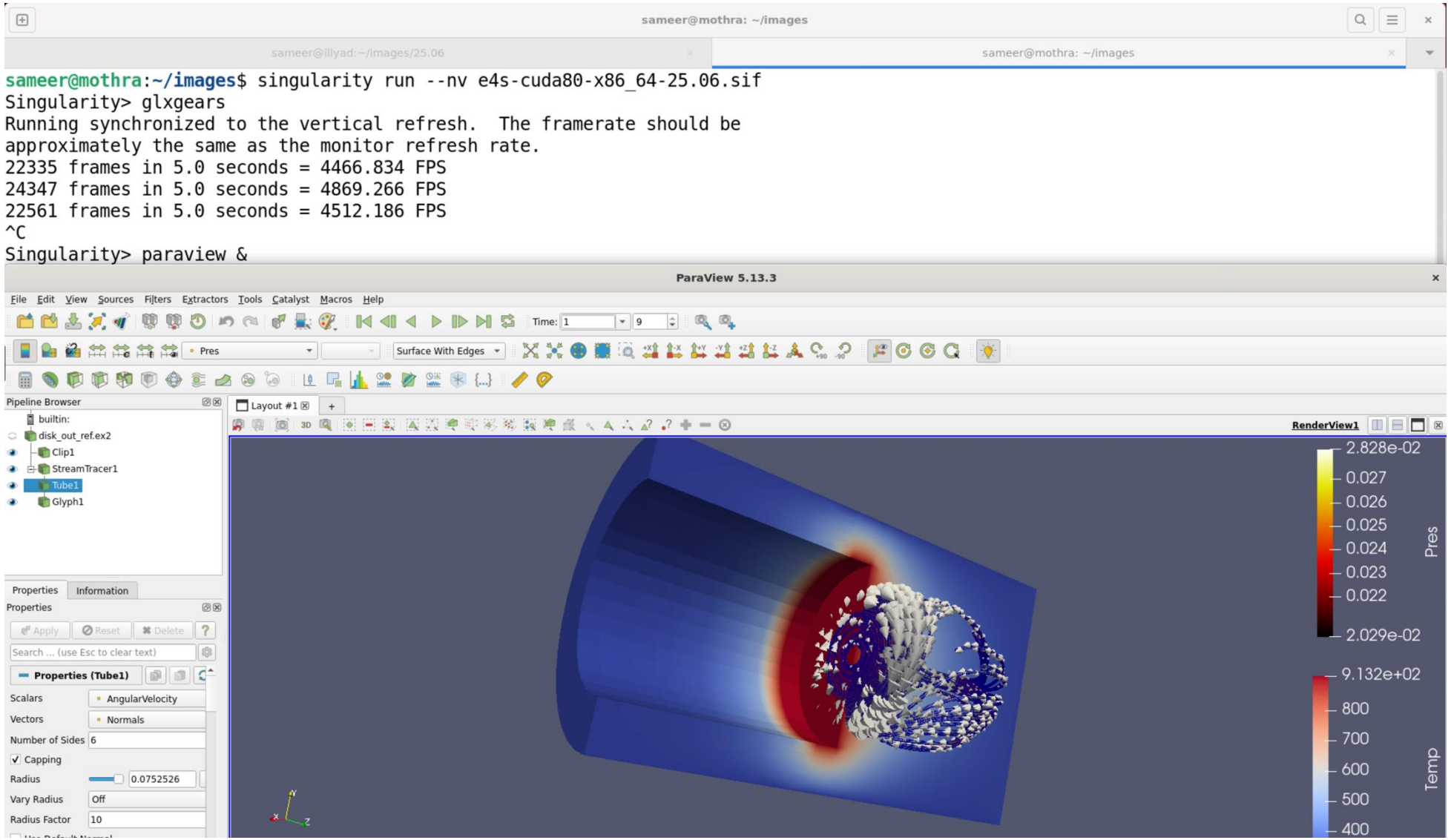
Creating a Chatbot using Vllm using E4S 25.06 image for x86_64



- NVIDIA H100 (cuda90) GPU on x86_64
- Vllm chatbot running after huggingface-cli login
- Using local H100 GPU

GPU accelerated 3D graphics using E4S 25.06 image for x86_64



- Rendering on an NVIDIA A100 (cuda80) GPU on x86_64
- ParaView
- Using Adaptive Computing's Heidi/ODDC remote desktop

https://e4s.io

Frank@UO:
A hardware platform for CI for performance tools

https://oaciss.uoregon.edu/frank

@

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Why is Continuous Integration (CI) infrastructure critical?

- Faster development and delivery
  - Integrate code changes frequently
  - Receive immediate feedback on their work
  - Deploy code to production faster
- Improved Code Quality
  - Automated testing
  - Consistent builds
  - Early bug detection
- Continuous improvement
- Risk reduction

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What hardware do our performance tools projects need for CI testing?

- GPUs from multiple vendors: NVIDIA, AMD, Intel
  - Different GPU architectures:
    - NVIDIA GH200, H100, A100, V100,…
    - AMD MI300A, MI210, MI100, MI50, …
    - Intel Data Center Max GPU 1100 series (PVC), DG1, A770, B580,…
- Operating Systems and Programming Environments
  - HPE Cray Programming Environment
  - RHEL, Debian, Ubuntu, SLES, …
  - GNU, AMD, NIVIDIA, Intel, LLVM compilers with MVAPICH, Cray-mpich, Intel MPI, …
- Network interconnects
  - NDR, HDR, EDR Infiniband
  - 100Gbps Ethernet
  - Two identical nodes for multi-node testing

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Frank@UO

Private https://oaciss.uoregon.edu/frank

Log in

Category Discussion Read View source View history Search OACISS Systems Wiki

Category:Servers

Help

This is a list of all OACISS servers in the Frank cluster at UO. You may also select a section header to view the Wiki-generated category index for systems of that type.

Some relevant pages:

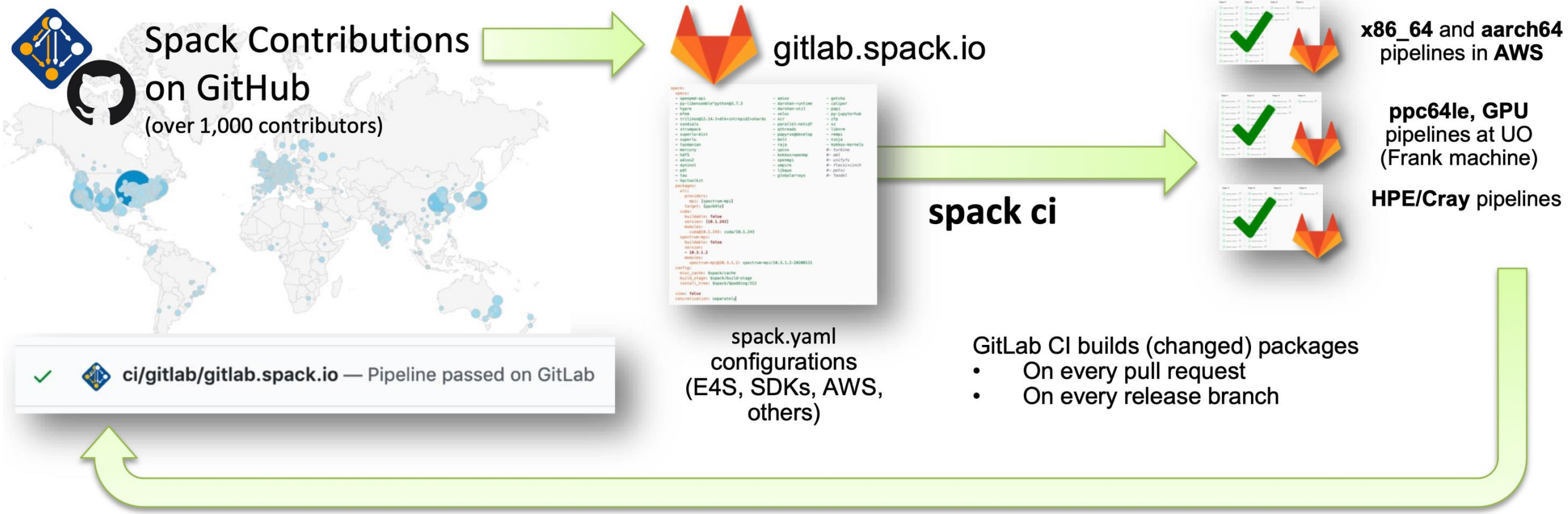
- Introduction and about <- click me
- The NetworkInfrastructure page describes the host naming (dns) conventions, as well as documenting the physical setup and connections within the OACISS racks in the machine room. All OACISS systems automatically search .nic.uoregon.edu for DNS, so only the short hostname is needed for ssh internally.
- The Service:storage describes available storage for users of OACISS systems. OACISS currently has a total of just under 350TB of online storage available.
- The new HowtoMPI page describes various tested-working MPI setups and the steps

Click on the server links to access more information about individual machines. Note that only the three machines designated as login gateways (orthus, sphinx, cerberus) are accessible by machines outside of nic.uoregon.edu.

IMPORTANT: Cerberus is in the process of being decommissioned and replaced with a new and much more capable system, Sphinx. Sphinx is the new secondary login node.

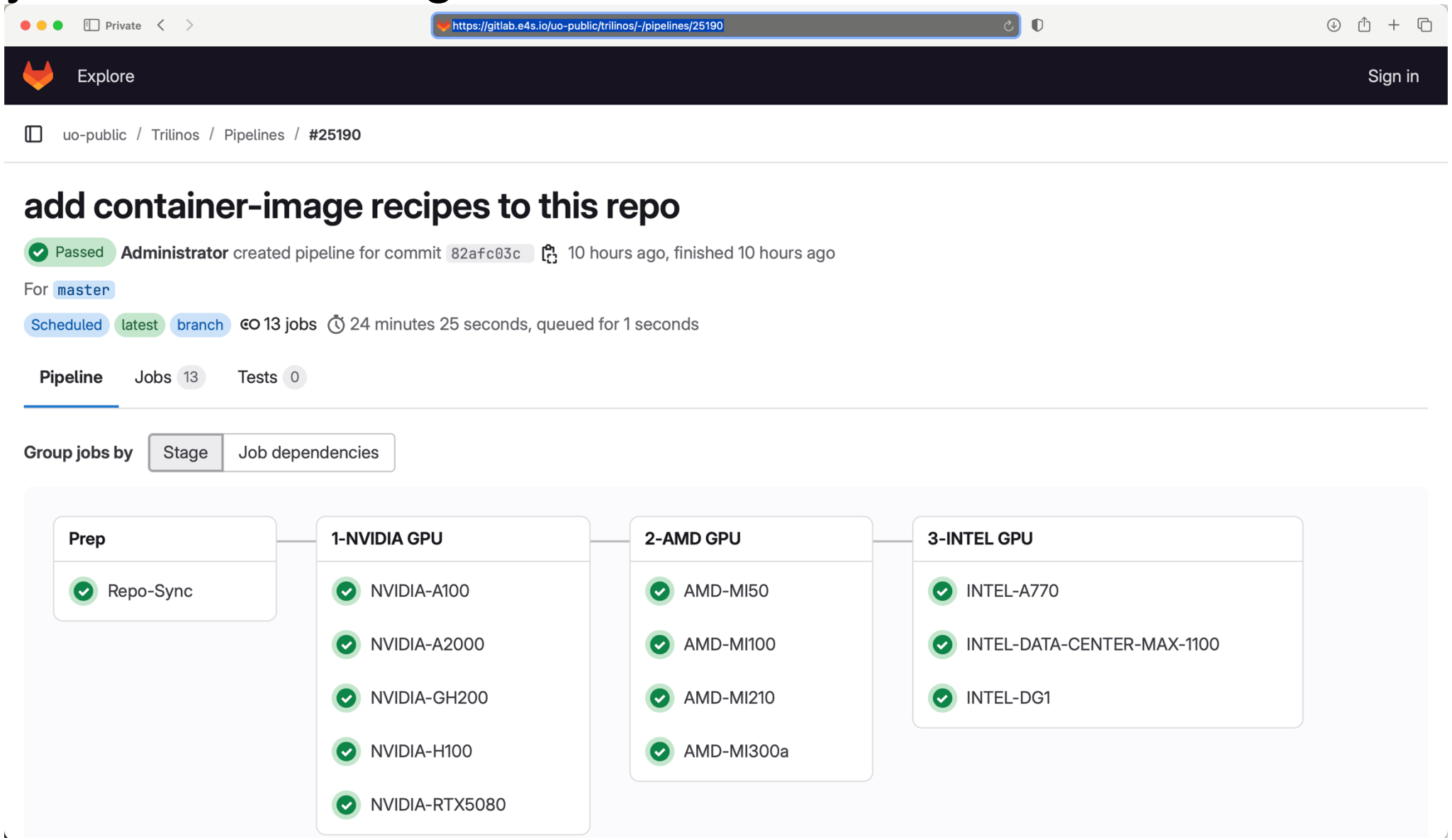
Nodes in Computing Center datacenter						
Name	**Description**	**OS**	**Model**	**Processors**	**Local Network**	**Physical location**
Compute: Orthus	**Primary login gateway**	RHEL-8.8	VM	6 x Cascade Lake	10GbE	
Compute: Odyssey	AMD quad MI300A system	RHEL 8.10	SM AS-4145-GT	4 x MI300a, 24cpu	10GbE	R81.U27
Compute: Pinwheel	2xMI210 Debian 12 system	Debian 12	SM AS-2024US-TRT	2 x Epyc Milan 7413	10GbE	R81.U32
Compute: Headroom	Intel Data Center Max 1100 (Ponte Vecchio)	Ubuntu 22	Supermicro	2 x Xeon 4410T @ 3GHz	10GbE	R82.U8
Compute: Hopper1/2	NVIDIA Grace-Hopper GH200	RHELf 9.3	Quanta S74G-2U	Grace (72c)+GH200 Hopper GPU @ 3.4GHz	10GbE + Connect X-7 200 Gbps (pt2pt w/hopper1/2.eth)	R81.U33-36
Compute: Grace1/2	NVIDIA Grace-Grace	Ubuntu 22.04 LTS	Supermicro ARS-221GL-NR01 (x2)	Grace-Grace (144c) Superchip @ 3.4GHz	10GbE + EDR 100 Gbps (pt2pt w/grace1/2)	R81.U4-8
Compute: Roberta	HPE CPE Epyc Genoa	RHEL 8.10	DL385 gen 11	2 x Epyc 9654 Genoa 96c @ 2.4GHz	10GbE + NDR 400 Gbps (pt2pt w/gary)	R82.U6
Compute: Gary	HPE CPE Epyc Genoa	RHEL 8.10	DL345 gen 11	Epyc 9124 Genoa 16c @ 3GHz	10GbE + NDR 400 Gbps (pt2pt w/roberta))	R82.U4
Compute: Picard	Atipa Sapphire Rapids + 2 A2000	RHEL 8.10	R283-S91	2 x 32c Xeon 6430 @ 3.4GHz	100GbE	R82.U6
Compute: Athena	4xA100 nvlink box	RHEL 8.10	Gigabyte RS292	2 x Epyc Milan 7763 5	10GbE	R85.U39

Spack relies on cloud CI to ensure that builds continue working

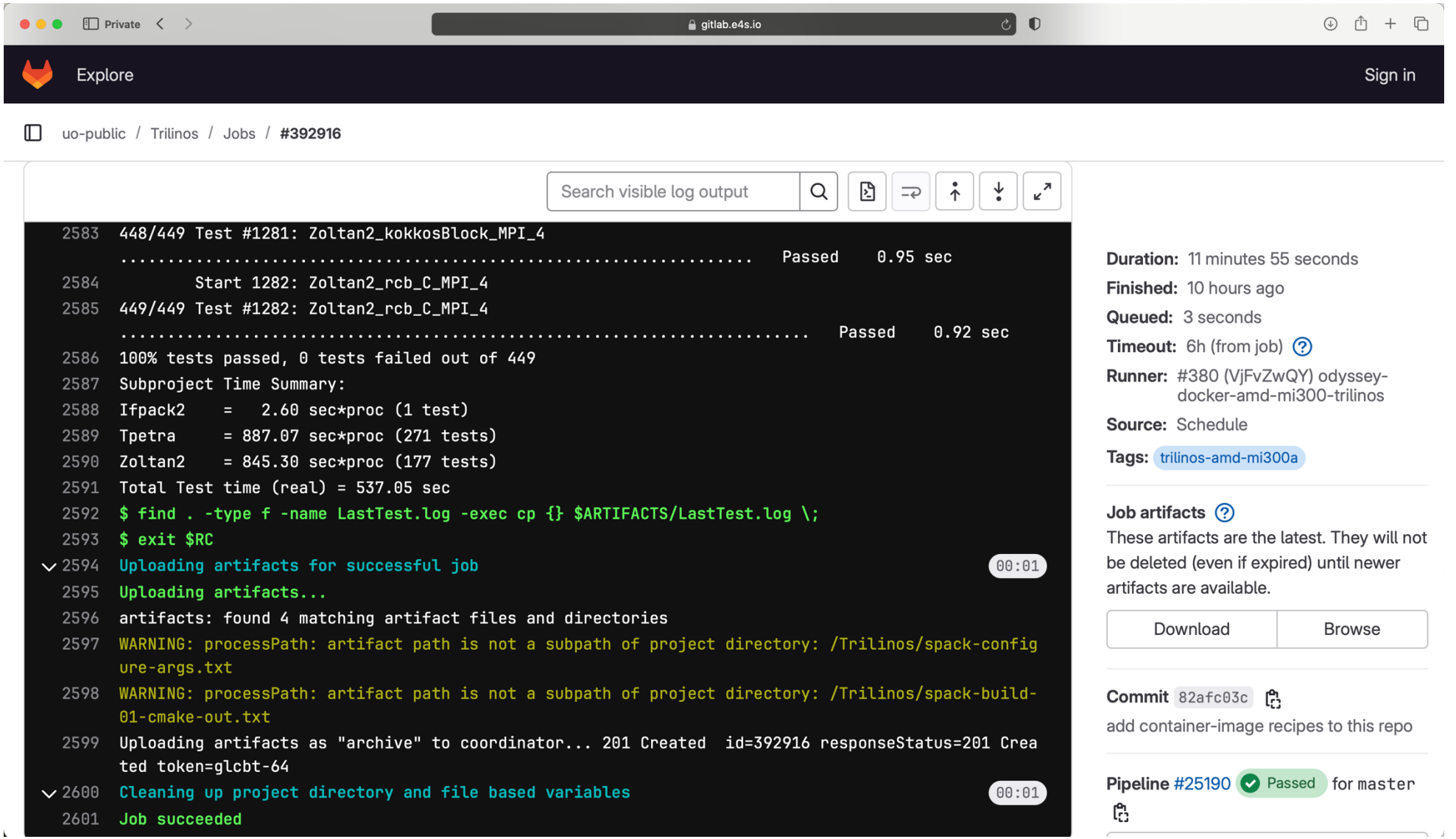


*LLNL-PRES-637654. Slide credit: Todd Gamblin, LLNL

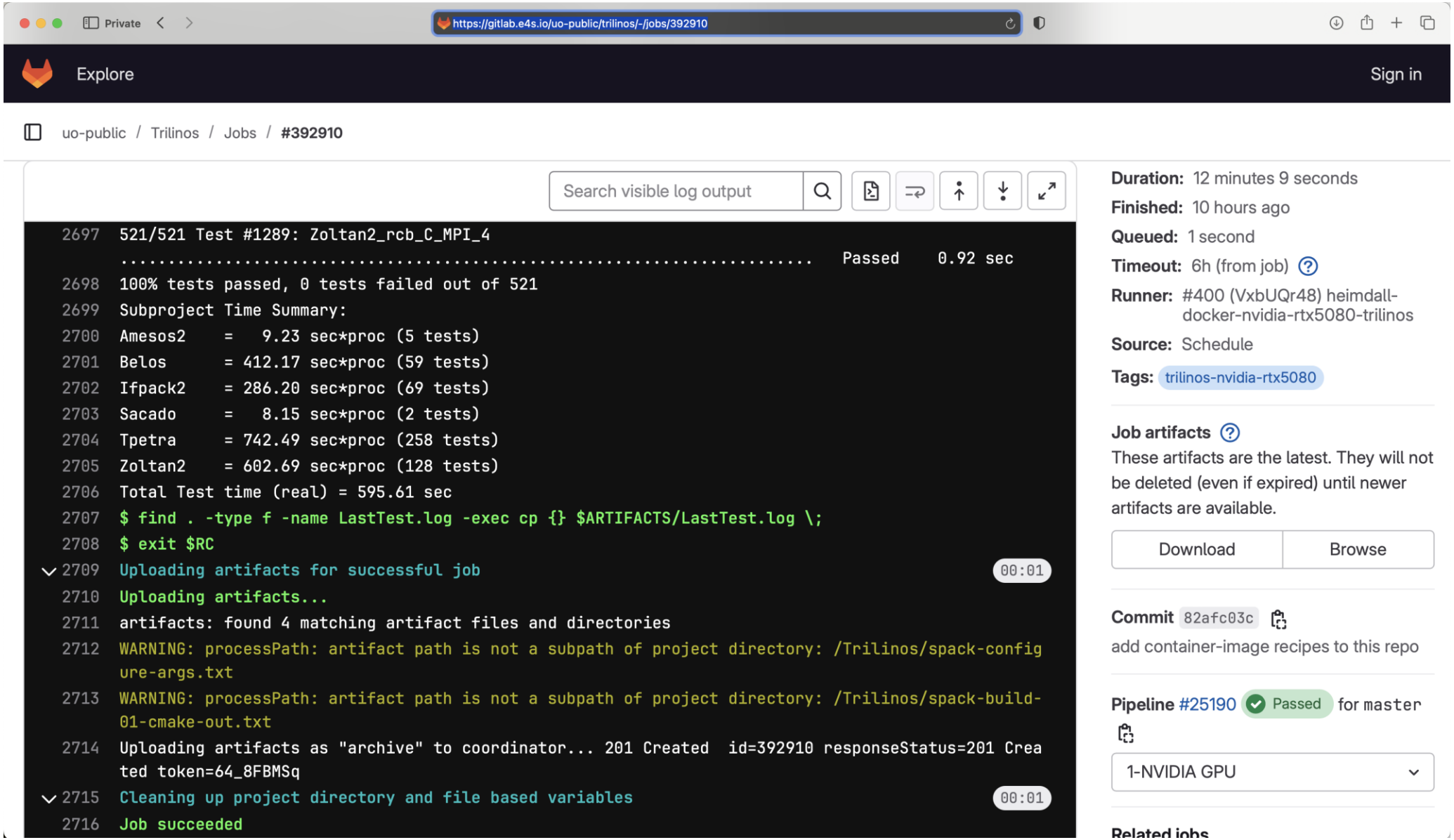
Nightly Trilinos CI using E4S containers on 12 GPU architectures



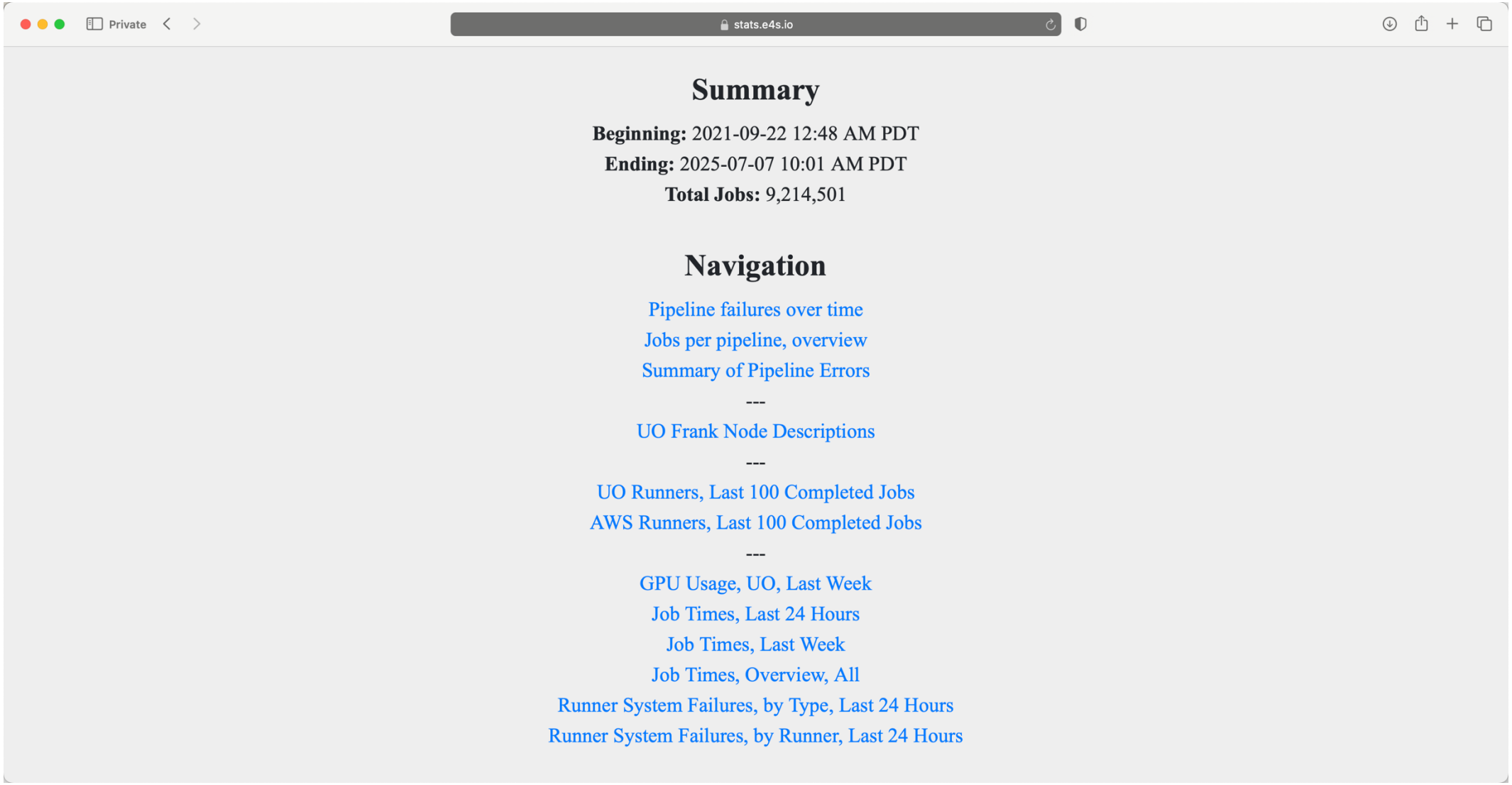
Nightly Trilinos CI using E4S on MI300A GPU: 449 tests



Nightly Trilinos CI using E4S containers on NVIDIA Blackwell GPU

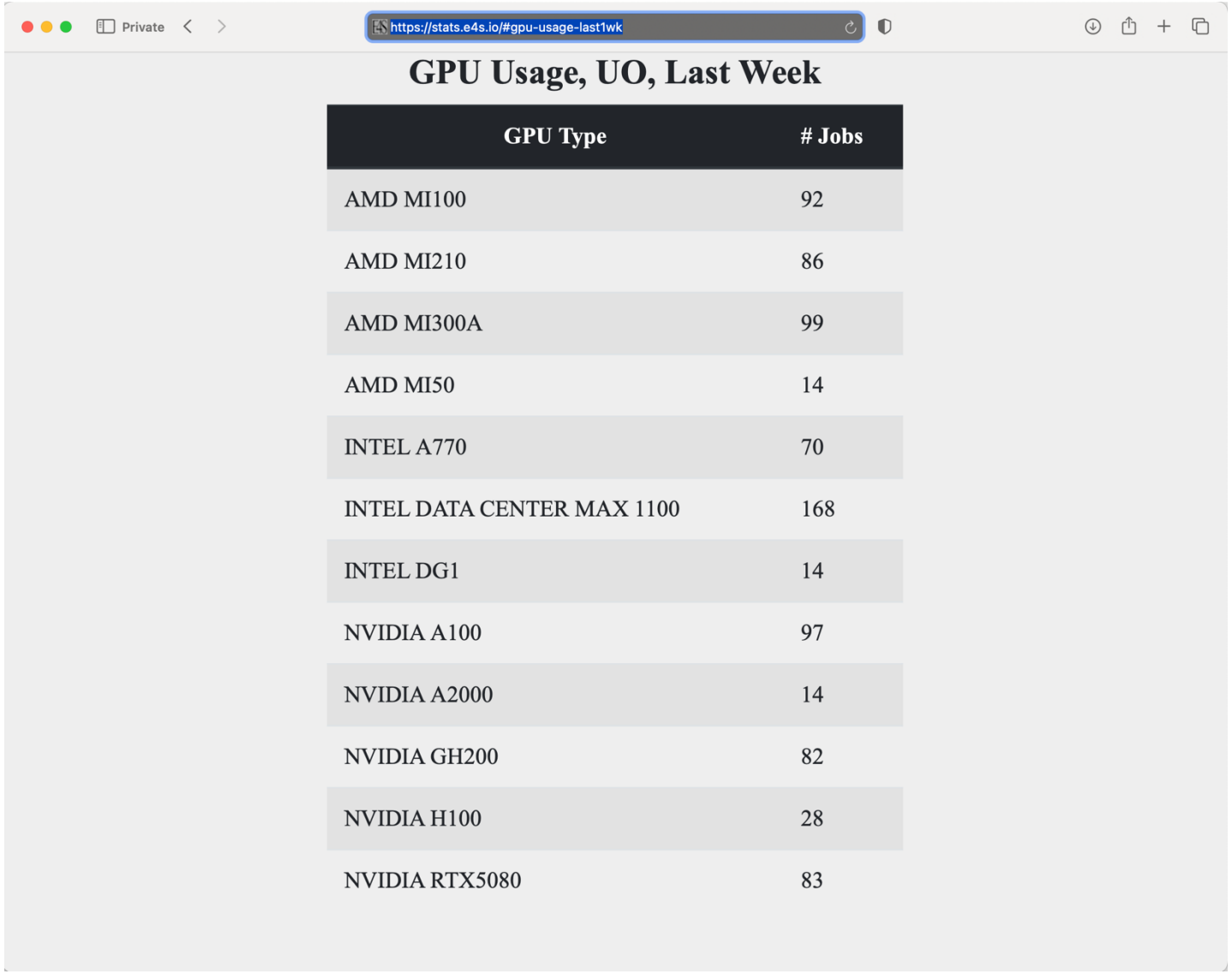


Monitoring Spack PR jobs on UO and AWS runners



https://stats.e4s.io

GPU jobs run on Frank@UO last week by GPU architecture



GPU Usage, UO, Last Week

GPU Type	# Jobs
AMD MI100	92
AMD MI210	86
AMD MI300A	99
AMD MI50	14
INTEL A770	70
INTEL DATA CENTER MAX 1100	168
INTEL DG1	14
NVIDIA A100	97
NVIDIA A2000	14
NVIDIA GH200	82
NVIDIA H100	28
NVIDIA RTX5080	83

https://stats.e4s.io

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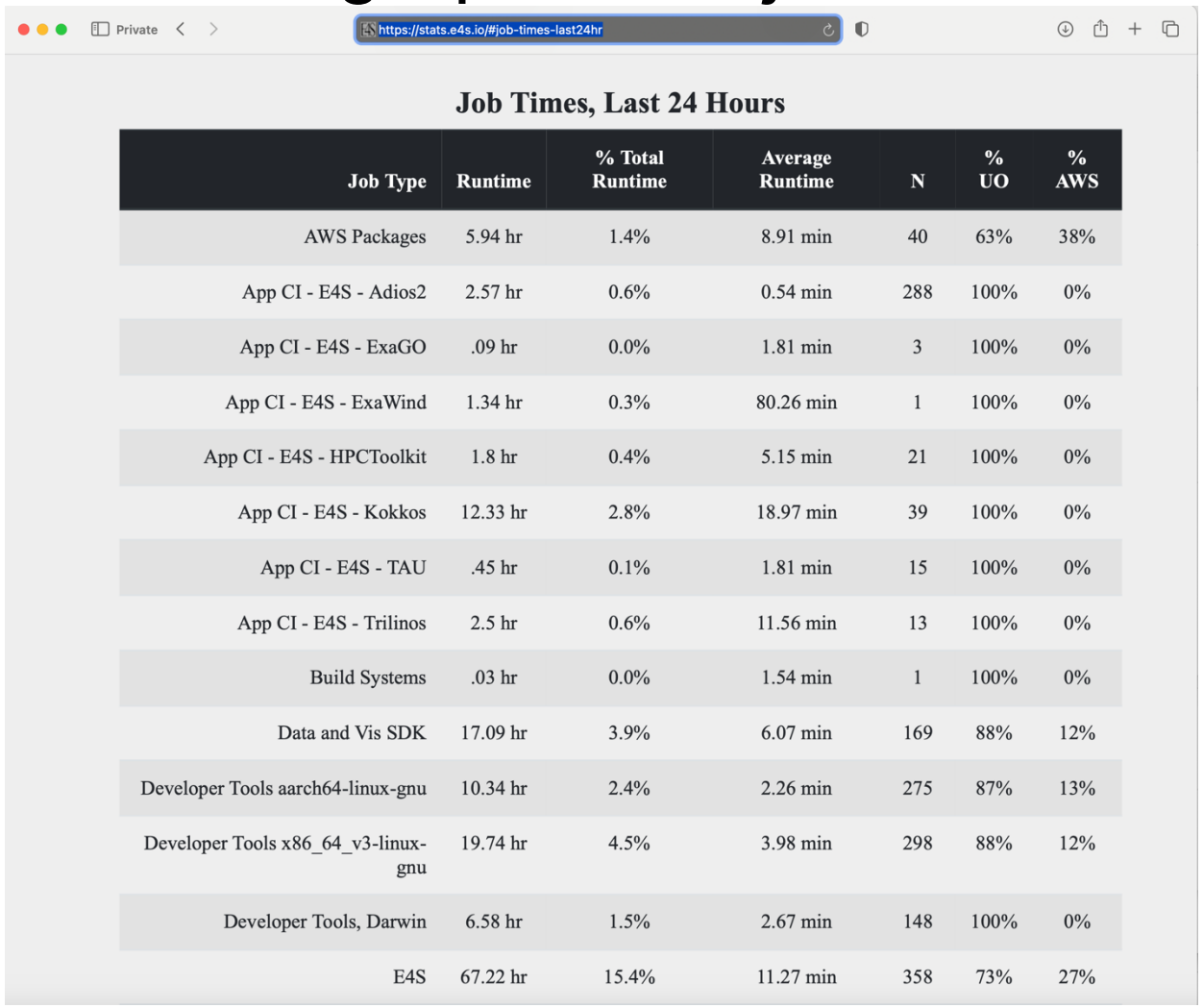
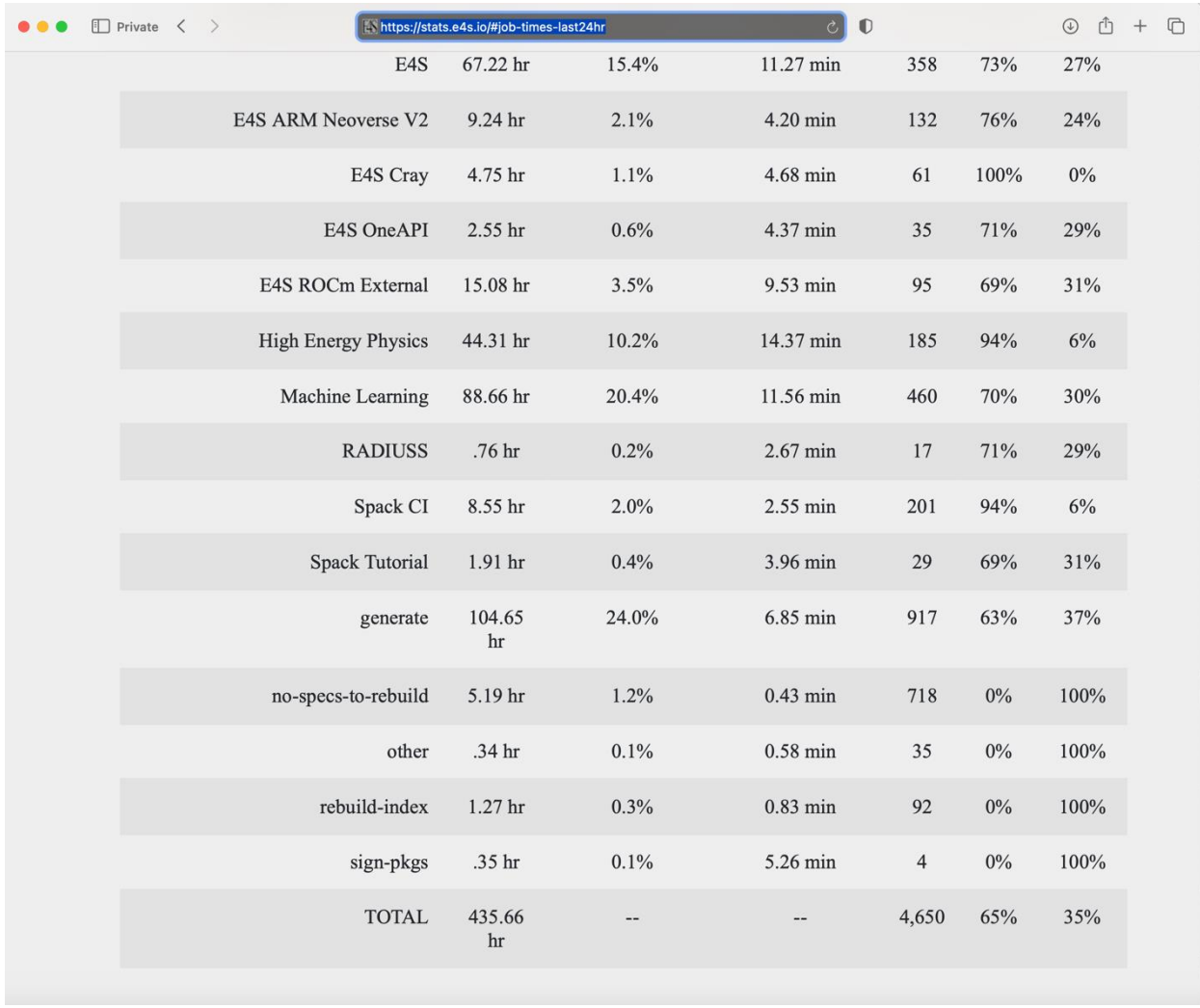
Monitoring Spack PR jobs on UO and AWS runners



Job Times, Last 24 Hours

Job Type	Runtime	% Total Runtime	Average Runtime	N	% UO	% AWS
AWS Packages	5.94 hr	1.4%	8.91 min	40	63%	38%
App CI - E4S - Adios2	2.57 hr	0.6%	0.54 min	288	100%	0%
App CI - E4S - ExaGO	.09 hr	0.0%	1.81 min	3	100%	0%
App CI - E4S - ExaWind	1.34 hr	0.3%	80.26 min	1	100%	0%
App CI - E4S - HPCToolkit	1.8 hr	0.4%	5.15 min	21	100%	0%
App CI - E4S - Kokkos	12.33 hr	2.8%	18.97 min	39	100%	0%
App CI - E4S - TAU	.45 hr	0.1%	1.81 min	15	100%	0%
App CI - E4S - Trilinos	2.5 hr	0.6%	11.56 min	13	100%	0%
Build Systems	.03 hr	0.0%	1.54 min	1	100%	0%
Data and Vis SDK	17.09 hr	3.9%	6.07 min	169	88%	12%
Developer Tools aarch64-linux-gnu	10.34 hr	2.4%	2.26 min	275	87%	13%
Developer Tools x86_64_v3-linux-gnu	19.74 hr	4.5%	3.98 min	298	88%	12%
Developer Tools, Darwin	6.58 hr	1.5%	2.67 min	148	100%	0%
E4S	67.22 hr	15.4%	11.27 min	358	73%	27%



E4S	67.22 hr	15.4%	11.27 min	358	73%	27%
E4S ARM Neoverse V2	9.24 hr	2.1%	4.20 min	132	76%	24%
E4S Cray	4.75 hr	1.1%	4.68 min	61	100%	0%
E4S OneAPI	2.55 hr	0.6%	4.37 min	35	71%	29%
E4S ROCm External	15.08 hr	3.5%	9.53 min	95	69%	31%
High Energy Physics	44.31 hr	10.2%	14.37 min	185	94%	6%
Machine Learning	88.66 hr	20.4%	11.56 min	460	70%	30%
RADIUSS	.76 hr	0.2%	2.67 min	17	71%	29%
Spack CI	8.55 hr	2.0%	2.55 min	201	94%	6%
Spack Tutorial	1.91 hr	0.4%	3.96 min	29	69%	31%
generate	104.65 hr	24.0%	6.85 min	917	63%	37%
no-specs-to-rebuild	5.19 hr	1.2%	0.43 min	718	0%	100%
other	.34 hr	0.1%	0.58 min	35	0%	100%
rebuild-index	1.27 hr	0.3%	0.83 min	92	0%	100%
sign-pkgs	.35 hr	0.1%	5.26 min	4	0%	100%
TOTAL	435.66 hr	--	--	4,650	65%	35%

https://stats.e4s.io

Data collected for past 24 hours on 7/7/2025
UO: 65% jobs, AWS: 35%

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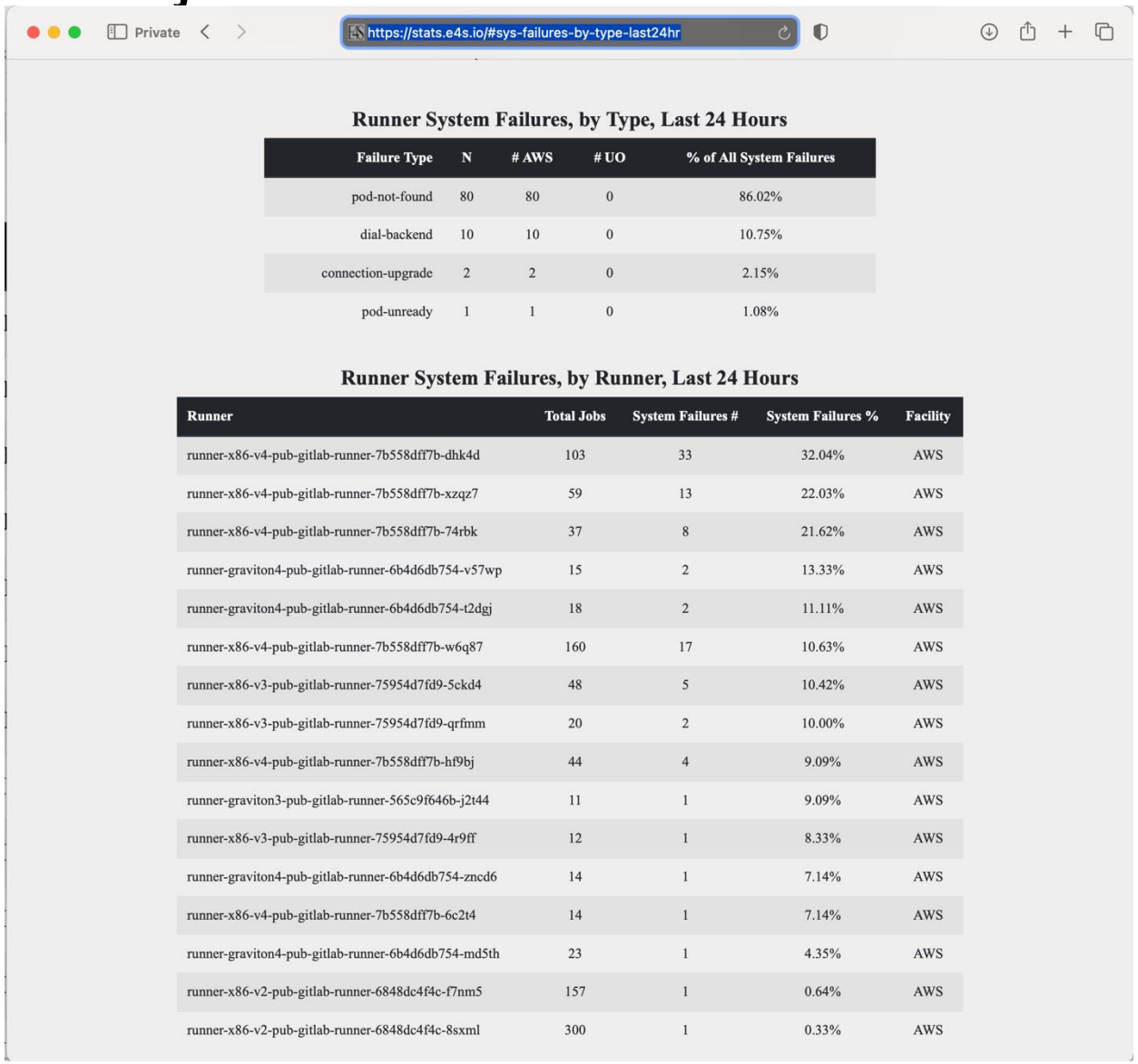
Monitoring Spack PR job failures on UO and AWS runners



Runner System Failures, by Type, Last 24 Hours

Failure Type	N	# AWS	# UO	% of All System Failures
pod-not-found	80	80	0	86.02%
dial-backend	10	10	0	10.75%
connection-upgrade	2	2	0	2.15%
pod-unready	1	1	0	1.08%

Runner System Failures, by Runner, Last 24 Hours

Runner	Total Jobs	System Failures #	System Failures %	Facility
runner-x86-v4-pub-gitlab-runner-7b558dff7b-dhk4d	103	33	32.04%	AWS
runner-x86-v4-pub-gitlab-runner-7b558dff7b-xzqz7	59	13	22.03%	AWS
runner-x86-v4-pub-gitlab-runner-7b558dff7b-74rbk	37	8	21.62%	AWS
runner-graviton4-pub-gitlab-runner-6b4d6db754-v57wp	15	2	13.33%	AWS
runner-graviton4-pub-gitlab-runner-6b4d6db754-t2dgj	18	2	11.11%	AWS
runner-x86-v4-pub-gitlab-runner-7b558dff7b-w6q87	160	17	10.63%	AWS
runner-x86-v3-pub-gitlab-runner-75954d7fd9-5ckd4	48	5	10.42%	AWS
runner-x86-v3-pub-gitlab-runner-75954d7fd9-qrfmm	20	2	10.00%	AWS
runner-x86-v4-pub-gitlab-runner-7b558dff7b-hf9bj	44	4	9.09%	AWS
runner-graviton3-pub-gitlab-runner-565c9f646b-j2t44	11	1	9.09%	AWS
runner-x86-v3-pub-gitlab-runner-75954d7fd9-4r9ff	12	1	8.33%	AWS
runner-graviton4-pub-gitlab-runner-6b4d6db754-zncd6	14	1	7.14%	AWS
runner-x86-v4-pub-gitlab-runner-7b558dff7b-6c2t4	14	1	7.14%	AWS
runner-graviton4-pub-gitlab-runner-6b4d6db754-md5th	23	1	4.35%	AWS
runner-x86-v2-pub-gitlab-runner-6848dc4f4c-f7nm5	157	1	0.64%	AWS
runner-x86-v2-pub-gitlab-runner-6848dc4f4c-8sxml	300	1	0.33%	AWS

Job failures in the last 24 hours
Data collected on 7/7/2025

https://stats.e4s.io

ParaTools Pro for E4S™: A cloud image for tool interoperability

https://paratoolspro.com

Key considerations for cloud-based deployment for E4S

- MPI - the core inter-node communication library has several implementations
  - Intel MPI, MVAPICH2-X, OpenMPI
  - Interfacing MPI with the job scheduling package (MOAB, Torque, SLURM)
- Cloud providers have different inter-node network adapters:
  - Elastic Fabric Adapter (EFA) on AWS
  - Infiniband on Azure
  - Mellanox Connect-X 5 Ethernet (ROCE) on Oracle Cloud Infrastructure (OCI)
  - IPU on Google Cloud (GCP)
- Intra-node communication with XPMEM (driver and kernel module support is critical)
- GPU Direct Async (GDR) support for communication between GPUs in MVPICH-Plus release
- ParaTools, Inc. building E4S optimized with MVAPICH-Plus for AWS, OCI, GCP, and Azure
- Using Adaptive Computing, Inc.’s Heidi/ODDC to launch E4S jobs on multiple cloud providers!

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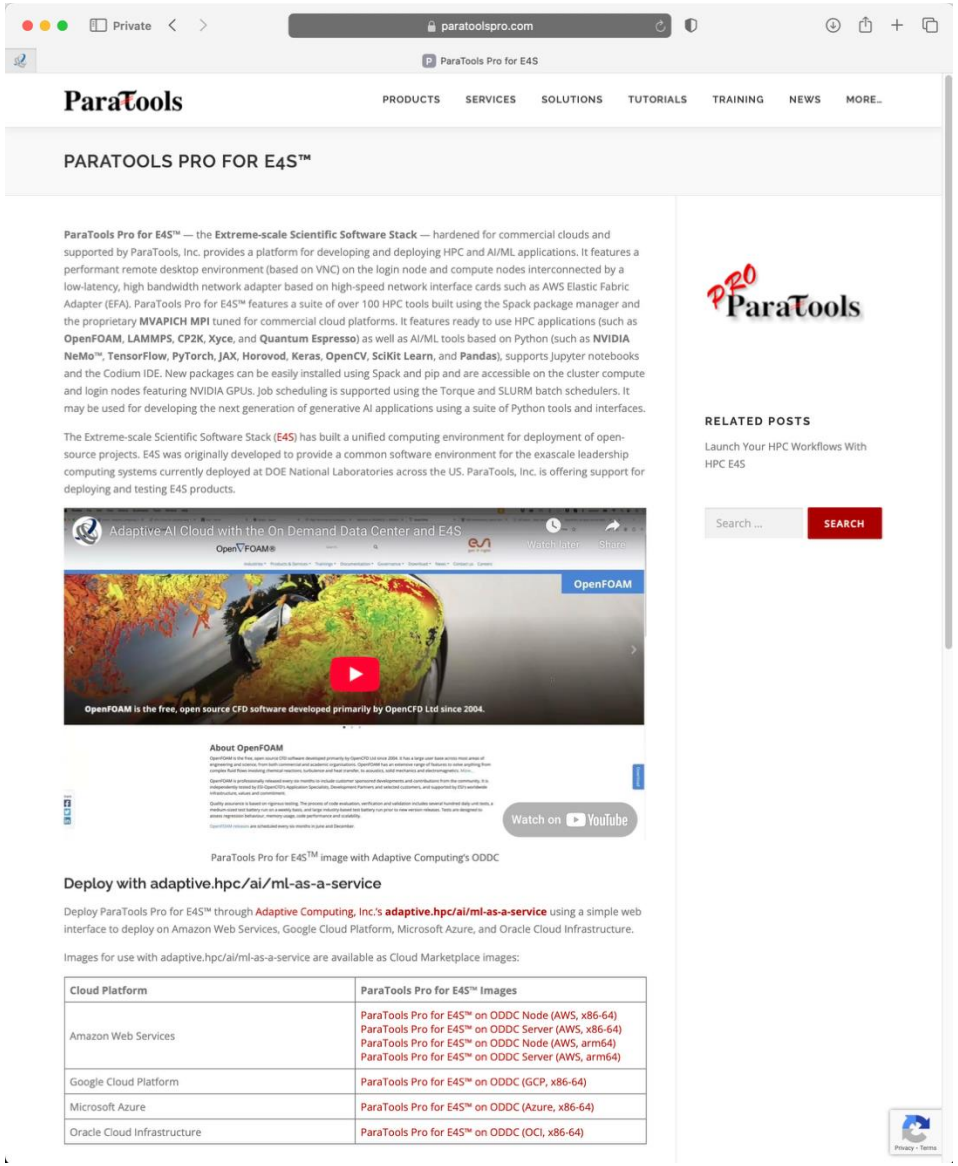
E4S on Commercial Cloud Platforms: ParaTools Pro for E4S™



- ParaTools Pro for E4S™* images in vendor marketplaces support:
  - AWS
  - Azure
  - Google Cloud (GCP)
  - Oracle Cloud Infrastructure (OCI)
- Supports SLURM and Torque for scheduling jobs on multi-node GPU accelerated nodes
- Shared GPU accelerated login node with a VNC based remote desktop
- Adaptive Computing's Heidi/ODDC
- AWS PCS and PC (x86, ARM64)
- Azure Cyclecloud
- Google GCluster

* Acknowledgment:
Supported by
DOE SBIR Phase I and II
DE-SC0022502

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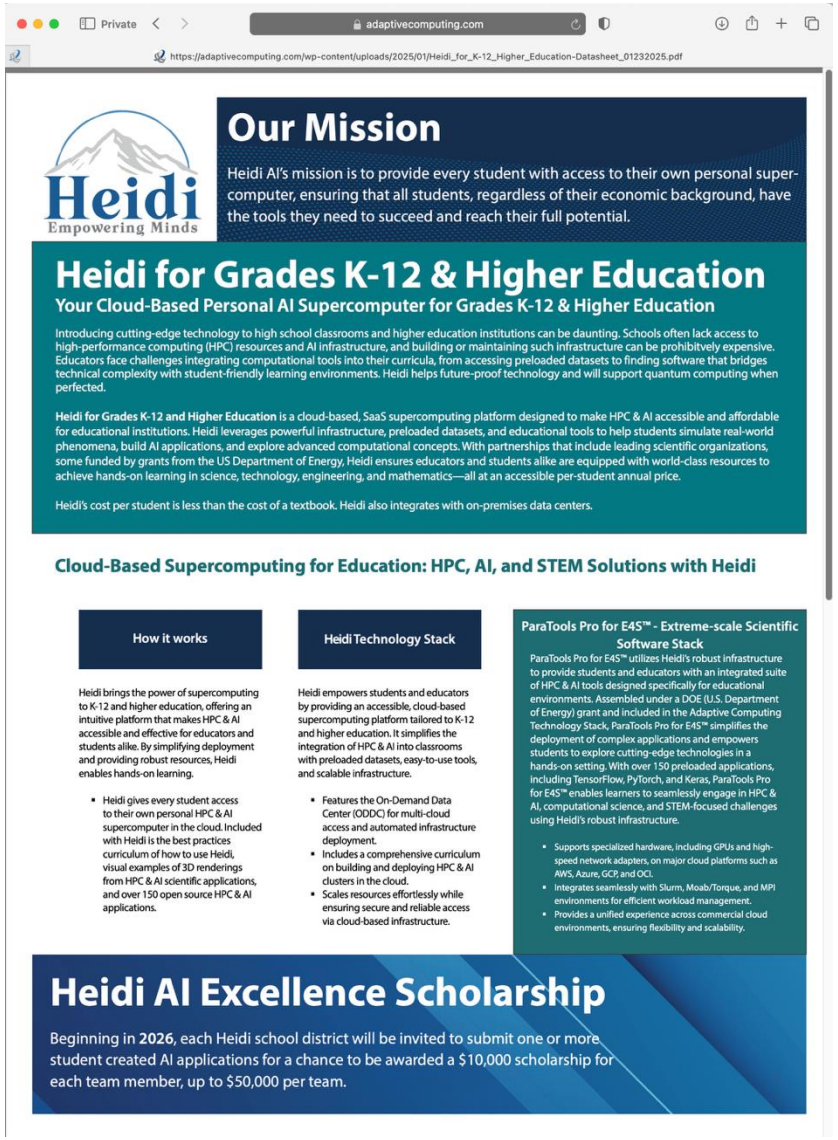
https://paratoolspro.com and https://www.energy.gov/technologytransitions/sbirsttr

E4S on Adaptive Computing's Heidi AI/On Demand Data Center (ODDC)



Heidi
Empowering Minds

Our Mission

Heidi AI's mission is to provide every student with access to their own personal super-computer, ensuring that all students, regardless of their economic background, have the tools they need to succeed and reach their full potential.

Heidi for Grades K-12 & Higher Education

Your Cloud-Based Personal AI Supercomputer for Grades K-12 & Higher Education

Introducing cutting-edge technology to high school classrooms and higher education institutions can be daunting. Schools often lack access to high-performance computing (HPC) resources and AI infrastructure, and building or maintaining such infrastructure can be prohibitively expensive. Educators face challenges integrating computational tools into their curricula, from accessing preloaded datasets to finding software that bridges technical complexity with student-friendly learning environments. Heidi helps future-proof technology and will support quantum computing when perfected.

Heidi for Grades K-12 and Higher Education is a cloud-based, SaaS supercomputing platform designed to make HPC & AI accessible and affordable for educational institutions. Heidi leverages powerful infrastructure, preloaded datasets, and educational tools to help students simulate real-world phenomena, build AI applications, and explore advanced computational concepts. With partnerships that include leading scientific organizations, some funded by grants from the US Department of Energy, Heidi ensures educators and students alike are equipped with world-class resources to achieve hands-on learning in science, technology, engineering, and mathematics—all at an accessible per-student annual price.

Heidi's cost per student is less than the cost of a textbook. Heidi also integrates with on-premises data centers.

Cloud-Based Supercomputing for Education: HPC, AI, and STEM Solutions with Heidi

How it works

Heidi brings the power of supercomputing to K-12 and higher education, offering an intuitive platform that makes HPC & AI accessible and effective for educators and students alike. By simplifying deployment and providing robust resources, Heidi enables hands-on learning.

- Heidi gives every student access to their own personal HPC & AI supercomputer in the cloud. Included with Heidi is the best practices curriculum of how to use Heidi, visual examples of 3D renderings from HPC & AI scientific applications, and over 150 open source HPC & AI applications.

Heidi Technology Stack

Heidi empowers students and educators by providing an accessible, cloud-based supercomputing platform tailored to K-12 and higher education. It simplifies the integration of HPC & AI into classrooms with preloaded datasets, easy-to-use tools, and scalable infrastructure.

- Features the On-Demand Data Center (ODDC) for multi-cloud access and automated infrastructure deployment.
- Includes a comprehensive curriculum on building and deploying HPC & AI clusters in the cloud.
- Scales resources effortlessly while ensuring secure and reliable access via cloud-based infrastructure.

ParaTools Pro for E4S™ - Extreme-scale Scientific Software Stack

ParaTools Pro for E4S™ utilizes Heidi's robust infrastructure to provide students and educators with an integrated suite of HPC & AI tools designed specifically for educational environments. Assembled under a DOE (U.S. Department of Energy) grant and included in the Adaptive Computing Technology Stack, ParaTools Pro for E4S™ simplifies the deployment of complex applications and empowers students to explore cutting-edge technologies in a hands-on setting. With over 150 preloaded applications, including TensorFlow, PyTorch, and Keras, ParaTools Pro for E4S™ enables learners to seamlessly engage in HPC & AI, computational science, and STEM-focused challenges using Heidi's robust infrastructure.

- Supports specialized hardware, including GPUs and high-speed network adapters, on major cloud platforms such as AWS, Azure, GCP, and OCI.
- Integrates seamlessly with Slurm, Moab/Torque, and MPI environments for efficient workload management.
- Provides a unified experience across commercial cloud environments, ensuring flexibility and scalability.

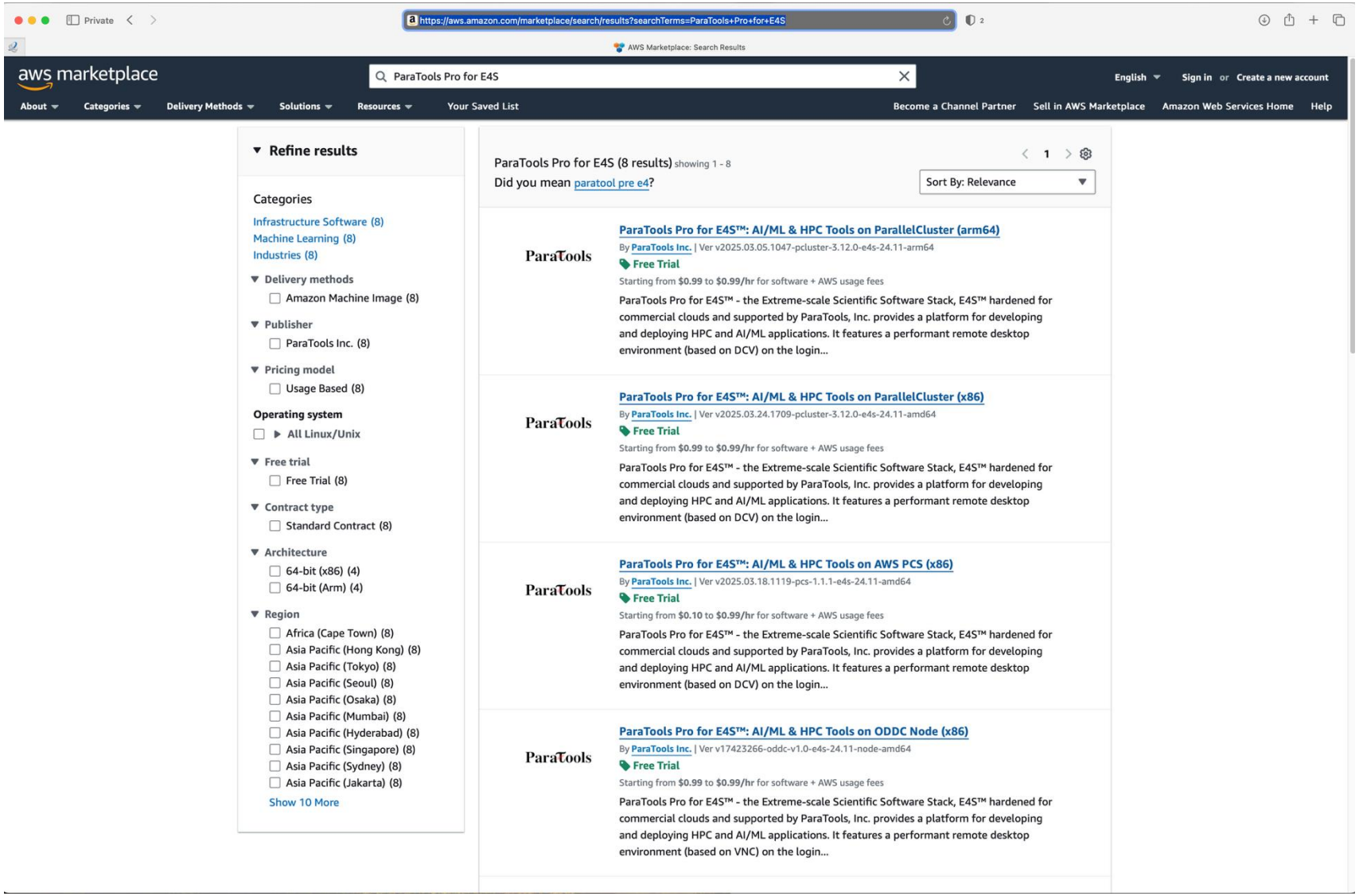
Heidi AI Excellence Scholarship

Beginning in **2026**, each Heidi school district will be invited to submit one or more student created AI applications for a chance to be awarded a $10,000 scholarship for each team member, up to $50,000 per team.

- ParaTools Pro for E4S™ images in commercial cloud marketplaces launched using Heidi
- Supports Torque for scheduling jobs on multi-node GPU accelerated nodes
- Shared GPU accelerated login node with a VNC based remote desktop

https://adaptivecomputing.com

ParaTools Pro for E4S™ on Commercial Clouds: AWS Marketplace



ParaTools Pro for E4S™ on AWS supports

- AWS Trainium and Inferentia custom AI hardware with NeuronX SDK
- AWS PCS and PC on x86_64 and aarch64 nodes
- NVIDIA GPUs
- SLURM (PCS and PC) and Torque (ODDC node/server)
- Also on AWS Marketplace in GovCloud (US East & West)
- Elastic Fabric Adapter (EFA)
- MVAPICH MPI [X-ScaleSolutions, LLC and The Ohio State University]

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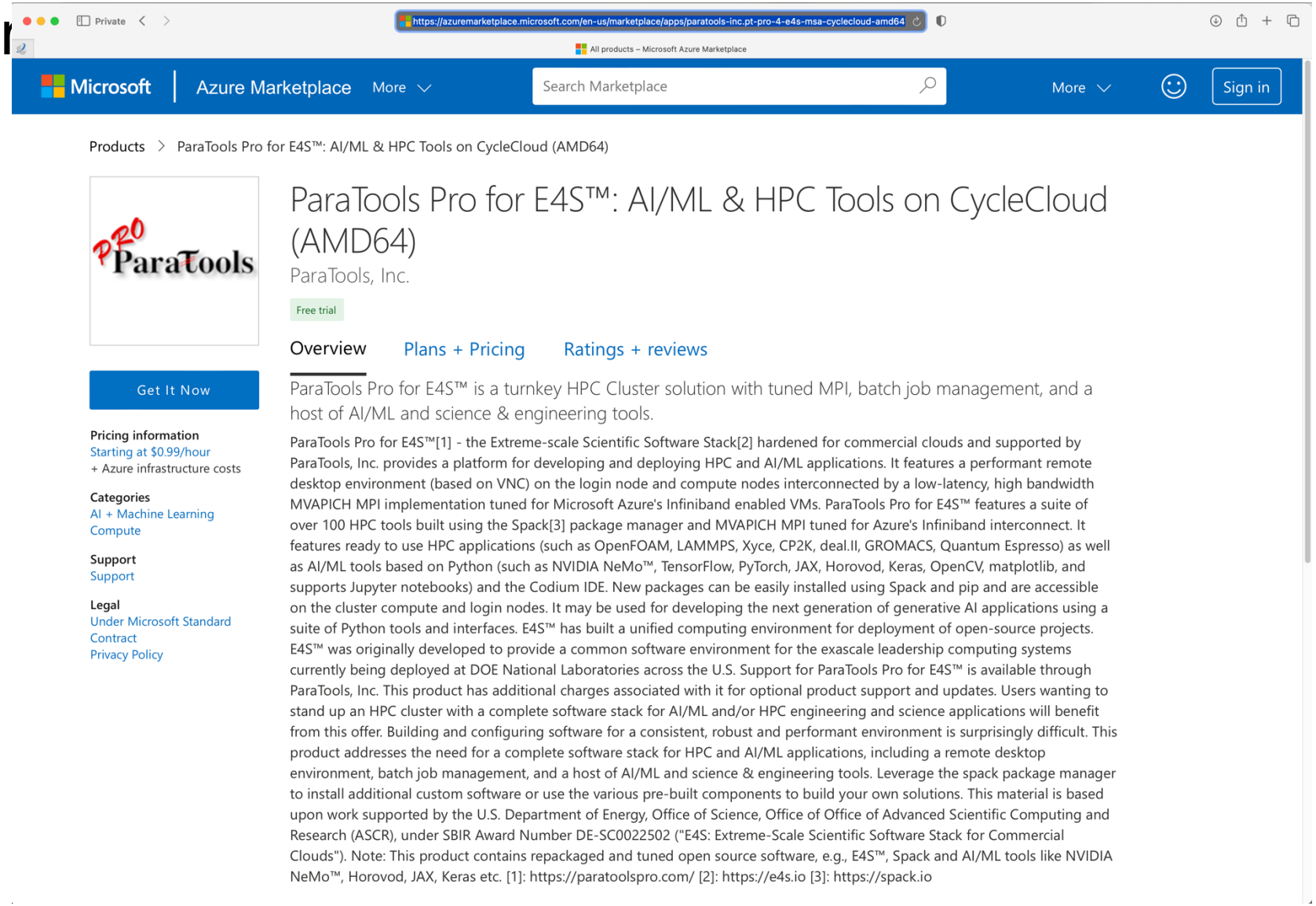
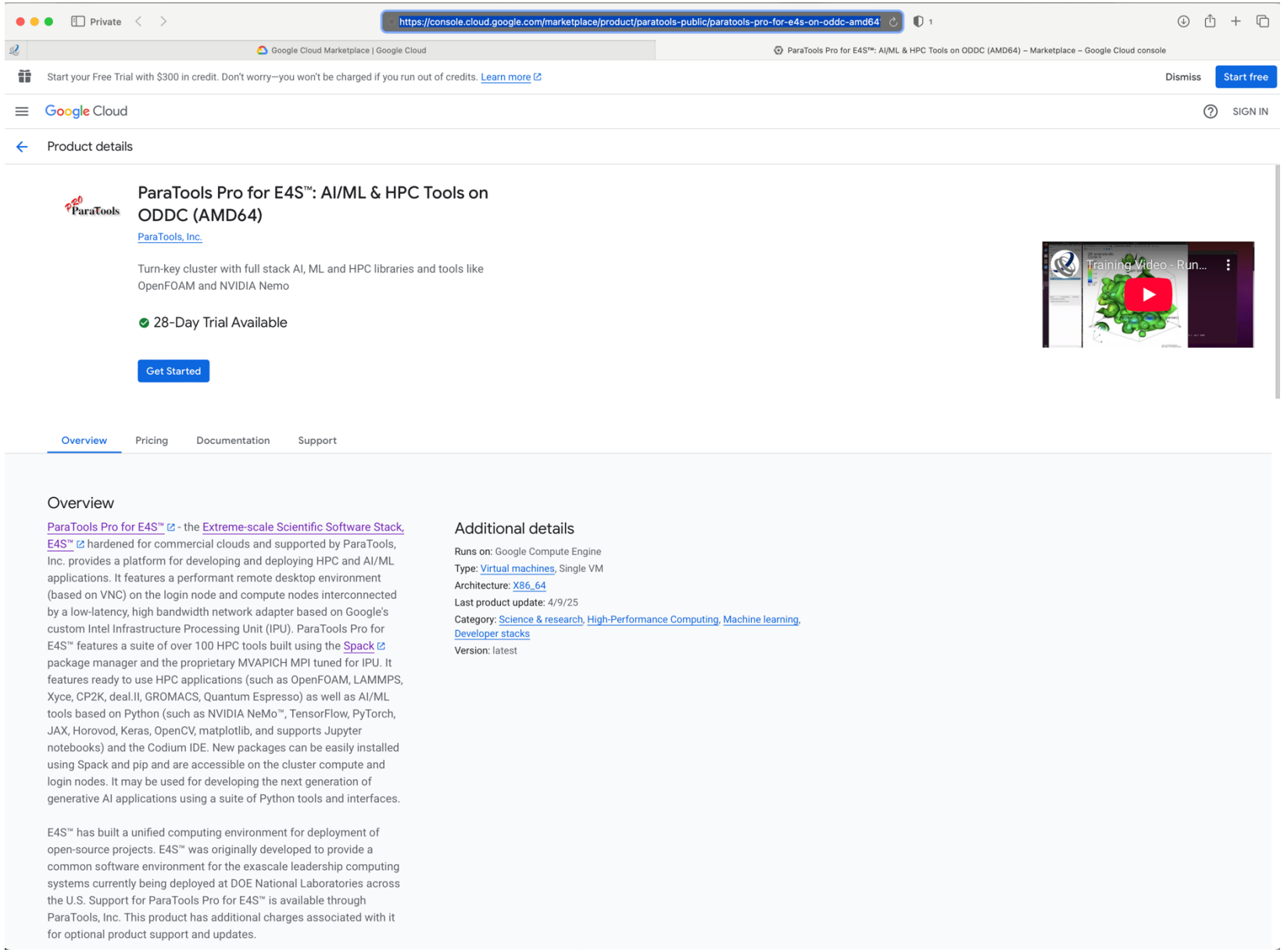
ParaTools Pro for E4S™ on Commercial Clouds: Azure Mar



ParaTools Pro for E4S™ on Azure Marketplace supports

- SLURM (Azure CycleCloud) and Torque schedulers (Adaptive Computing's ODDC)
- Support for Infiniband Network adapter

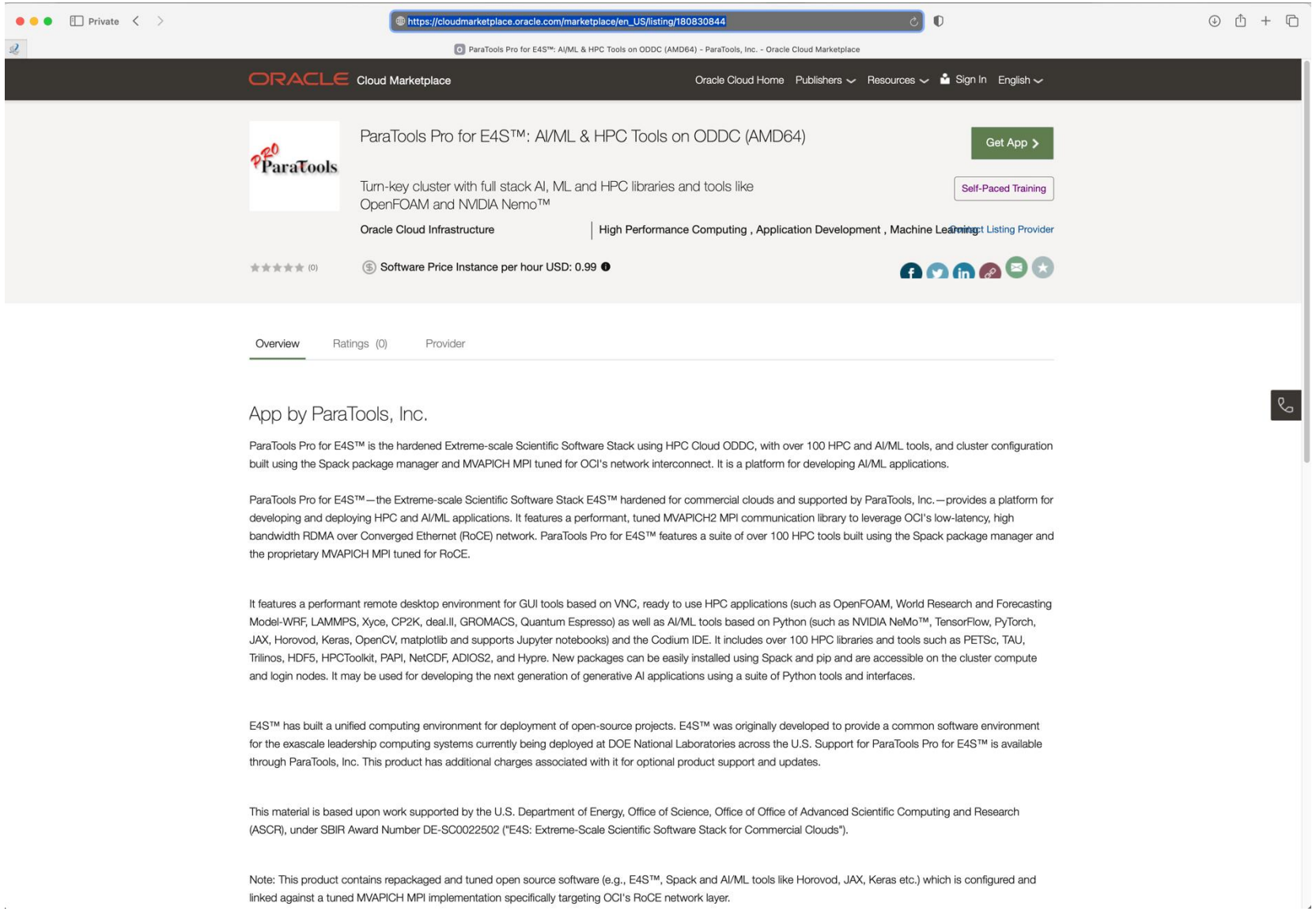
ParaTools Pro for E4S™ on Google Cloud Marketplace



ParaTools Pro for E4S™ Google Cloud Marketplace supports

- SLURM (GCluster) and Torque schedulers (Adaptive Computing's ODDC)
- Support for Google IPU network adapters

ParaTools Pro for E4S™ on Oracle Cloud Marketplace

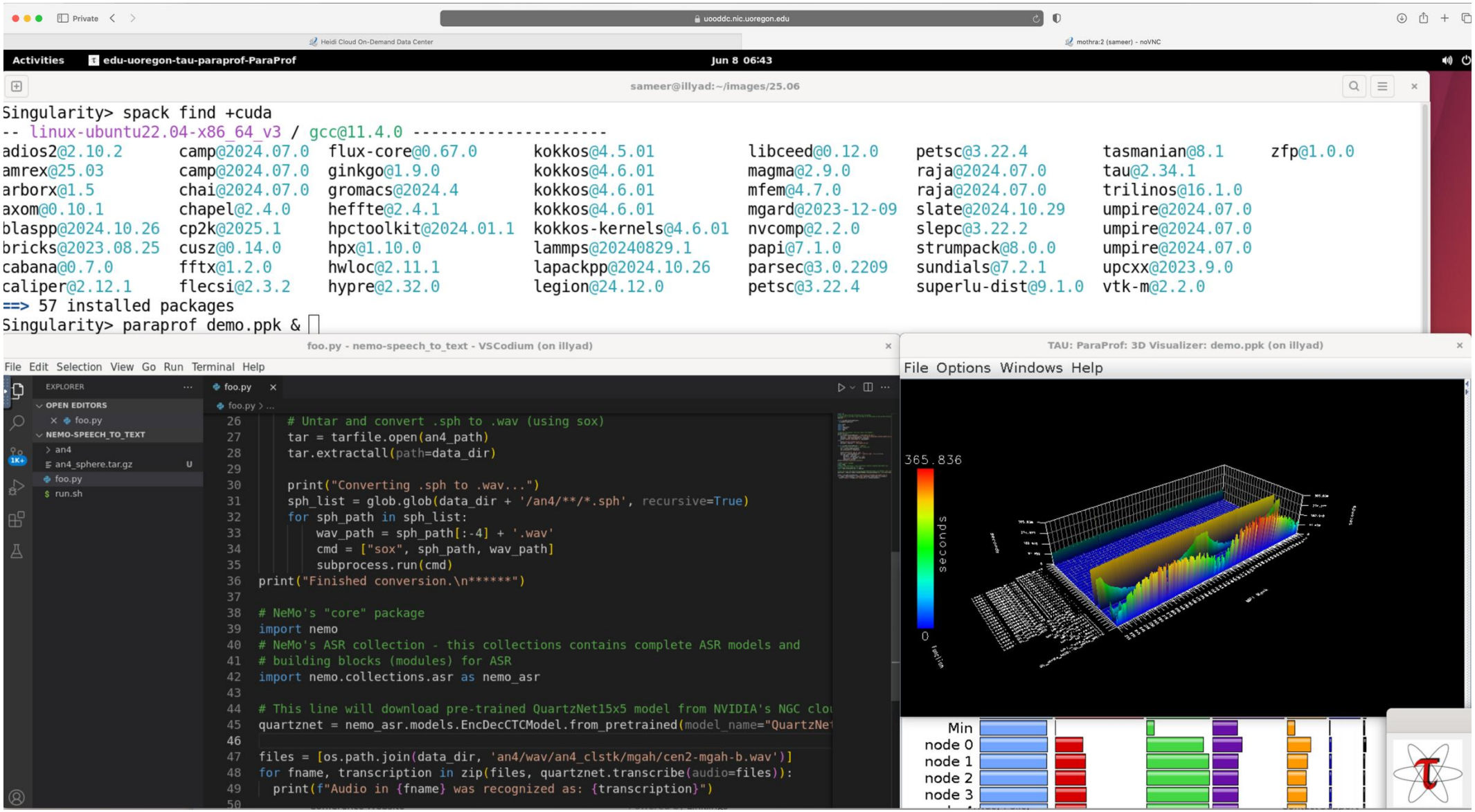


ParaTools Pro for E4S™
for Oracle Cloud Infrastructure
(OCI) Marketplace
supports Torque (ODDC) and
RDMA over Converged Ethernet
(RoCE) network adapters and
GPUs on login and compute nodes

Can E4S help provide a stable platform for tool development?

- Bare-metal installation as well as containers built with Spack
- Base containers that can be customized with e4s-alc
- Replace MPI in containerized E4S application with system MPI using e4s-cl
- Support for commercial cloud platforms
- What are we missing?

E4S: An HPC-AI Software Ecosystem for Science!



https://e4s.io

Acknowledgment

- *This work was supported by the U.S. Department of Energy, Office of Science, Advanced Computing Research, through the Next-Generation Scientific Software Technologies (NGSST) under contract DE-AC02-AC05-00OR22725, DOE SBIR DE-SC0022502, and NNSA Sandia contract 2542488.*

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- https://science.osti.gov/ascr
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- https://www.energy.gov/technologytransitions/sbirsttr

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Thank you

https://www.exascaleproject.org

This research was supported by the Exascale Computing Project (17-SC-20-SC), a joint project of the U.S. Department of Energy's Office of Science and National Nuclear Security Administration, responsible for delivering a capable exascale ecosystem, including software, applications, and hardware technology, to support the nation's exascale computing imperative.

Thank you to all collaborators in the ECP and broader computational science communities. The work discussed in this presentation represents creative contributions of many people who are passionately working toward next-generation computational science.

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