



Arm HPC Software Stack and HPC Tools

Centre for Development of Advanced Computing
(C-DAC) / National Supercomputing Mission
(NSM)

Arm in HPC Course

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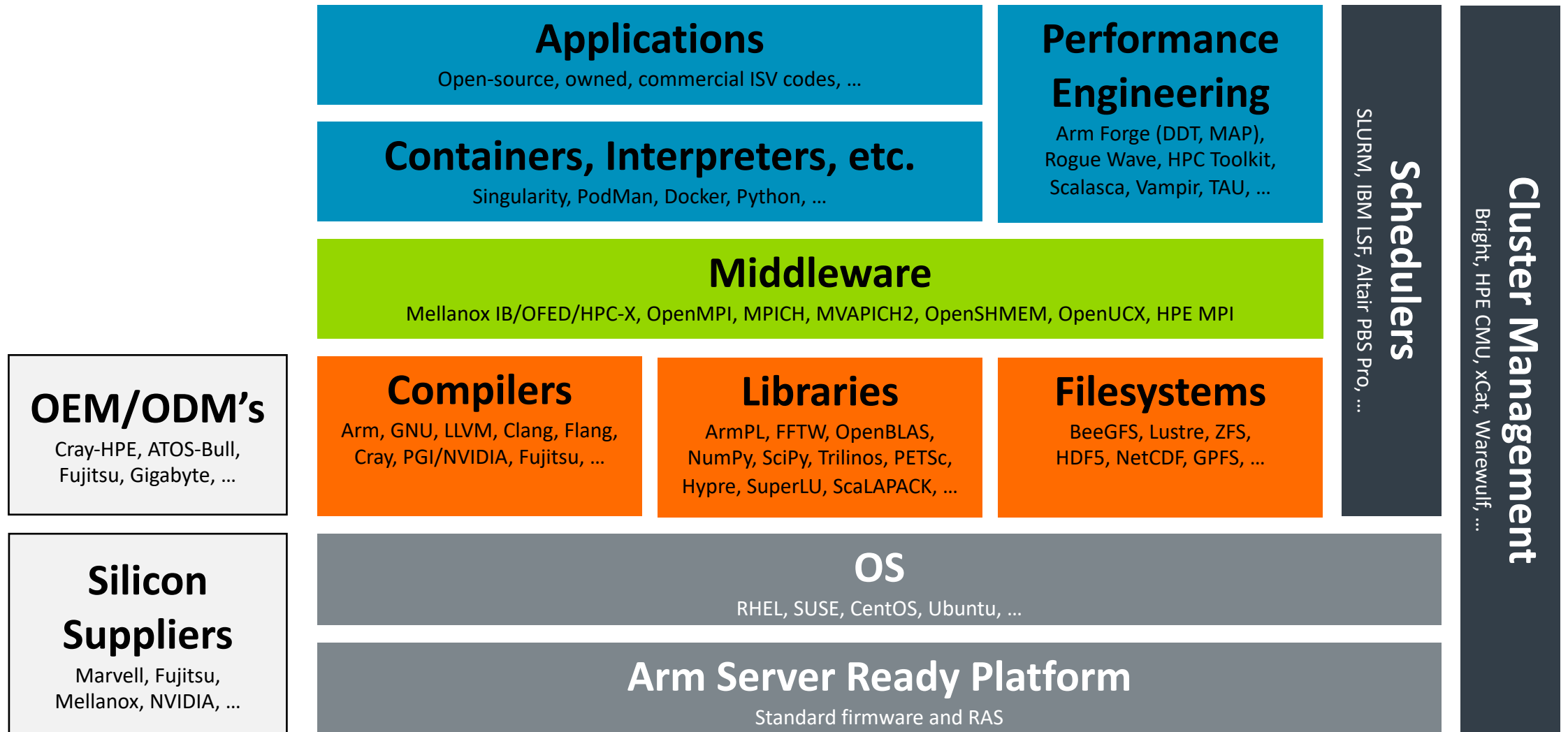
Agenda

- HPC Software Ecosystem
 - Overview
 - Applications
 - Community Support
- Compilers, Libraries and Tools
 - Open-source and Commercial
 - Compilers
 - Maths Libraries
 - Profiling and Debugging

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Software Ecosystem

HPC Ecosystem



General Software Ecosystem





– Easy HPC stack deployment on Arm

<https://developer.arm.com/solutions/hpc/hpc-software/openhpc>

OpenHPC is a community effort to provide a common, verified set of open source packages for HPC deployments

Arm and partners actively involved:

- Arm is a silver member of OpenHPC
- Linaro is on Technical Steering Committee
- Arm-based machines in the OpenHPC build infrastructure

Status: 2.0.0 release out now

- CentOS8 and OpenSUSE Leap 15 for Aarch64

Functional Areas	Components include
Base OS	CentOS 8.0, OpenSUSE Leap 15
Administrative Tools	Conman, Ganglia, Lmod, LosF, Nagios, pdsh, pdsh-mod-slurm, prun, EasyBuild, ClusterShell, mrsh, Genders, Shine, test-suite
Provisioning	Warewulf
Resource Mgmt.	SLURM, Munge
I/O Services	Lustre client (community version)
Numerical/Scientific Libraries	Boost, GSL, FFTW, Metis, PETSc, Trilinos, Hypre, SuperLU, SuperLU_Dist, Mumps, OpenBLAS, Scalapack, SLEPc, PLASMA, ptScotch
I/O Libraries	HDF5 (pHDF5), NetCDF (including C++ and Fortran interfaces), Adios
Compiler Families	GNU (gcc, g++, gfortran), LLVM
MPI Families	OpenMPI, MPICH
Development Tools	Autotools (autoconf, automake, libtool), Cmake, Valgrind, R, SciPy/NumPy, hwloc
Performance Tools	PAPI, IMB, pdttoolkit, TAU, Scalasca, Score-P, SIONLib

Ceph on Arm

<https://community.arm.com/developer/tools-software/hpc/b/hpc-blog/posts/arm-demonstrates-leading-performance-on-ceph-storage-cluster>

- Ceph enables scalable deployment of distributed storage systems.
- Comparison between Ampere eMAG and Intel Xeon Gold 6142.
- Showed a 26% performance improvement over the comparison cluster.
- 50% lower power.
- Potential for 40% CapEx savings.



Software Ecosystem – Open Source Enablement

Arm actively develops both open source and commercial tools

Open-source compilers

GCC and LLVM toolchains have active development work from Arm

- Our commercial compiler feeds into both LLVM and Flang
- Optimizations are targeted at:
 - Improving functionality
 - Increasing performance across Arm partner cores
 - Specific micro-architectural tuning work

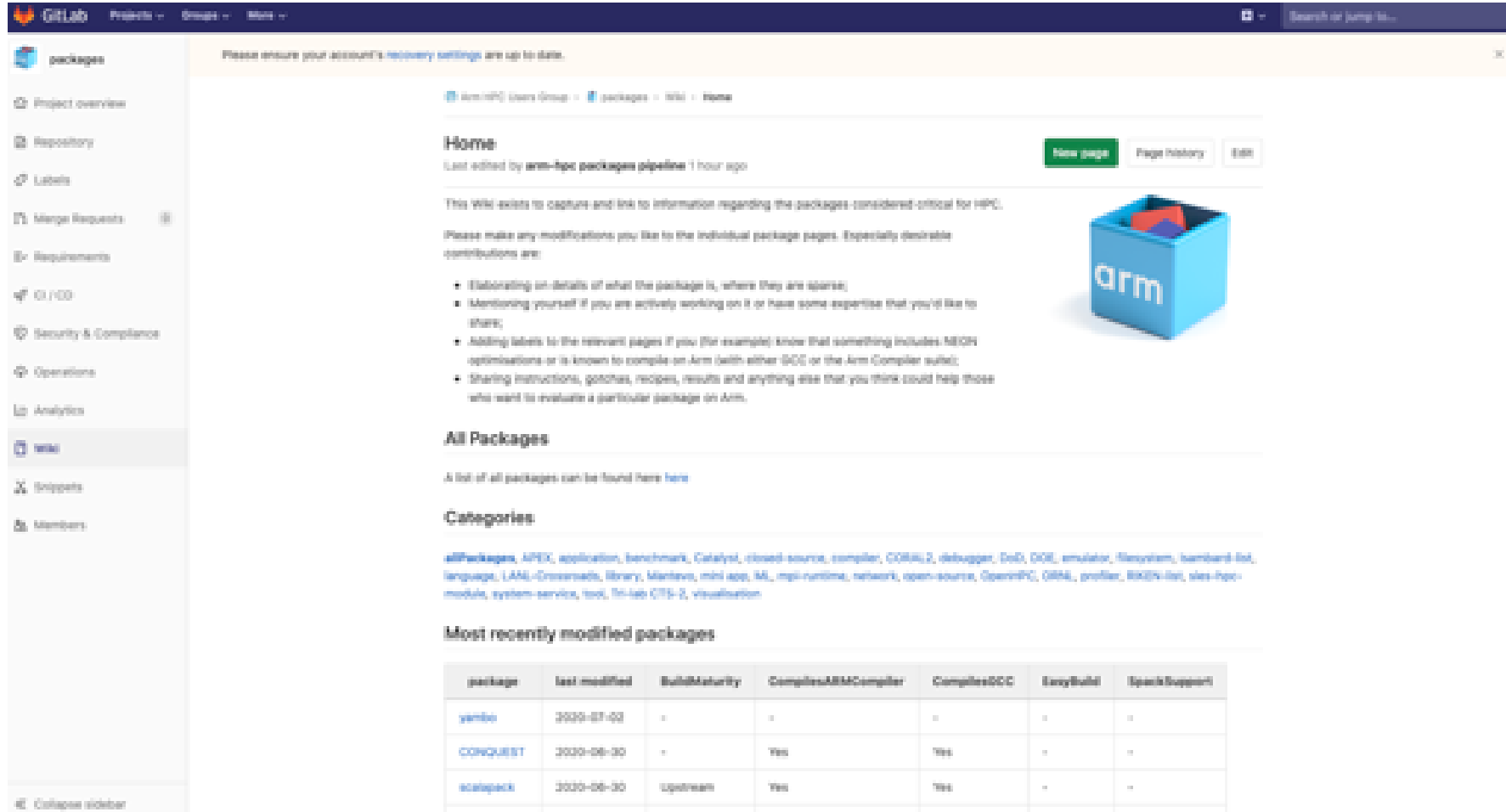
Supporting libraries and tools

Packages such as OpenBLAS and FFTW have contributions from our silicon partners and OEMs

We work with many communities to get Arm platforms better supported, such as the various MPI implementations, and are on the OpenMP steering committee

Applications in the Community

wiki.arm-hpc.org



The screenshot shows the GitHub interface for the `arm-hpc` organization's wiki. The left sidebar contains navigation links for `packages`, `Project overview`, `Repository`, `Labels`, `Merge Requests`, `Requirements`, `CI / CD`, `Security & Compliance`, `Operations`, `Analytics`, `Wiki`, `Snippets`, and `Members`. The main content area is titled `Home` and includes a `New page` button, `Page history`, and `Edit` options. The page content includes a warning about recovery settings, a description of the wiki's purpose, a list of packages considered critical for HPC, a list of categories, and a table of most recently modified packages.

Home

Last edited by `arm-hpc packages pipeline` 1 hour ago

This Wiki exists to capture and link to information regarding the packages considered critical for HPC.

Please make any modifications you like to the individual package pages. Especially desirable contributions are:

- Elaborating on details of what the package is, where they are applied;
- Mentioning yourself if you are actively working on it or have some expertise that you'd like to share;
- Adding labels to the relevant pages if you (for example) know that something includes NEON optimisations or is known to compile on Arm (with either GCC or the Arm Compiler suite);
- Sharing instructions, gotchas, recipes, results and anything else that you think could help those who want to evaluate a particular package on Arm.

All Packages

A list of all packages can be found [here](#)

Categories

`allPackages`, `APEX`, `application`, `benchmark`, `Catalyst`, `closed-source`, `compiler`, `CORAL2`, `debugger`, `DevD`, `DOE`, `emulator`, `filesystem`, `hardware-fpga`, `language`, `LANL-Crossroads`, `library`, `Marlins`, `mini app`, `ML`, `mpi-runtime`, `network`, `open-source`, `OpenHPC`, `ORCA`, `profiler`, `ROSEN-1st`, `sles-hpc-module`, `system-service`, `tool`, `Ti-lab CTS-2`, `visualisation`

Most recently modified packages

package	last modified	BuildMaturity	CompilesARMCompiler	CompilesGCC	EasyBuild	SparkSupport
yambo	2020-07-02	-	-	-	-	-
CONQUEST	2020-06-30	-	Yes	Yes	-	-
scalapack	2020-06-30	upstream	Yes	Yes	-	-

Applications



Applications & frameworks

abinit, psdns, arbor, qmcpack, castep, quantumespresso, flecsale, raja, gromacs, sparta, kokkos, specfem3d, tensorflow, geant4, lammmps, sw4, pytorch, mxnet, nalu, milc, thornado, namd. vasp, nwchem, openfoam, wrf...



Mini apps

branson, pennant. cloverleaf, pf3dkernels, cloverleaf3d, quicksilver, e3smkernels, snap, kripke, snbone, lulesh.f tealeaf, miniamr, minife, minighost, nekbone. neutral...



Benchmarks

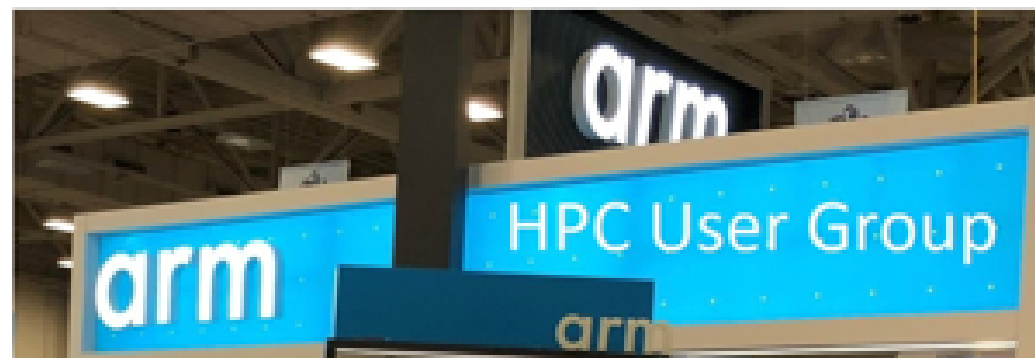
amg, nsimd, carmpl, nsimd-sve, clom, npb, elefun, polybench. epcc_c, stream, epcc_f, tsvc, umt, graph500, xsbench, hpcg, hpl hydrobench, ncar...

Community resources

<https://gitlab.com/arm-hpc/packages/wiki/>

Community Groups

<https://arm-hpc.groups.io/g/ahug>



Arm HPC User Group (AHUG) ahug@arm-hpc.groups.io

The Arm HPC User Group collaboration and info-sharing site for end-users and ecosystem partners. Please do NOT post any restricted or confidential information on this site.

This site offerings the following:

- A focal point for HPC leadership to guide and influence the direction of the collaboration in support of the Arm HPC ecosystem and its user group.
- Curated/moderated main and sub-groups aligned with Arm HPC ecosystem initiatives, deployments, projects.
- Email reflectors (arm-hpc@groups.io) reaching all members as well as separate email aliases for each sub-group.
- Topic discussions for the main AHUG arm-hpc group and each sub-group.
- User directories and points of contact.

This site is NOT intended to duplicate or replace existing Arm HPC content portals and resources such as:

- <https://developer.arm.com/hpc> (Arm's hosted HPC ecosystem portal covering ecosystem news, blogs, presentations, training, software, tools, etc)
- <https://gitlab.com/arm-hpc/packages/wikis/home> (Arm HPC SW Packages Wiki)
- <https://community.arm.com/tv/hpc> (Arm Community HPC Blog landing page)

Discussion in this forum is vastly preferred, in order to reach the widest range of recipients and promote the most vibrant discussion possible.

AHUG Topics of discussion: <https://arm-hpc.groups.io/g/ahug/topics>

Arm Developer

<https://developer.arm.com/solutions/hpc>

The screenshot shows the 'HPC on Arm' page on the Arm Developer website. The page has a dark header with the 'armDeveloper' logo and navigation links. Below the header, there's a breadcrumb trail: 'Home | Solutions | High-Performance Computing'. The main title 'HPC on Arm' is prominently displayed. A secondary navigation bar includes links for 'Overview', 'HPC Software', 'HPC Hardware', 'Blog', 'News', 'Events', 'Presentations', 'Tutorials', and 'Resources'. The main content area features four circular icons representing different stages of the HPC workflow: 'Get started' (gear icon), 'Develop' (microscope icon), 'Run' (document icon), and 'Collaborate' (puzzle piece icon). Each icon is accompanied by a brief description and a 'Learn more' button. The bottom section, titled 'Software Ecosystem for HPC on Arm', lists various tools and resources organized into three columns: Applications, Compilers, Debug tools, and Profiling tools; Python packages, Math libraries, and File systems; and Parallelism, Operating Systems, and Workload managers.

armDeveloper

IP Products ▾ Tools and Software ▾ Architectures ▾ Solutions ▾ Community ▾ Support ▾ Documentation ▾ Downloads ▾

[Home](#) | [Solutions](#) | High-Performance Computing

HPC on Arm

[Overview](#) [HPC Software ▾](#) [HPC Hardware](#) [Blog](#) [News](#) [Events](#) [Presentations](#) [Tutorials](#) [Resources ▾](#)



Get started

Learn about HPC on 64-bit Arms (AArch64) platforms.

[Get started on Arm](#)



Develop

Maximum performance for your HPC and scientific codes.

[Learn more](#)



Run

Build and run common HPC applications on Arm.

[Learn more](#)



Collaborate

Join and share with a growing community of HPC users.

[Learn more](#)

Software Ecosystem for HPC on Arm

Learn more about commercial and open-source HPC tools.

Applications	Python packages	Parallelism
Compilers	Math libraries	Operating Systems
Debug tools	File systems	Workload managers
Profiling tools		

Events and Hackathons

<https://gitlab.com/arm-hpc/training/arm-sve-tools>



Join us for another Arm Scalable Vector Extension Hackathon! This hands-on, non-NDA event will introduce vector length agnostic programming and jumpstart developers targeting the first CPU to implement SVE, the Fujitsu A64FX. Hands-on exercises will introduce SVE compilers, libraries, and tools from Fujitsu, Cray, Arm, and GNU, and show how popular HPC codes can take advantage of SVE. Bring your own code or use our prepared hands-on exercises!

This event is generously supported by Fujitsu and the University of Bristol. Fujitsu will provide remote access to a [Fujitsu PRIMEHPC FX700](#) system. The University of Bristol will provide access to the [HPE Apollo 80](#) partition of [Isambard 2](#), the largest Arm-based supercomputer in Europe. Don't miss out! Remote access details will be provided to all registered attendees.

arm

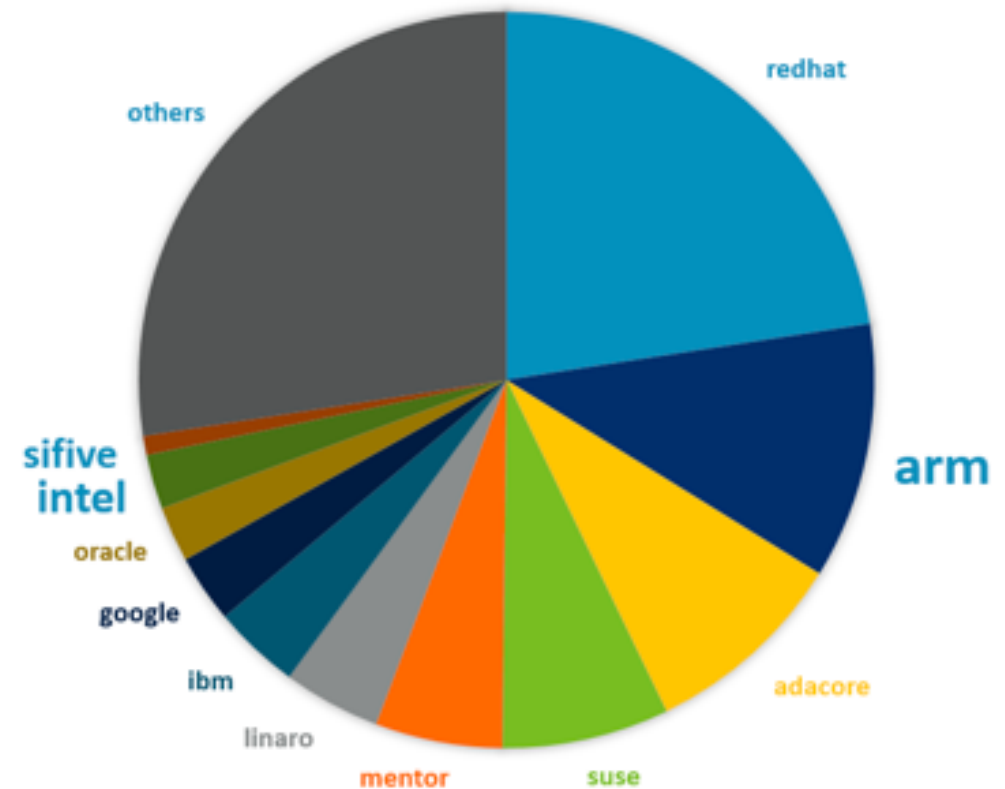
Compilers, Libraries and Tools

GNU compilers are a solid option

With Arm being significant contributor to upstream GNU projects



- GNU compilers are first class Arm compilers
 - Arm is one of the largest contributors to GCC
 - Focus on enablement and performance
 - Key for Arm to succeed in Cloud/Data center segment
- GNU toolchain ships with Arm Allinea Studio
 - Best effort support
 - Bug fixes and performance improvements in upcoming GNU releases



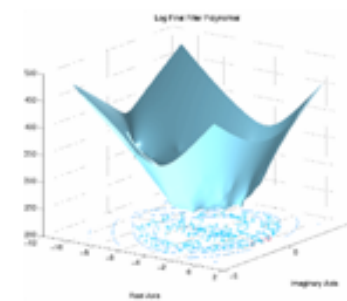
GCC

GCC 10.2

- GCC 10.2
 - Scalable Vector Extension (SVE) ACLE types and intrinsics now supported(`arm_sve.h`)
 - Improved vectorizer for SVE (gather loads, scatter stores and cost model)
 - ACLE intrinsics enables support for
 - The Transactional Memory Extension
 - The Matrix Multiply extension
 - Armv8.6-A features, e.g. the bfloat16 extension `-march=armv8.6-a`
 - SVE2 with `-march=armv8.5-a+sve2`
- GCC 11.0
 - Support for the Fujitsu A64FX `-mcpu=a64fx`

Open Source Maths Libraries

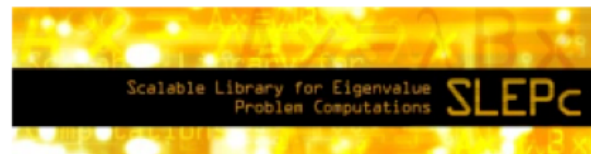
<https://developer.arm.com/solutions/hpc/hpc-software/categories/math-libraries>



ARPACK

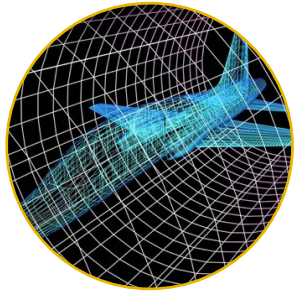


Eigen



And OpenBLAS, FFTW, BLIS, PETSc, ATLAS, PBLAS, ScaLAPACK

arm ALLINEA STUDIO



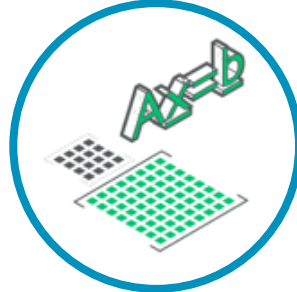
Fortran Compiler

- Fortran 2003 support
- Partial Fortran 2008 support
- OpenMP 3.1
- Directives to support explicit vectorization control
- SVE



C/C++ Compiler

- C++ 14 support
- OpenMP 4.5 without offloading
- SVE



Performance Libraries

- Optimized math libraries
- BLAS, LAPACK and FFT
- Threaded parallelism with OpenMP
- Optimized maths intrinsics



Forge

- Profile, Tune and Debug
- Scalable debugging with DDT
- Parallel Profiling with MAP



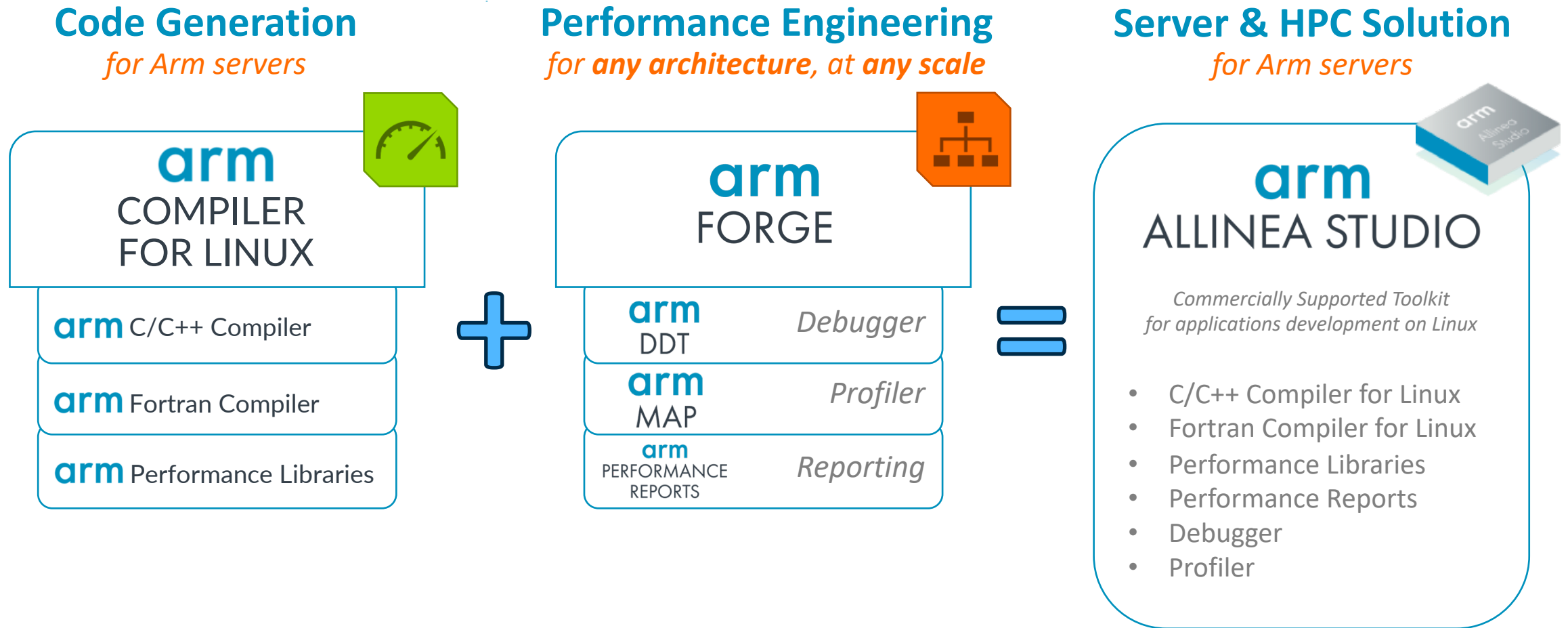
Performance Reports

- Analyze your application
- Memory, MPI, Threads, I/O, CPU metrics

Tuned by Arm for server-class Arm-based platforms

Server & HPC Development Solutions from Arm

Best in class commercially supported tools for Linux and high-performance computing



Arm Compiler for HPC: Front-end

Clang and Flang

C/C++

- Clang front-end
 - C11 including GNU11 extensions and C++14
 - Arm's 10-year roadmap for Clang is routinely reviewed and updated to respond to customers
- C11 with GNU11 extensions and C++14
- **Auto-vectorization for SVE and NEON**
- OpenMP 4.5

Fortran

- Flang front-end
 - Extended to support gfortran flags
- Fortran 2003 with some 2008
- **Auto-vectorization for SVE and NEON**
- OpenMP 3.1
- Transition to flang "F18" in progress
 - Extensible front-end written in C++17
 - Complete Fortran 2008 support
 - OpenMP 4.5 support

arm PERFORMANCE LIBRARIES



Best-in-class performance



Commercially Supported
by Arm

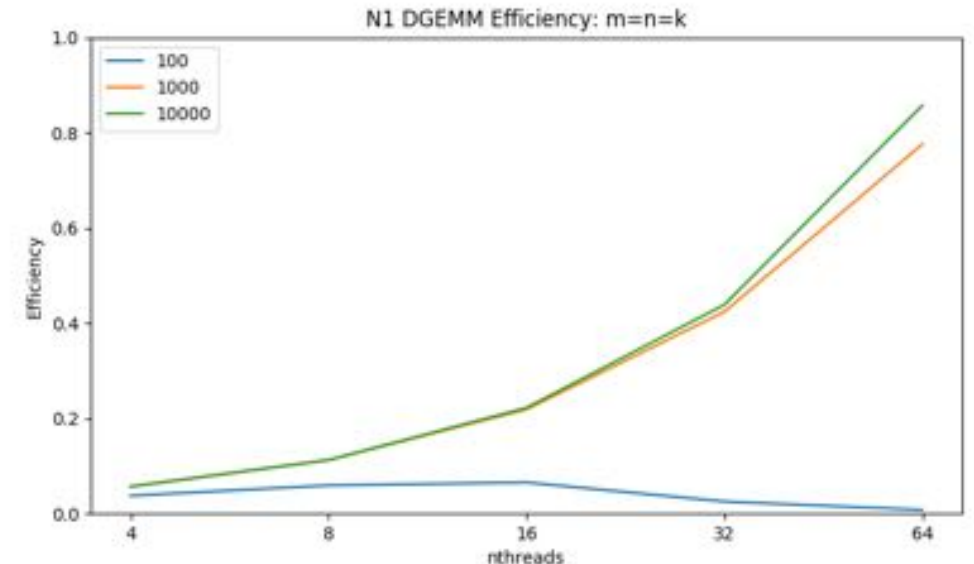


Validated with
NAG test suite

- Commercial 64-bit ArmV8-A math Libraries
 - Commonly used low-level maths routines – BLAS, LAPACK and FFT
 - Optimised maths intrinsics
 - Validated with NAG's test suite, a de facto standard
- Best-in-class performance with commercial support
 - Tuned by Arm for specific cores – like Arm Neoverse-N1
 - Maintained and supported by Arm for wide range of Arm-based SoCs
- Silicon partners can provide tuned micro kernels for their SoCs
 - Partners can contribute directly through open source routes
 - Parallel tuning within our library increases overall application performance

Optimised Maths Libraries (Arm Performance Libraries)

- Arm produce a set of accelerated maths routines
 - Microarchitecture tuned for each Arm core
 - BLAS, LAPACK, FFT (Standard interface)
 - Tuned math calls
 - Transcendentals (libm) + string functions
 - Sparse operations
 - SpMV / SpMM
 - Available for GCC and Arm compiler
- Other vendor maths libraries also available
 - HPE/Cray (LibSci), Fujitsu (SSL2), NVIDIA HPC SDK math libraries



DGEMM Performance on the
Neoverse N1 for different matrix sizes
Max efficiency 85.7%

Forge

Debug, profile and analyse at scale

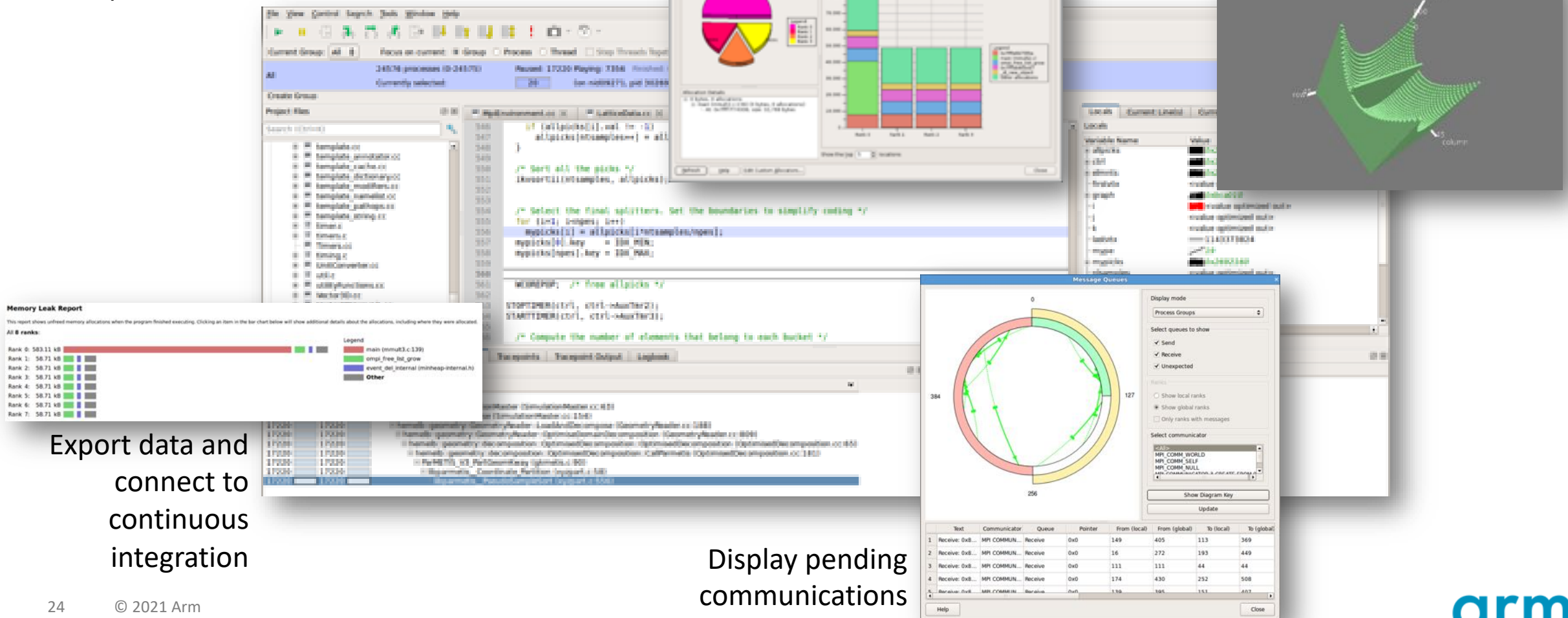
- CUDA GDB is now shipped on AArch64
- Assembly debugging mode in DDT
- RHEL 8 support
- GDB 8.2 (default)
- Python debugging in DDT
- Perf Metrics support for A76 and Neoverse-N1 CPUs
- Configurable perf metric support
- Statistical Profiling Extension (SPE) in MAP
- Release 21.0

Arm Forge – DDT Parallel Debugger

Switch between
MPI ranks and
OpenMP threads

Analyze memory usage

Visualize data structures



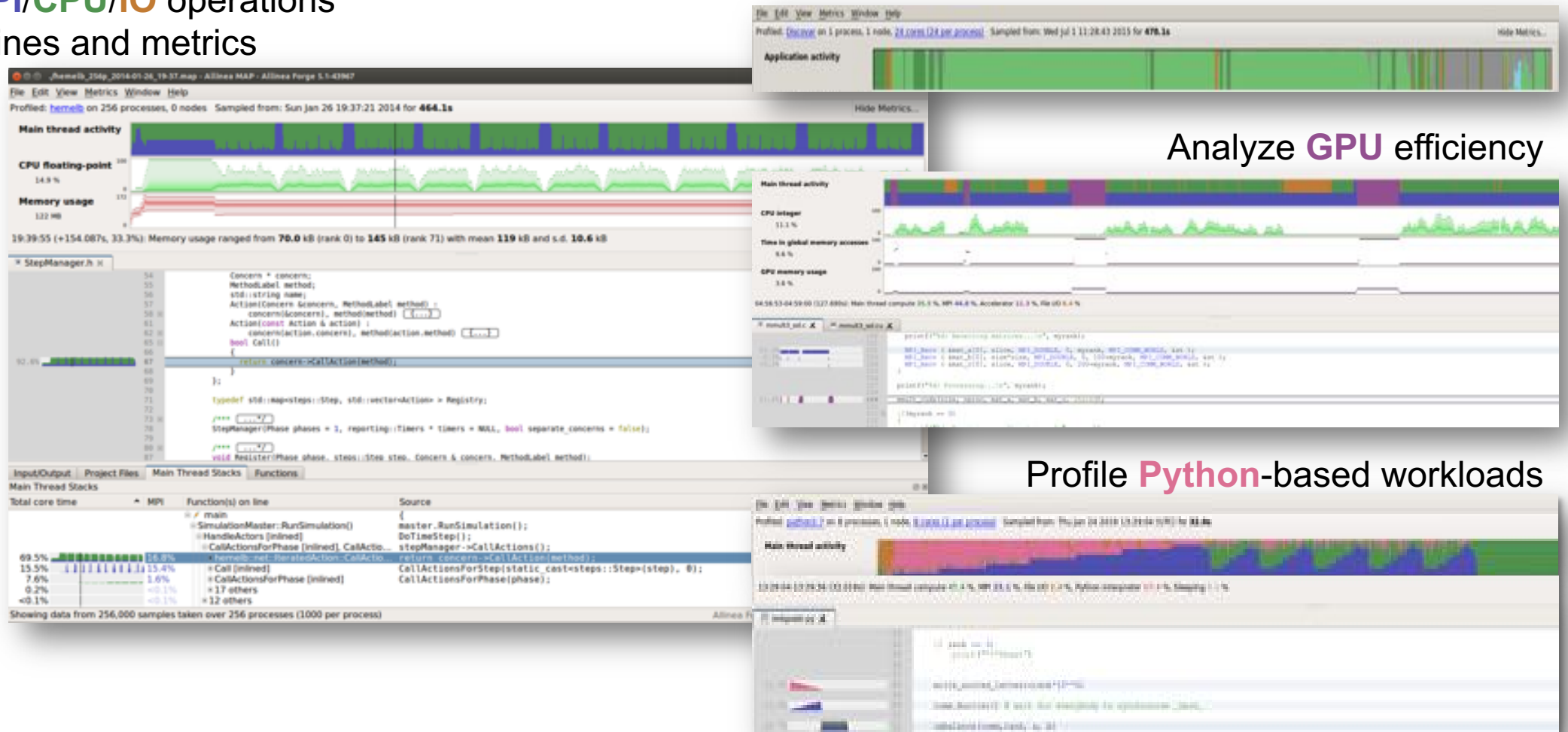
Arm Forge – MAP Multi-node Low-overhead Profiler

Understand **MPI**/**CPU**/**IO** operations thanks to timelines and metrics

Inspect **OpenMP** activity

Analyze **GPU** efficiency

Investigate annotated source code and stack view



Vendor and Partner Compilers, Libraries and Tools

- NVIDIA HPC SDK 21.1.0
 - Fortran, C, C++,
CUDA, OpenACC,
math libraries,
Nsight profiler
- Fujitsu Compiler
 - MPI and Coarrays,
SSL II math libraries,
IDE debugger and
profiler
- HPE Cray Compiling
Environment
 - MPI, LibSci,
Perftools



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Thank You

Danke

Gracias

谢谢

ありがとう

Asante

Merci

감사합니다

धन्यवाद

Kiitos

شكراً

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