# ARM HPC Ecosystem

**ARM**

Darren Cepulis

HPC Segment Manager

ARM Business Segment Group

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# ARM Collaboration for Exascale Programs

## United States

ARM is currently a participant in two Department of Energy funded pre-Exascale projects: Data Movement Dominates and Fast Forward 2.

## Japan

Fujitsu and RIKEN announced that the Post-K system targeted at Exascale will be based on ARMv8 with new Scalable Vector Extensions.

## European Union

Through FP7 and Horizon 2020, ARM has been involved in several funded pre-Exascale projects including the Mont Blanc program which deployed one of the first ARM prototype HPC systems.

## China

James Lin, vice director for the Center of HPC at Shanghai Jiao Tong University claims China will build three pre-Exascale prototypes to select the architecture for their Exascale system. The three prototypes are based on AMD, SunWei TaihuLight, and ARMv8.

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# ARM HPC deployments starting in 2H2017

## Two recent announcements about ARM in HPC in Europe:



**insideHPC**

**Bull Atos to Build HPC Prototype for Mont-Blanc Project using Cavium ThunderX2 Processor**

January 16, 2017 by staff

Today the Mont-Blanc European project announced it has selected Cavium's ThunderX2 ARM server processor to power its new HPC prototype.

The new Mont-Blanc prototype will be built by Atos, the coordinator of phase 3 of Mont-Blanc, using its Bull expertise and products. The platform will leverage the infrastructure of the Bull sequana pre-exascale supercomputer range for network, management, cooling, and power. Atos and Cavium signed an agreement to collaborate to develop this new platform, thus making Mont-Blanc an Alpha-site for ThunderX2.

**Bull** atos technologies



University of BRISTOL — GW4

January 17th 2017

## Announcing the GW4 Tier 2 HPC service, 'Isambard': named after Isambard Kingdom Brunel

**System specs:**

- Cray CS-400 system
- **10,000+** ARMv8 cores
- HPC optimised software stack
- Technology comparison:
  - x86, KNL, Pascal
- To be installed March-Dec 2017
- £4.7m total project cost over 3 years

I.K.Brunel 1804-1859

Simon McIntosh Smith, simonm@cs.bris.ac.uk, @simonmcs          5          bristol.ac.uk

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# Japan Exascale

## Post-K: Fujitsu HPC CPU to Support ARM v8 — ARM FUJITSU

Post-K fully utilizes Fujitsu proven supercomputer microarchitecture

Fujitsu, as a lead partner of ARM HPC extension development, is working to realize ARM Powered® supercomputer w/ high application performance

ARM v8 brings out the real strength of Fujitsu's microarchitecture

| HPC apps acceleration feature | Post-K | FX100 | FX10 | K computer |
|---|---|---|---|---|
| FMA: Floating Multiply and Add | ✔ | ✔ | ✔ | ✔ |
| Math. acceleration primitives* | ✔ Enhanced | ✔ | ✔ | ✔ |
| Inter core barrier | ✔ | ✔ | ✔ | ✔ |
| Sector cache | ✔ Enhanced | ✔ | ✔ | ✔ |
| Hardware prefetch assist | ✔ Enhanced | ✔ | ✔ | ✔ |
| Tofu interconnect | ✔ Integrated | ✔ Integrated | ✔ | ✔ |

* Mathematical acceleration primitives include trigonometric functions, sine & cosines, and exponential...

slides from Fujitsu at ISC'16

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# Foundational SW Ecosystem for HPC

- Linux OS's – RedHat, SUSE, CENTOS, UBUNTU,…
- Compilers – ARM, GNU, LLVM,…
- Libraries – ARM, OpenBLAS, BLIS, ATLAS, FFTW…
- Parallelism – OpenMP, OpenMPI, MVAPICH2,…
- Debugging – Allinea, RW Totalview, GDB,…
- Analysis – ARM, Allinea, HPCToolkit, TAU,…
- Job schedulers – LSF, PBS Pro, SLURM,…
- Cluster mgmt – Bright, CMU, warewulf,…

Commercial

Open-source

# Predictable Baseline

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# openHPC – now on ARM

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

## ARM's participation:

- Silver member of OpenHPC
- ARM is on the OpenHPC Technical Steering Committee in order to drive ARM architecture build support

## Status (April 2017):

- 1.3.0 release out now
- All packages built on ARMv8 for both CentOS and SUSE
- ARM-based machines are being used for builds in the OpenHPC build infrastructure at TACC
- https://github.com/arm-hpc/ohpc/

| Functional Areas | Supported packages / components |
|---|---|
| Base OS | RHEL/CentOS 7.1, SLES 12 |
| Administrative Tools | Conman, Ganglia, Lmod, LosF, ORCM, Nagios, pdsh, prun |
| Provisioning | Warewulf |
| Resource Mgmt. | SLURM, Munge. Altair PBS Pro |
| I/O Services | Lustre client (community version) |
| Numerical, Scientific Libraries | Boost, GSL, FFTW, Metis, PETSc, Trilinos, Hypre, SuperLU, Mumps |
| I/O Libraries | HDF5 (pHDF5), NetCDF (including C++ and Fortran interfaces), Adios |
| Compiler Families | GNU (gcc, g++, gfortran) |
| MPI Families | OpenMPI, MVAPICH2 |
| Development Tools | Autotools (autoconf, automake, libtool), Valgrind,R, SciPy/NumPy |
| Performance Tools | PAPI, Intel IMB, mpiP, pdtoolkit TAU |

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# ARM HPC tools commercial portfolio

## ARM C/C++ Compiler

COMMERCIALLY SUPPORTED
FOR HPC APPLICATIONS

## ARM Performance Libraries

BLAS, LAPACK and FFT
MICRO-ARCHITECTURALLY TUNED

## ARM Code Advisor

ACTIONABLE ADVICE TO
OPTIMIZE YOUR CODE

## ARM SVE C/C++ Compiler

COMPILER SUPPORT FOR
ARM SCALABLE VECTOR EXTENSION

## ARM Instruction Emulator

DEVELOP SOFTWARE FOR
TOMORROW'S HARDWARE TODAY

## Allinea Forge (DDT+MAP)

CODE DEBUGGING and PROFILING
TOOLS for HPC APPLICATIONS

## Allinea Performance Reports

MONITOR AND TUNE APPLICATION
PERFORMANCE IN THE FIELD

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# ARM Compiler

Commercially supported C/C++ compiler for Linux user-space HPC applications
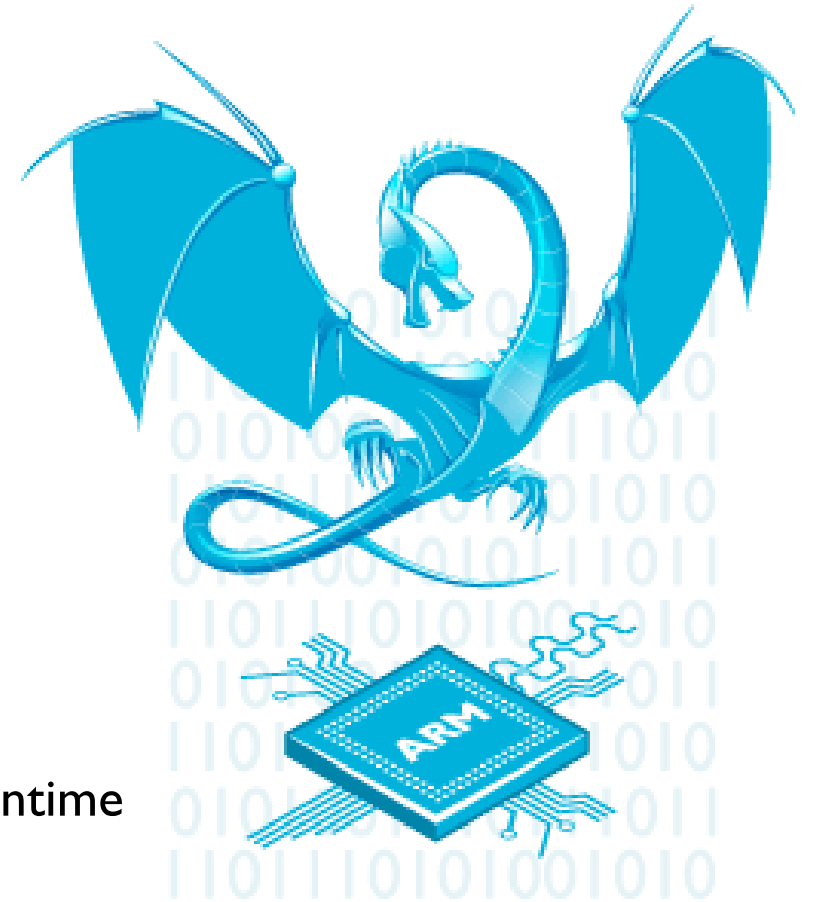
## LLVM-based

- LLVM-based
- ARM-on-ARM compiler
- For application development (not bare-metal/embedded)

## Fortran in the works

- Leveraging on-going PGI FLANG collaboration

## OpenMP

- Uses latest open source (now ARM-optimized) LLVM OpenMP runtime

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# ARM Performance Libraries

## Optimized BLAS, LAPACK and FFT

### Commercial 64-bit ARMv8 math libraries

- Commonly used low-level math routines - BLAS, LAPACK and FFT.
- Validated with NAG's test suite, a de-facto standard.

Performance on par
with best-in-class math libraries

### Best-in-class performance with commercial support

- Tuned by ARM for Cortex-A72, Cortex-A57 and Cortex-A53.
- Maintained and Supported by ARM for a wide range of ARM-based SoCs.
- Regular benchmarking against open source alternatives.

Commercially Supported
by ARM

### Silicon partners can provide tuned micro-kernels for their SoCs

- Partners can collaborate directly working with our source-code and test suite.
- Alternatively they can contribute through open source route.

Validated with
NAG test suite

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# Open source in the ARM HPC ecosystem

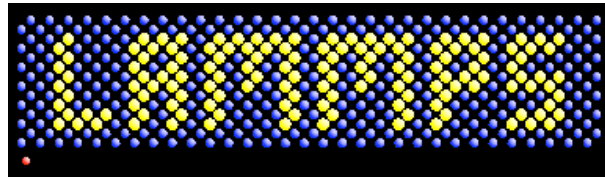- Many open-source applications have been ported to ARMv8 for a variety of HPC sectors:

Open▽FOAM

NAMD
Scalable Molecular Dynamics

GROMACS FAST. FLEXIBLE. FREE.

QUANTUMESPRESSO

Geant 4

LAMMPS

WRF

Further reading:

www.arm.com/hpc

https://www.nextplatform.com/2017/03/15/arm-antes-hpc-software-stack/

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# Server OS support solidifies for ARM in 2016

- **SUSE (SLES 12)** providing first commercial enterprise Linux distribution optimized for ARM-based 64-bit servers - https://www.suse.com/products/arm

- **Red Hat** Enterprise Linux Server for ARM (RHELSA) 7.3 release with single-host virtualization based on KVM, Ceph for prototyping and deploying and initial support for Red Hat Developer Toolset (latest stable open source C and C++) http://red.ht/2flVOH7

- **CentOS 7.3** for ARM64 released with greatly improved support for Cavium ThunderX SoC family https://lists.centos.org/pipermail/centos-announce/2017-January/022193.html

- **Canonical** and ARM collaborate on commercial Ubuntu OpenStack and Ceph for ARMv8 servers: https://insights.ubuntu.com/2016/10/17/canonical-and-arm-collaborate-on-openstack/

- **FreeBSD** 11 released - ARM joins x86 as primary architectures supported - https://www.freebsdfoundation.org/blog/freebsd-takes-open-source-to-11-with-latest-release/ and https://www.freebsd.org/releases/11.0R/relnotes.html

- **Xen** hypervisor 4.8 released - Updates focus on ARM server enhancements, security hardening and quality code: http://www.marketwired.com/press-release/xen-project-hypervisor-continues-to-expand-into-embedded-use-cases-in-latest-release-2181499.htm

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