arm

Software Ecosystem for Arm-based HPC

CUG 2018 - Stockholm
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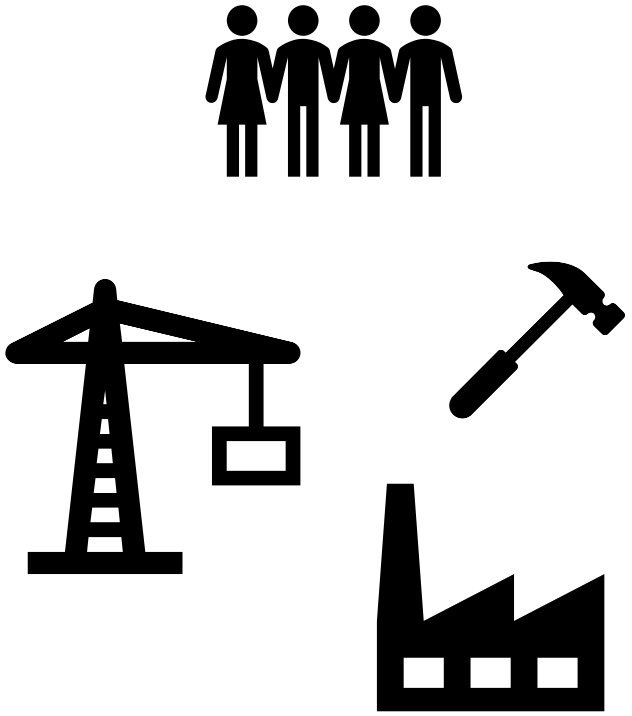
Ecosystem for HPC

List of components needed:

- Linux OS availability
- Compilers
- Libraries
- Job schedulers
- Debuggers
- Profilers



Mix of open source and commercial products and applications…

https://developer.arm.com/hpc/hpc-software

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Arm development tools portfolio for HPC

Arm Allinea Studio

Develop and run on today's hardware

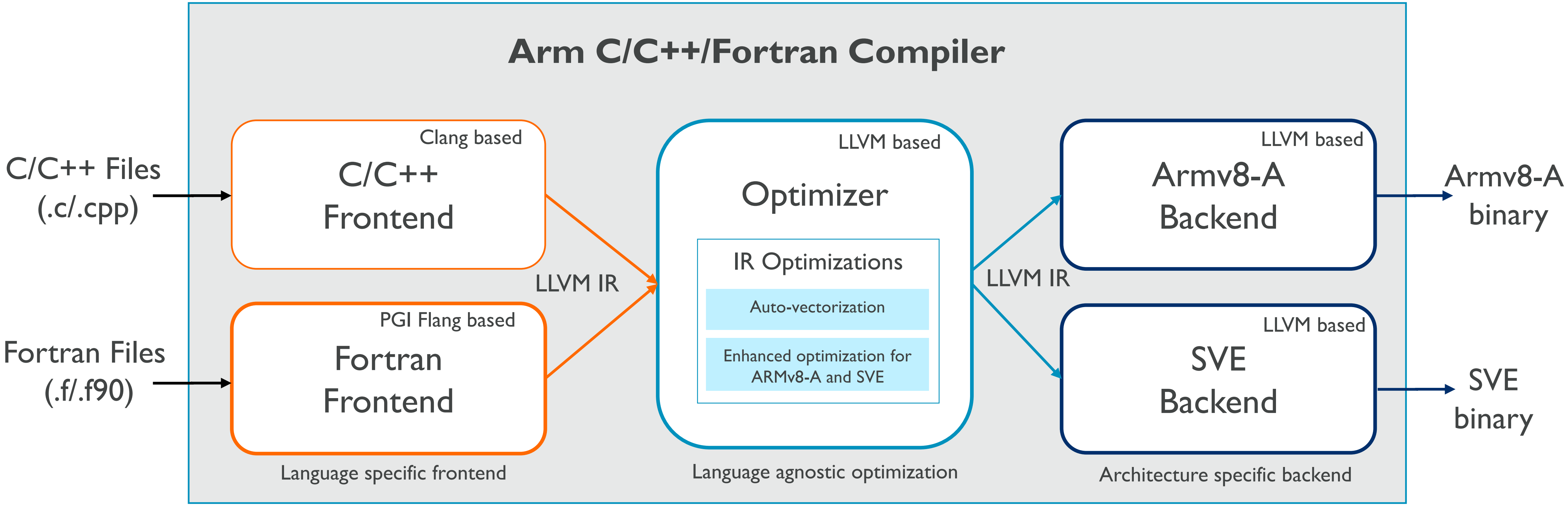
Arm Compiler for HPC	Arm Performance Libraries	Arm Forge Professional	Arm Performance Reports
Linux user space compiler for HPC applications	BLAS, LAPACK and FFT	Multi-node interoperable profiler and debugger	Interoperable application performance insight

and also…

Explore tomorrow's architecture today

Arm Code Advisor	Arm Instruction Emulator
Understand what the compiler could/could not do	Run SVE binaries on today's hardware

Arm Compiler – Building on LLVM, Clang and Flang projects

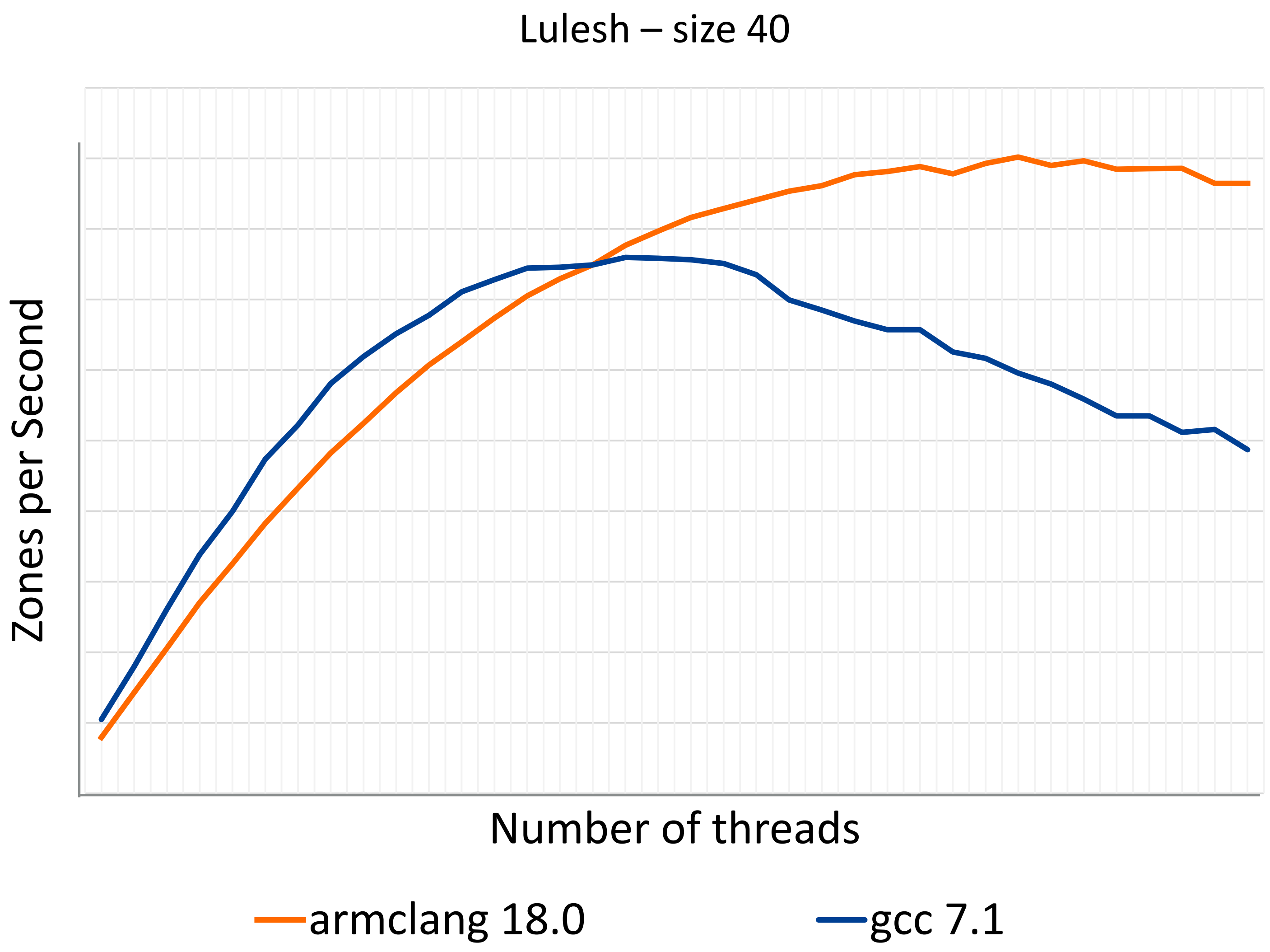


Arm Compiler – OpenMP scaling

Better scaling at higher thread count

Arm Compiler uses libomp based optimized OpenMP runtime

For Lulesh (Livermore Unstructured Lagrangian Explicit Shock Hydrodynamics), Arm Compiler shows better scaling than GCC for higher thread count



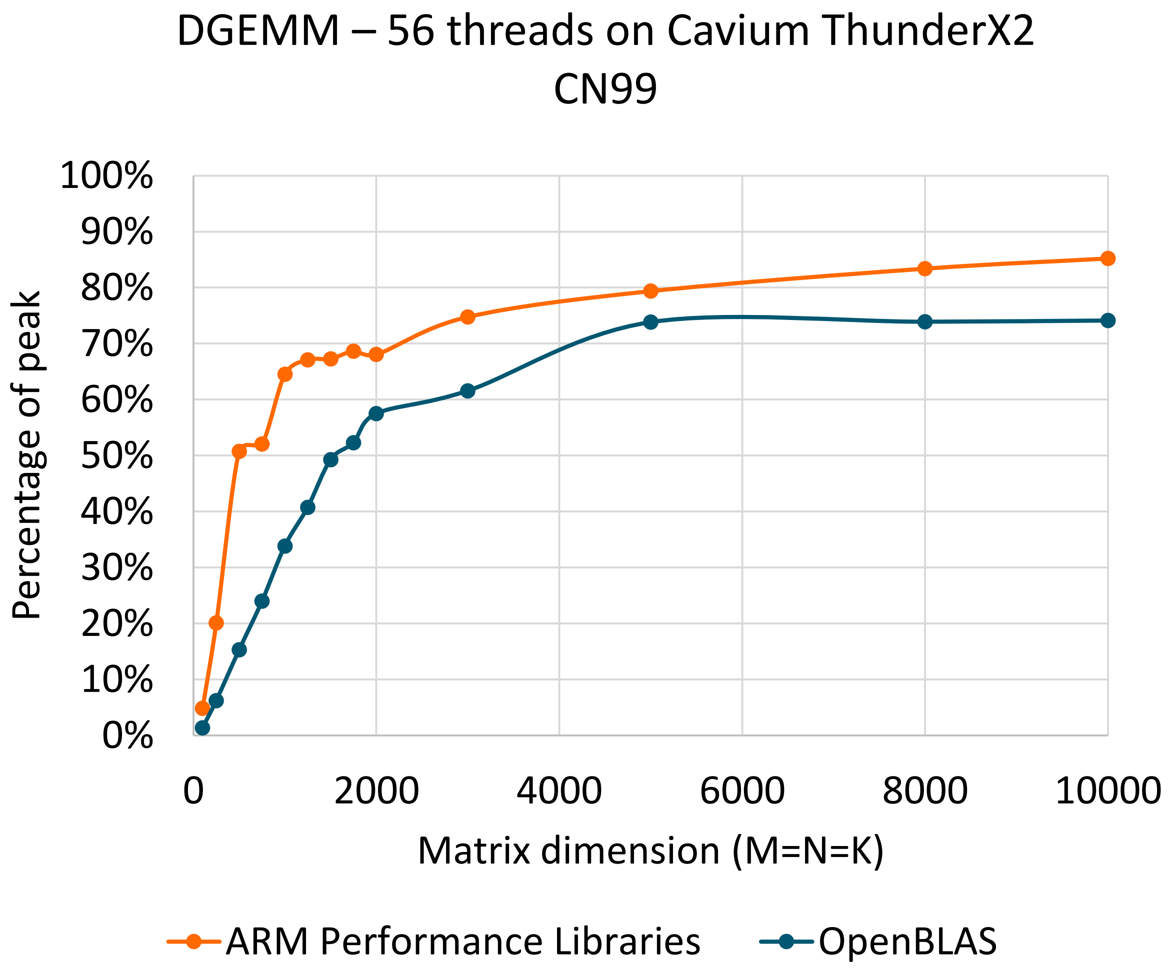
DGEMM performance on Cavium ThunderX2

Excellent serial and parallel performance

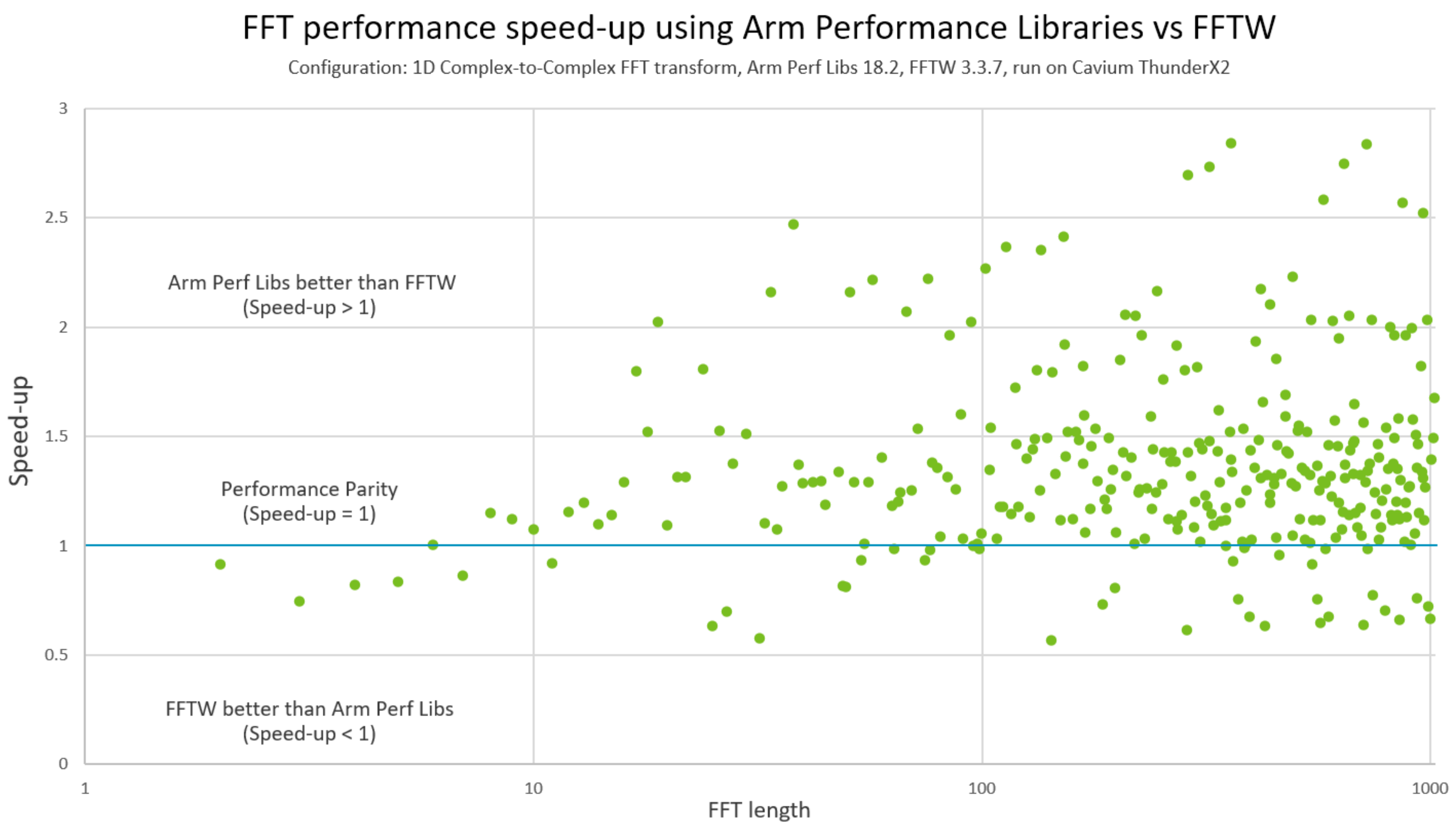
Achieving very high performance at the node level leveraging high core counts and large memory bandwidth

Single core performance at 95% of peak for DGEMM

Parallel performance significantly higher than OpenBLAS



Arm Performance Libraries



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Arm HPC ecosystem

Porting to Arm

Arm is engaging directly with partners and HPC scientific code developers to support porting and optimisation of common HPC libraries, tools and applications

Initial focus on successfully building with both **Arm** and **GCC** compilers across a broad front

Often only modest changes to environment variables, build scripts and architecture files are needed

Degree of commonality between codes

Example: Particle in Cell codes

Two different approaches

VPIC

Explicit 2nd order push, charge conserving

FDTD fields

C & C++ with MPI & pthreads

Low particle order

Heavily optimised push, previously tuned for specific platforms

Vector kernel

https://github.com/lanl/vpic

EPOCH

Explicit 2nd order push, charge conserving

FDTD fields

Fortran with MPI

High order particles

Flexible, extensible, versatile

Linked list storage

Dependencies: SDF

http://www.ccpp.ac.uk

Example: Leveraging Arm intrinsics from C

VPIC

VPIC's v4 kernel pushes four particles at a time – optimised with SSE SIMD calls

Arm's NEON instructions offer similar functionality

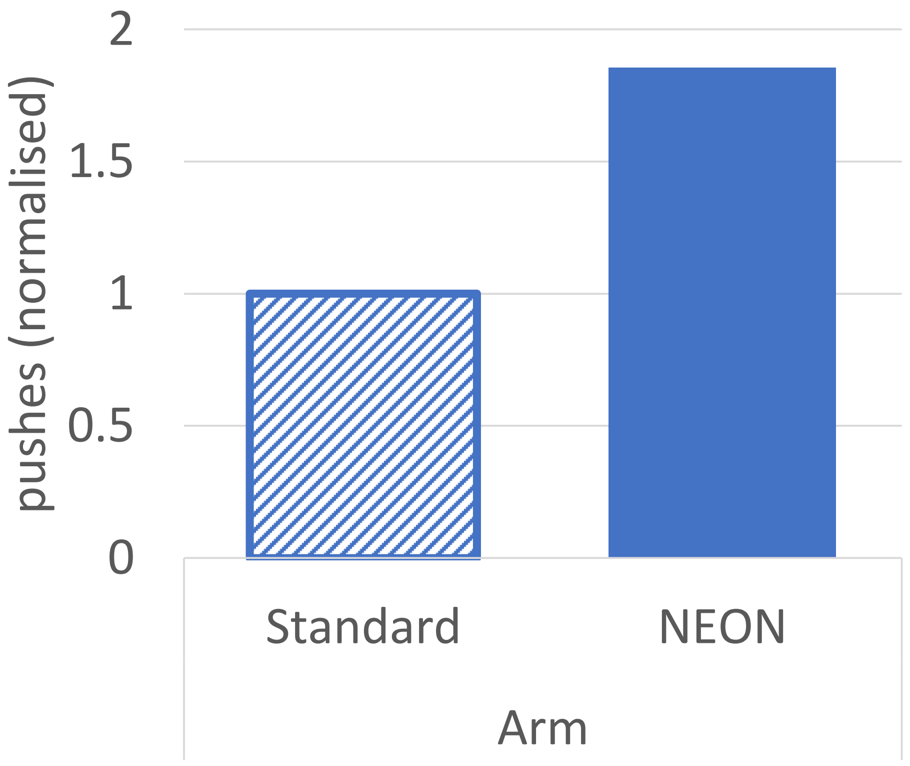
Datatypes and intrinsic calls from SSE can be mapped over to NEON in many cases

Projects like SIMD Everywhere:

https://github.com/nemequ/simde

may help generate portable code able to exploit Arm's vector calls

Could such vectorised kernels stand to benefit from Arm's SVE instructions?



Example: Leveraging Arm intrinsics from Fortran

EPOCH

Particle prefetch

Uses intel’s _mm_prefetch to improve performance of linked-list

src/housekeeping/prefetch.f90

```
SUBROUTINE prefetch_particle(p)
 TYPE(particle),INTENT(INOUT) :: p
#ifdef PREFETCH
 CALL mm_prefetch(p%part_p(1))
 CALL mm_prefetch(p%weight)
#endif
END SUBROUTINE prefetch_particle
```

Arm C compiler preload

Use __pld in place of _mm_prefetch

Requires Fortran 2003’s C-binding

```
INTERFACE
 SUBROUTINE arm_prefetch(p, x, w) BIND(C)
  USE, INTRINSIC :: iso_c_binding
  REAL(c_double),DIMENSION(3) :: p
  REAL(c_double), DIMENSION(c_ndims) :: x
  REAL(c_double) :: w
 END SUBROUTINE arm_prefetch
END INTERFACE
```

C wrapper

src/housekeeping/arm_intrinsics.c

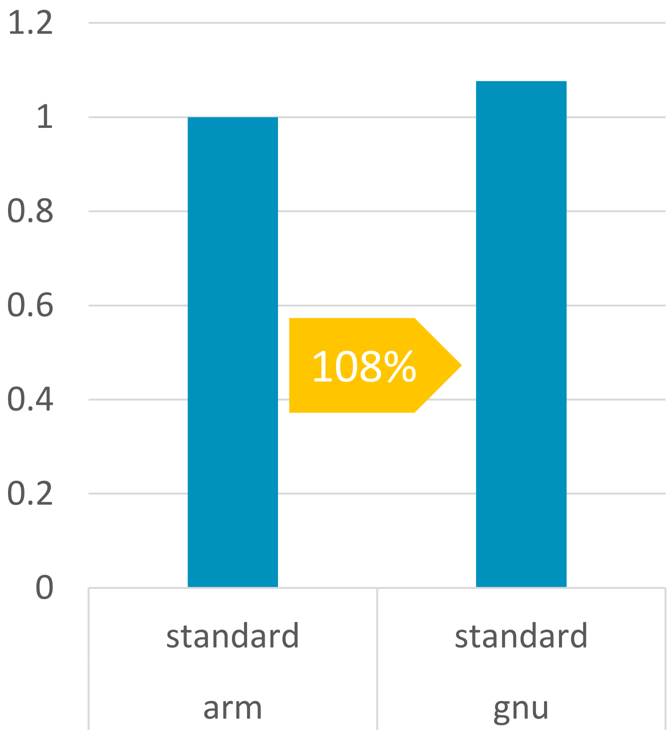
```
#include<arm_acle.h>
void arm_prefetch(void const* p)
{
  __pld(p);
  return;
}
```

A similar approach can be used to call GCC’s __builtin_prefetch

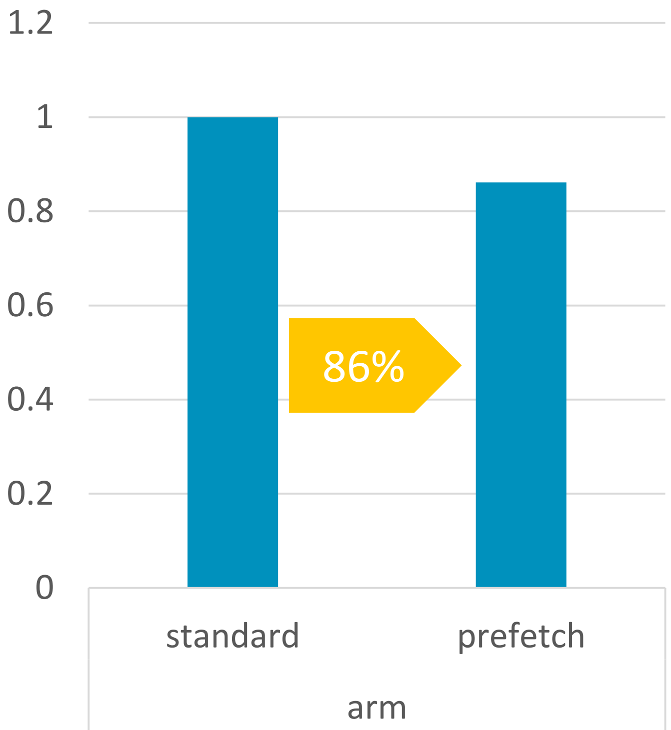
Example: Performance improvement

Speed-up memory-bound code

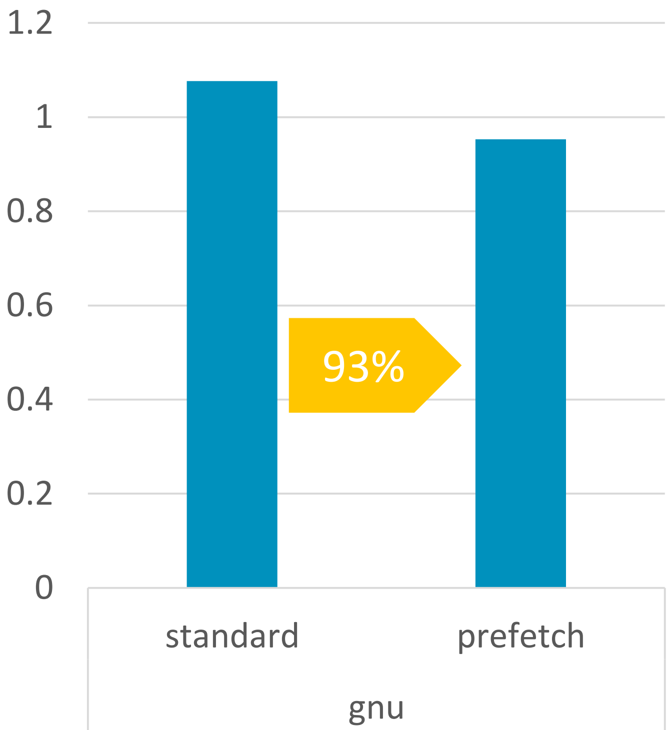
Armflang vs. GNU



Armflang with preload



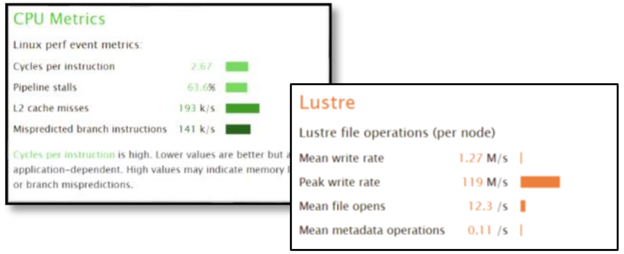
GNU with prefetch



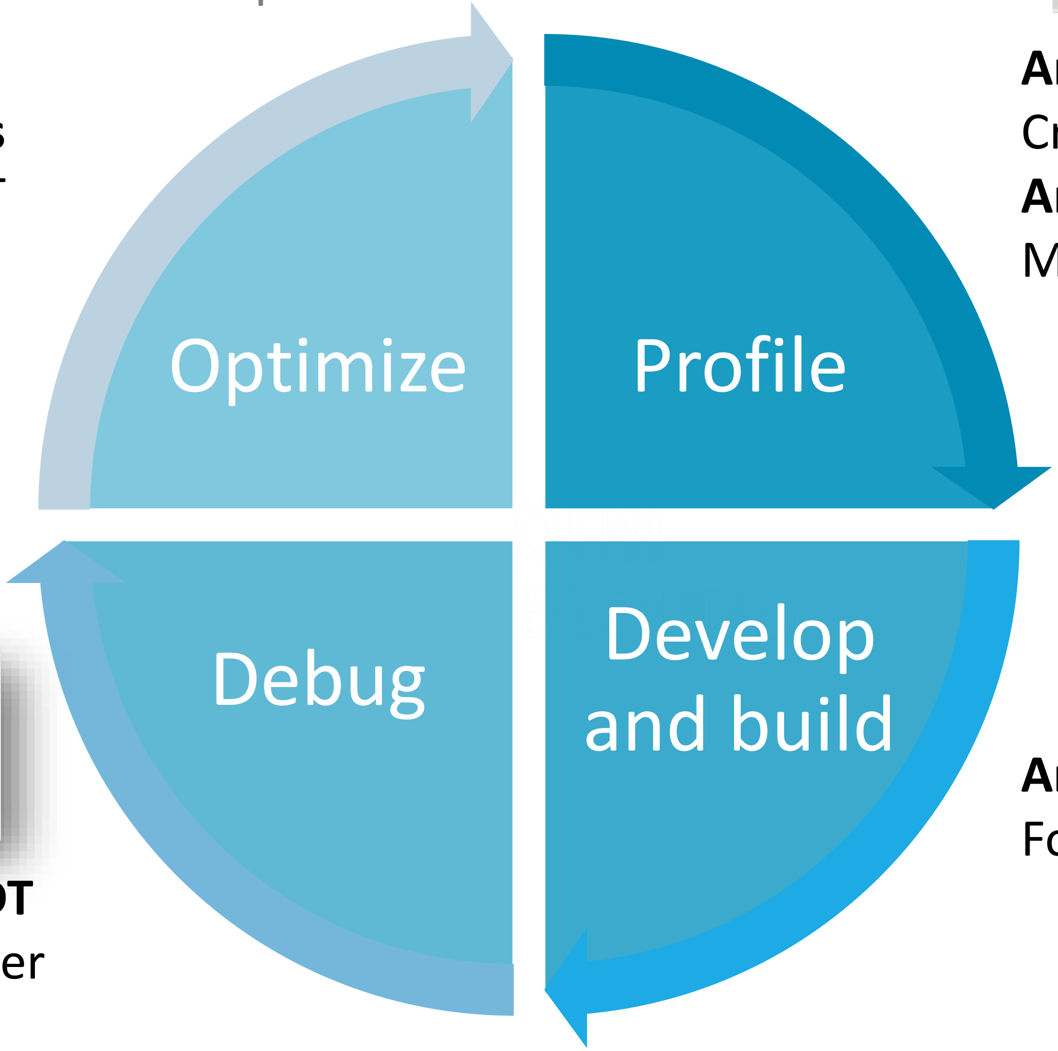
arm ALLINEA STUDIO

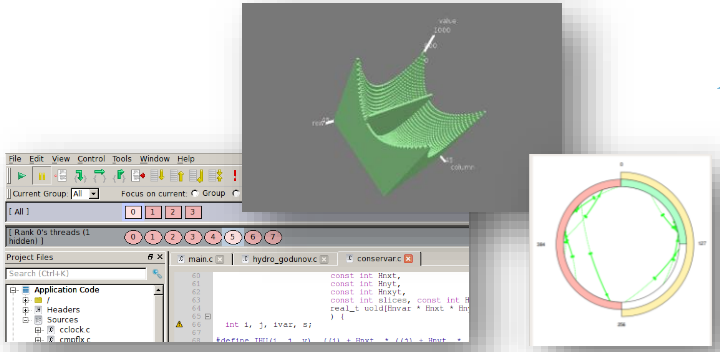
Meets the requirements of HPC developers on Arm

Arm MAP
Cross-platform lightweight profiler
Arm Performance Reports
Maximize System Efficiency



Arm Performance Libraries
BLAS, LAPLACK, FFT





Arm DDT
Cross-platform parallel debugger

Arm Compiler for HPC
For C, C++ and Fortran codes

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Community building

Outside the people we collaborate with, various complementary Arm HPC communities already exist:

- Arm HPC User Group (SC) and GoingArm (ISC/ArmRS)
- Arm HPC Google Group (https://groups.google.com/forum/#!forum/arm-hpc)
- Arm HPC GitLab pages (https://gitlab.com/arm-hpc/)

Encouraging our partners to use GitLab is a priority

Our app work is **engaging with code owners and users** to get suitable test cases, to get Arm support built in, and including helping them make AArch64 testing part of their development processes

Community site – gitlab.com/arm-hpc

https://gitlab.com/arm-hpc/packages/wikis/home

Dynamic list of common HPC applications

Provides focus for porting progress

Community driven.

Maintained by Arm, but anyone can join and contribute.

Allows developers to share recipes, and learn from progress on other applications

Provides a mechanism for tracking status of applications and package sets (e.g. OpenHPC packages, Mantevo, etc.)

Up-to-date summary of package status

Package	External URL	Last Wiki Update	BuildMaturity	CompilesARMCompiler	CompilesGCC	NEONOptimized
EPOCH	http://www.ccpp.ac.uk	19/10/17 22:10:20	NeedsPatch	Yes	Yes	-
SDF	https://github.com/keithbennett/SDF	20/10/17 00:13:45	NeedsPatch	Yes	Yes	-
VPIC	https://github.com/lanl/vpic	19/10/17 22:10:20	-	Yes	Yes	-
adios	http://www.olcf.ornl.gov/center-projects/adios/	17/07/17 23:33:11	-	Yes	Yes	-
arpack	http://www.caam.rice.edu/software/ARPACK/	17/07/17 23:33:11	-	Yes	-	-
autoconf	http://www.gnu.org/software/autoconf/autoconf.html	01/08/17 21:48:30	-	Yes	Yes	-
automake	http://www.gnu.org/software/automake	18/07/17 13:41:43	-	Yes	Yes	-
bookleaf	https://uk-mac.github.io/BookLeaf/	17/07/17 23:33:11	-	Yes	Yes	-
boost	http://www.boost.org	18/07/17 11:29:00	-	Yes	Yes	-
ccs-qcd	https://github.com/fiber-miniapp/ccs-qcd	01/08/17 21:43:40	-	Yes	-	-
cloverleaf	http://uk-mac.github.io/CloverLeaf/	19/10/17 22:10:20	Upstream	Yes	Yes	-
cloverleaf3d	http://uk-mac.github.io/CloverLeaf3D/	24/07/17 21:41:31	Upstream	Yes	Yes	-
comd	http://exmatex.github.io/CoMD	24/07/17 21:36:31	Upstream	Yes	Yes	-
dgemm	http://www.nersc.gov/research-and-development/apex/apex-benc	24/07/17 21:36:31	NeedsPatch	Yes	Yes	-
ffb	http://www.ciss.iis.u-tokyo.ac.jp/riss/english/project/fluid/	24/07/17 21:36:31	-	Yes	-	-
fftw	https://github.com/FFTW/fftw3	17/07/17 23:33:11	-	Yes	Yes	Yes
gnu-scientific-library	http://www.gnu.org/software/gsl/	18/07/17 07:08:24	-	Yes	Yes	-
gromacs	http://www.gromacs.org/	24/07/17 21:36:31	-	Yes	Yes	-
hdf5	http://www.hdfgroup.org	17/07/17 23:33:11	-	Yes	Yes	-
hpc-challenge	http://icl.cs.utk.edu/hpcc/index.html	24/07/17 21:36:31	Upstream	Yes	Yes	-
hpccg	http://mantevo.org/downloads/HPCCG-1.0.html	24/07/17 21:36:31	Upstream	Yes	Yes	-
hpcg	http://www.nersc.gov/research-and-development/apex/apex-benc	24/07/17 21:48:22	Upstream	Yes	Yes	-
hypre	https://computation.llnl.gov/project/linear_solvers/software.php	17/07/17 23:33:11	-	Yes	Yes	-
imb		17/07/17 23:33:11	-	Yes	Yes	-
lammps	http://lammps.sandia.gov/	19/10/17 22:10:20	-	Yes	Yes	-
libtool		18/07/17 13:41:43	-	Yes	Yes	-
lulesh	https://codesign.llnl.gov/lulesh.php	17/07/17 23:33:11	-	Yes	-	-
metis		17/07/17 23:33:11	-	Yes	Yes	-
miniaero	http://mantevo.org/downloads/miniAero_1.0.html	24/07/17 21:36:31	NeedsPatch	Yes	Yes	-
miniamr	http://mantevo.org/downloads/miniAMR_1.0.html	24/07/17 21:36:31	Upstream	Yes	Yes	-
minife	http://www.nersc.gov/users/computational-systems/cori/nersc-8-p	24/07/17 21:36:31	Upstream	Yes	Yes	-
minighost	http://www.nersc.gov/users/computational-systems/cori/nersc-8-p	24/07/17 21:36:31	Upstream	Yes	Yes	-
minimd	http://mantevo.org/downloads/miniMD_1.2.html	24/07/17 21:36:31	NeedsPatch	Yes	Yes	-
minixyce	http://mantevo.org/downloads/miniXyce_1.0.html	24/07/17 21:36:31	Upstream	Yes	Yes	-
mpich		19/10/17 22:10:20	NeedsPatch	Yes	Yes	-
mumps		17/07/17 23:33:11	-	Yes	Yes	-
mvapich-2	http://mvapich.cse.ohio-state.edu	21/08/17 13:26:19	Upstream	Yes	Yes	-
namd	http://www.ks.uiuc.edu/Research/namd/	24/07/17 21:36:31	NeedsPatch	Yes	Yes	-

Tack!

Thank You!

Danke!

Merci!

谢谢!

ありがとう!

Gracias!

Kiitos!

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धन्यवाद

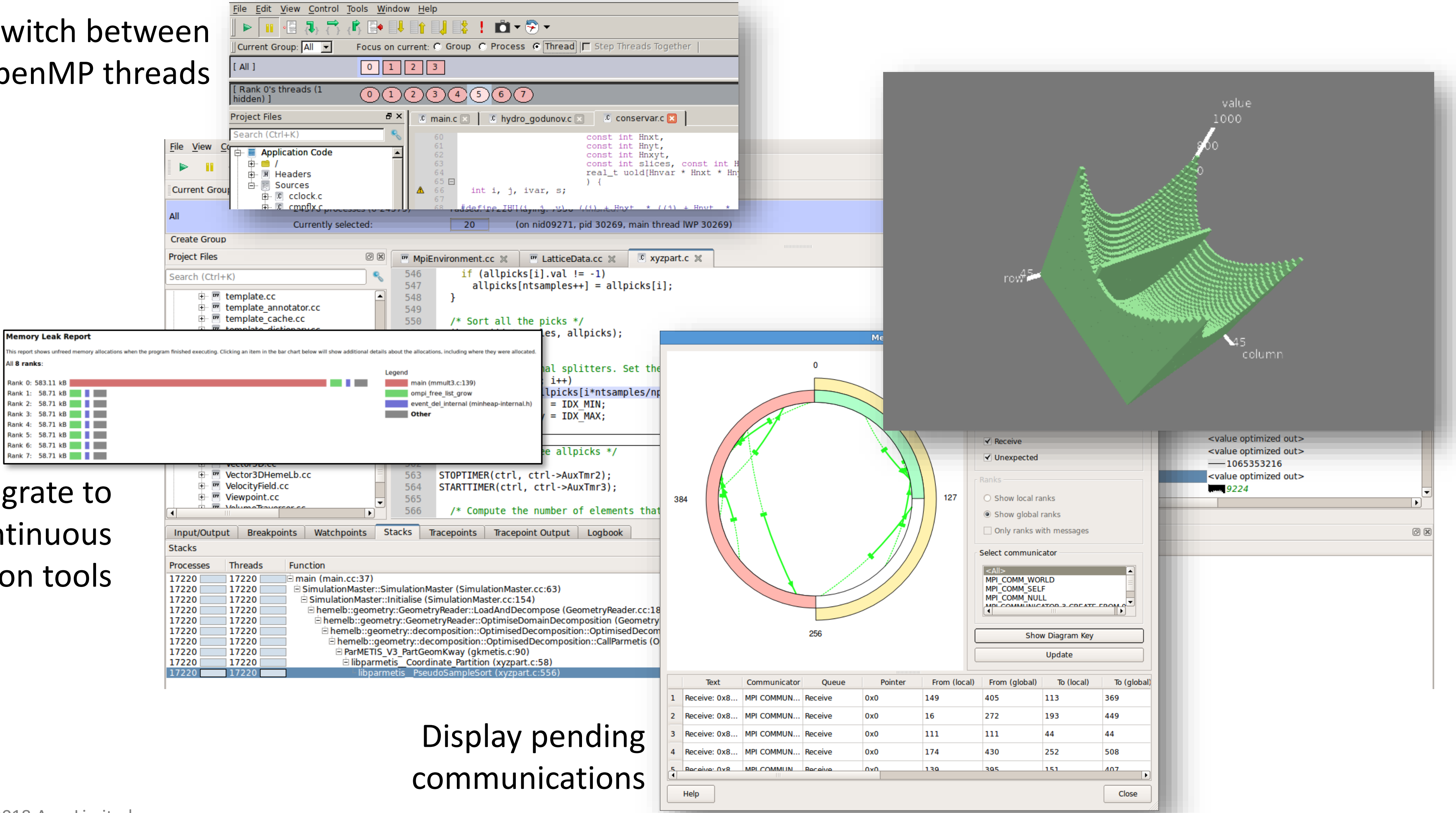
Migrate and debug application to Arm

Switch between OpenMP threads

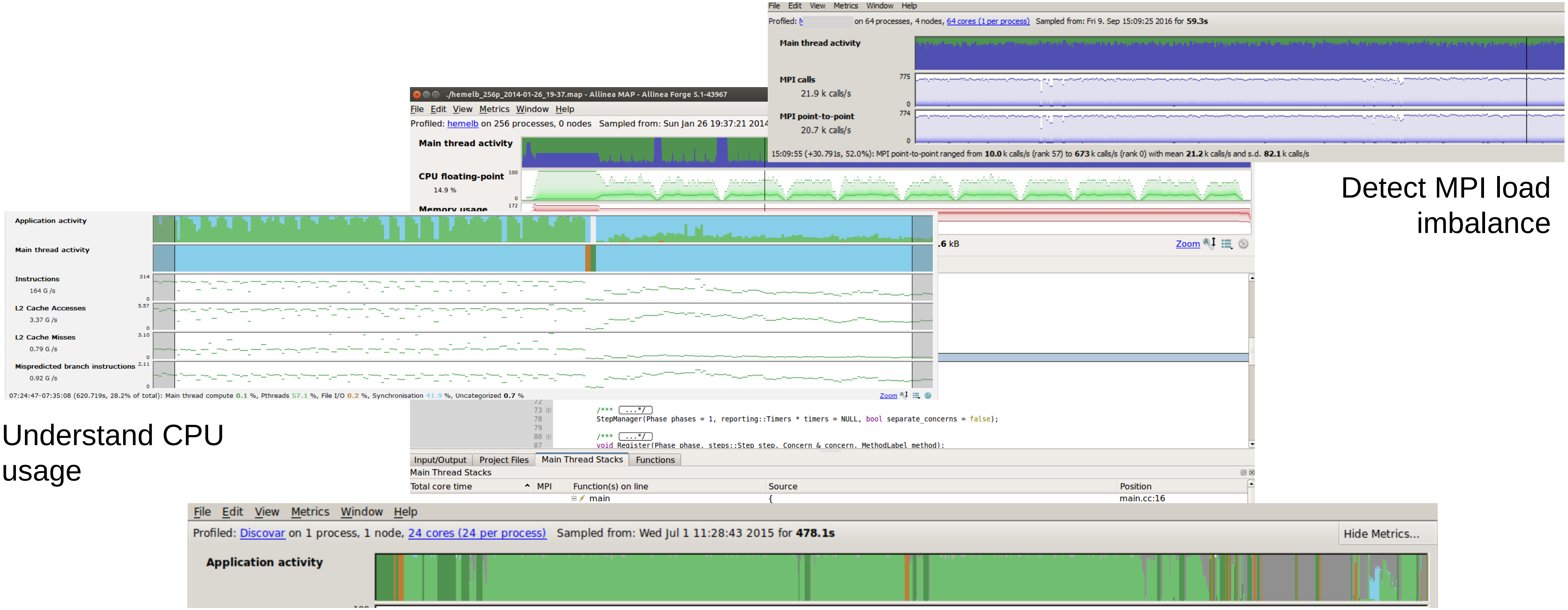
Visualise data structures

Integrate to continuous integration tools

Display pending communications



Optimise for Arm platforms

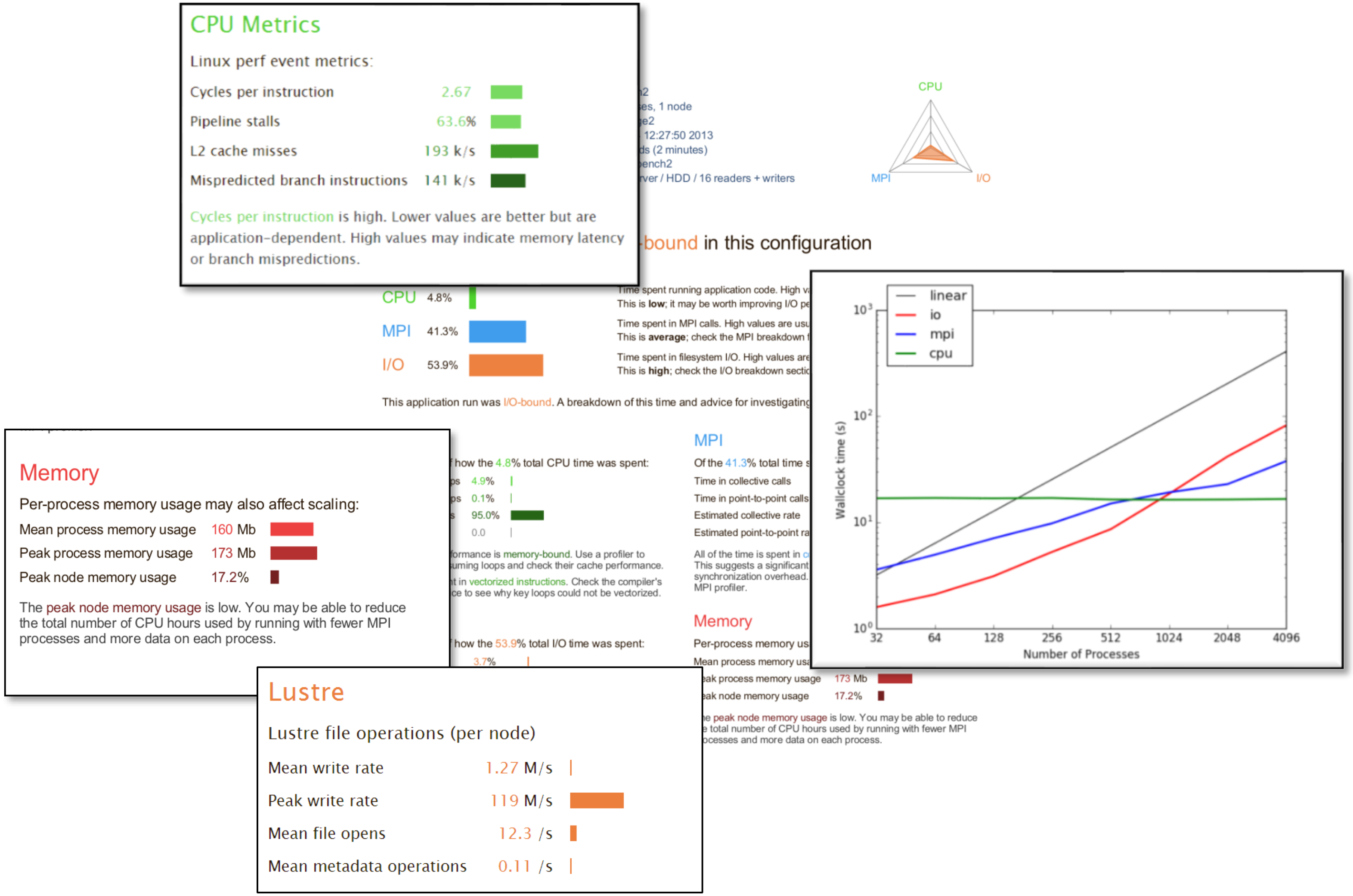


Detect MPI load imbalance

Understand CPU usage

Identify regions of high OpenMP synchronisation

Maximize System Efficiency



Aggregate data

