

SAND2020-7755PE

The Kokkos EcoSystem

C++ Performance Portability for the HPC Community

July 28, 2020

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Current Generation: Programming Models OpenMP 3, CUDA and OpenACC depending on machine



LANL/SNL Trinity
Intel Haswell / Intel KNL
OpenMP 3



LLNL SIERRA
IBM Power9 / NVIDIA Volta
CUDA / OpenMP^(a)



ORNL Summit
IBM Power9 / NVIDIA Volta
CUDA / OpenACC / OpenMP^(a)



SNL Astra
ARM CPUs
OpenMP 3



Riken Fugaku
ARM CPUs with SVE
OpenMP 3 / OpenACC^(b)

Upcoming Generation: Programming Models OpenMP 5, CUDA, HIP and DPC++ depending on machine



NERSC Perlmutter
AMD CPU / NVIDIA GPU
CUDA / OpenMP 5^(c)



ORNL Frontier
AMD CPU / AMD GPU
HIP / OpenMP 5^(d)



ANL Aurora
Xeon CPUs / Intel GPUs
DPC++ / OpenMP 5^(e)



LLNL El Capitan
AMD CPU / AMD GPU
HIP / OpenMP 5^(d)

(a) Initially not working. Now more robust for Fortran than C++, but getting better.

(b) Research effort.

(c) OpenMP 5 by NVIDIA.

(d) OpenMP 5 by HPE.

(e) OpenMP 5 by Intel.

Industry Estimate

A full time software engineer writes 10 lines of production code per hour: 20k LOC/year.

- ▶ Typical HPC production app: 300k-600k lines
 - ▶ Sandia alone maintains a few dozen
- ▶ Large Scientific Libraries:
 - ▶ E3SM: 1,000k lines
 - ▶ Trilinos: 4,000k lines

Conservative estimate: need to rewrite 10% of an app to switch Programming Model

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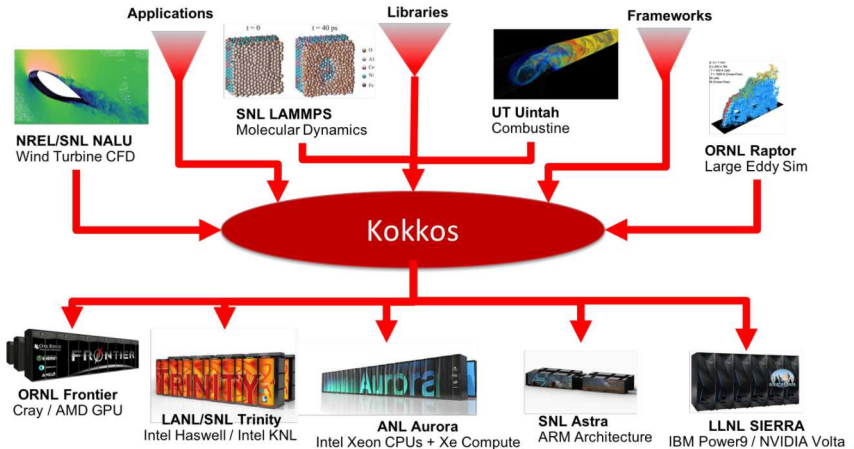
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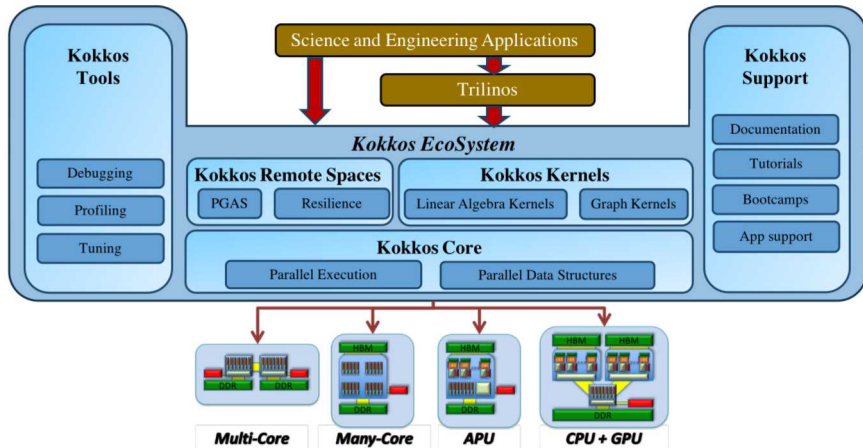
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Software Cost Switching Vendors

Just switching Programming Models costs multiple person-years per app!

- ▶ A C++ Programming Model for Performance Portability
 - ▶ Implemented as a template library on top CUDA, HIP, OpenMP, ...
 - ▶ Aims to be descriptive not prescriptive
 - ▶ Aligns with developments in the C++ standard
- ▶ Expanding solution for common needs of modern science and engineering codes
 - ▶ Math libraries based on Kokkos
 - ▶ Tools for debugging, profiling and tuning
 - ▶ Utilities for integration with Fortran and Python
- ▶ Is an Open Source project with a growing community
 - ▶ Maintained and developed at <https://github.com/kokkos>
 - ▶ Hundreds of users at many large institutions

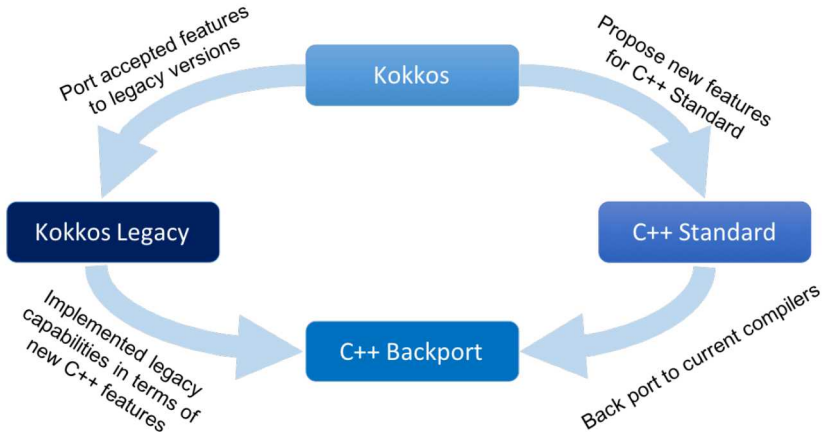






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Kokkos Support	C.R. Trott , G. Shipmann, G. Womeldorff, and all of the above former: H.C. Edwards, G. Lopez, F. Foertter

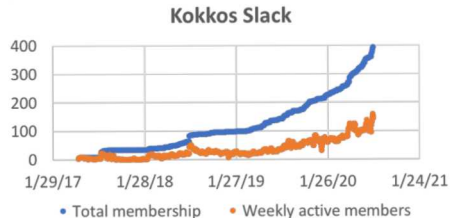
Kokkos helps improve ISO C++



Ten current or former Kokkos team members are members of the ISO C++ standard committee.

Kokkos has a growing OpenSource Community

- ▶ 18 ECP projects list Kokkos as Critical Dependency
 - ▶ 41 list C++ as critical
 - ▶ 19 list Lapack as critical
 - ▶ 17 list Fortran as critical
- ▶ Slack Channel: 400 members from 69 institutions
 - ▶ 20% Sandia Nat. Lab.
 - ▶ 35% other US Labs
 - ▶ 20% universities
 - ▶ 25% other
- ▶ GitHub: 600+ stars



The Kokkos Lectures

Join The Kokkos Lectures for a full introduction. 16 hours of lectures with associated exercises as homework.

- ▶ 07/17 *Module 1: Introduction, Building and Parallel Dispatch*
- ▶ 07/24 *Module 2: Views and Spaces*
- ▶ 07/31 *Module 3: Data Structures + MultiDimensional Loops*
- ▶ 08/07 *Module 4: Hierarchical Parallelism*
- ▶ 08/14 *Module 5: Tasking, Streams and SIMD*
- ▶ 08/21 *Module 6: Internode: MPI and PGAS*
- ▶ 08/28 *Module 7: Tools: Profiling, Tuning and Debugging*
- ▶ 09/04 *Module 8: Kernels: Sparse and Dense Linear Algebra*
- ▶ 09/11 *Reserve Day*

Online Resources:

- ▶ <https://github.com/kokkos>:
 - ▶ Primary Kokkos GitHub Organization
- ▶ <https://github.com/kokkos/kokkos-tutorials/wiki/Kokkos-Lecture-Series>:
 - ▶ Slides, recording and Q&A for the Full Lectures
- ▶ <https://github.com/kokkos/kokkos/wiki>:
 - ▶ Wiki including API reference
- ▶ <https://kokkosteam.slack.com>:
 - ▶ Slack channel for Kokkos.
 - ▶ Please join: fastest way to get your questions answered.
 - ▶ Can whitelist domains, or invite individual people.