

SAND2020-7755PE

The Kokkos EcoSystem

C++ Performance Portability for the HPC Community

July 28, 2020

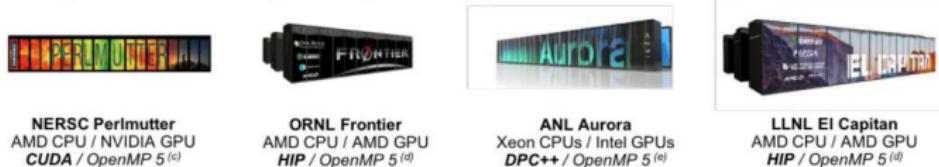
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Current Generation: Programming Models OpenMP 3, CUDA and OpenACC depending on machine



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



- (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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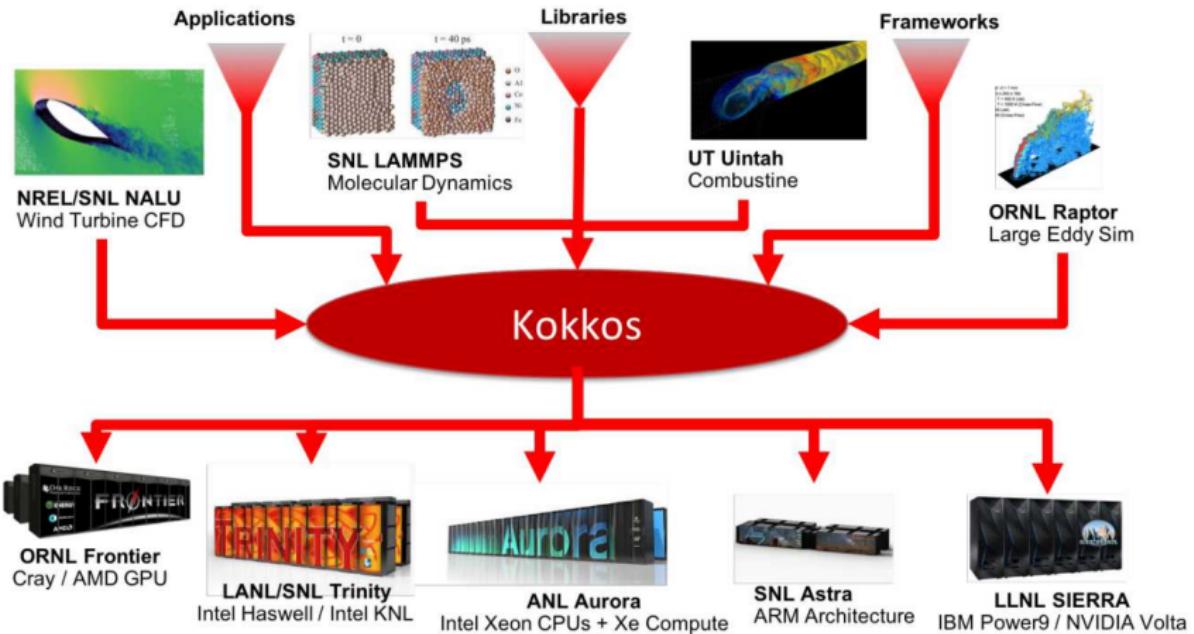
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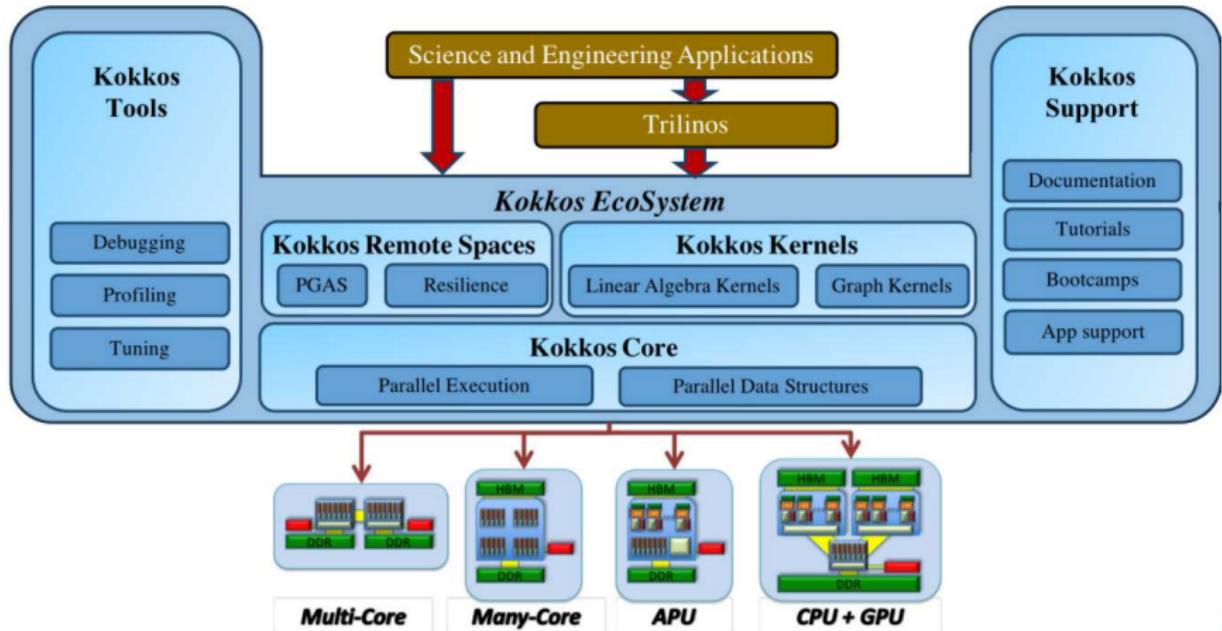
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Software Cost Switching Vendors

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







Kokkos Core:

C.R.Trott, J. Ciesko, V. Dang, N. Ellingwood, D.S. Hollman, D. Ibanez, J. Miles, J. Wilke, H. Finkel, N. Liber, D. Lebrun-Grandie, D. Arndt, B. Turcksin, J. Madsen, R. Gayatri
former: H.C. Edwards, D. Labreche, G. Mackey, S. Bova, D. Sunderland

Kokkos Kernels:

S. Rajamanickam, L. Berger, V. Dang, N. Ellingwood, E. Harvey, B. Kelley, K. Kim, C.R. Trott, J. Wilke, S. Acer

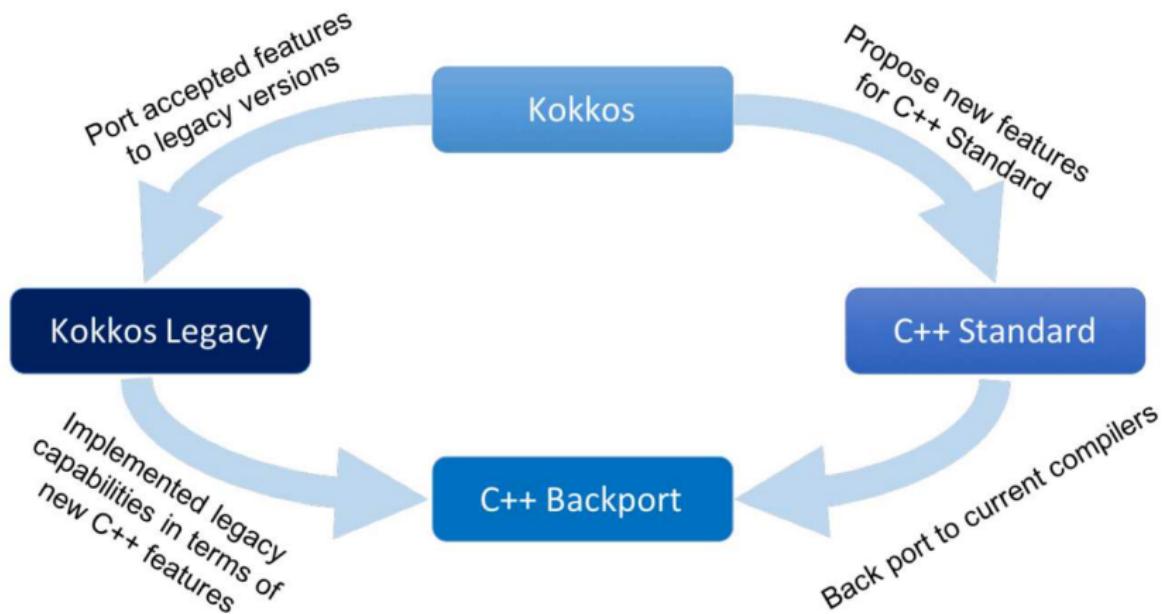
Kokkos Tools

D. Poliakoff, C. Lewis, S. Hammond, D. Ibanez, J. Madsen, S. Moore, C.R. Trott

Kokkos Support

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

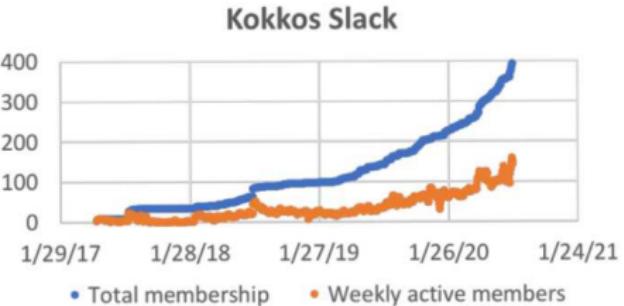
Kokkos helps improve ISO C++



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:](https://github.com/kokkos)
 - ▶ Primary Kokkos GitHub Organization
- ▶ [https://github.com/kokkos/kokkos-tutorials/wiki/Kokkos-Lecture-Series:](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:](https://github.com/kokkos/kokkos/wiki)
 - ▶ Wiki including API reference
- ▶ [https://kokkosteam.slack.com:](https://kokkosteam.slack.com)
 - ▶ Slack channel for Kokkos.
 - ▶ Please join: fastest way to get your questions answered.
 - ▶ Can whitelist domains, or invite individual people.