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ShyLU: Domain Decomposition and Subdomain Solvers
Kokkoskernels: Performance-portable Math and Graph Kernels

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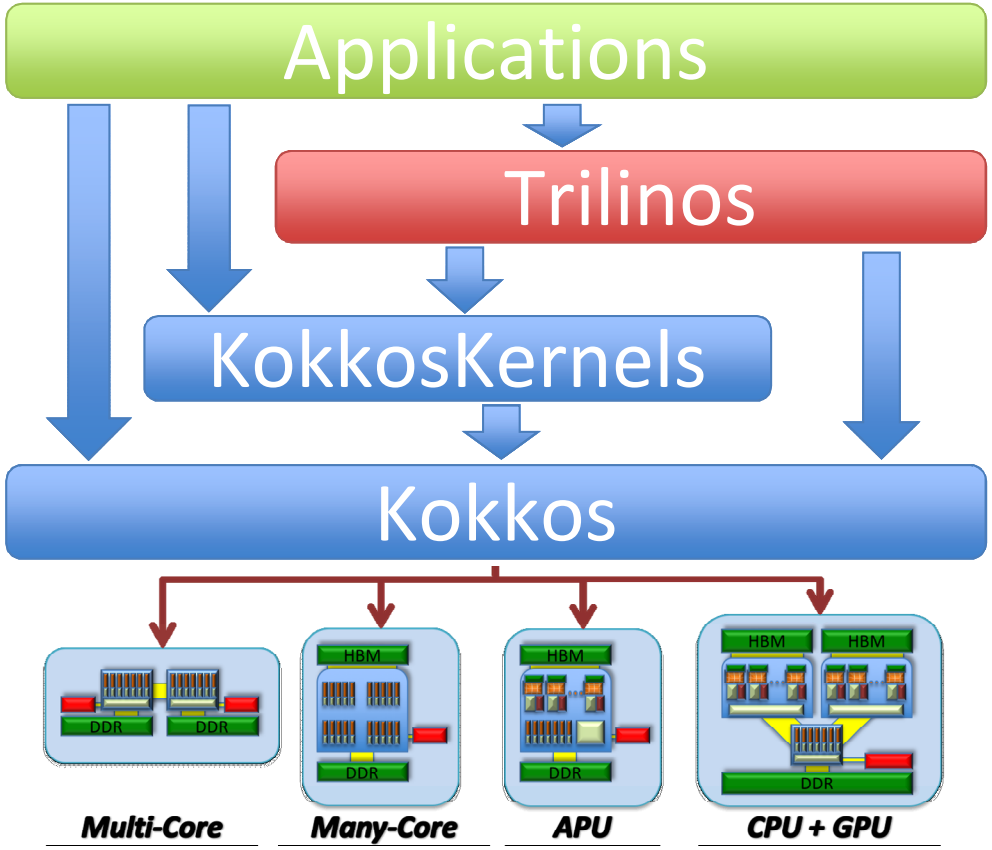
Overview of the technology

- Technology Area: ShyLU and Kokkoskernels
- FASTMath Tasks
  - Scalable Solvers for land ice simulation
  - Performance-portable kernels for MHD and QCD simulations
- Relevant Software Tools
  - ShyLU
    - Part of Trilinos Linear Solvers
    - https://github.com/trilinos/Trilinos/
  - Kokkoskernels
    - part of Kokkos performance-portable ecosystem
    - https://github.com/kokkos/kokkos-kernels
- Applications Impacted
  - Land Ice – Albany/FELIX
  - MHD –Drekar
  - QCD – Jefferson Labs

Technical description of technology : Kokkoskernels

KokkosKernels provides math kernels for dense and sparse linear algebra as well as graph computations. It has multiple aims:

- Portable BLAS, Sparse and Graph kernels
- Generic implementations for various scalar types and data layouts
- Access to major vendor optimized math libraries.
- Expand the scope of BLAS to hierarchical implementations.



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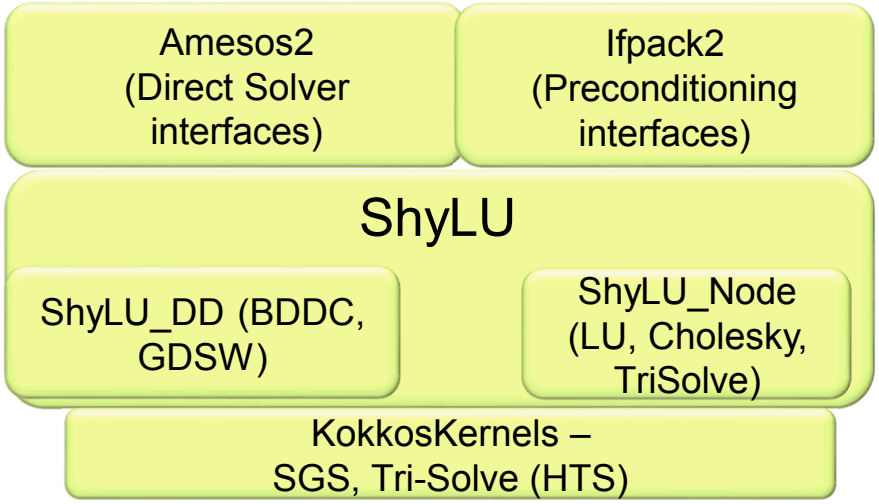
Technical description of technology : ShyLU

ShyLU is a Trilinos package for domain decomposition solvers and node level solvers

- Balancing Domain Decomposition (BDDC), Generalized Dryja-Smith-Widlund (GDSW) preconditioners
- Multithreaded LU, Cholesky, and Triangular solvers
- Interfaces through Amesos2 and Ifpack2 packages in Trilinos



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Proposed work in FASTMath including internal collaborations

- Provide scalable, performance-portable solvers for Albany/FELIX land ice code
  - Scalable preconditioners that support on-node erformance-portability is the primary goal
- Provide performance-portable smoothers and kernels needed by the multigrid codes such as MueLU
  - E.g: Smoothers, Matrix-Matrix multiply, and graph algorithms
- Provide performance-portable kernels for small dense matrices required by the QCD code
  - A shuffle operation seems to be the key based on initial discussion with the application

Description of the software tools

- ShyLU
  - Domain Decomposition and Subdomain solvers
  - BDDC and GDSW preconditioners at the MPI level
  - Multithreaded LU, Cholesky, and Triangular solve at the node level
  - Available in Trilinos https://github.com/trilinos/Trilinos/
- Kokkoskernels
  - Performance-Portable Math and Graph kernels
  - Sparse/Dense linear algebra kernels, Batched kernels and Graph Kernels
  - Available in Kokkos https://github.com/kokkos/kokkos-kernels

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Application interactions

- Albany/FELIX
  - PoC : Mauro Perego
  - Scalable solvers for Albany/FELIX on architectures such as KNL and GPUs
  - Ability to run Albany/FELIX implicit solvers on different architectures
- QCD
  - PoC : Balint Joo, Jefferson Labs
  - Performance-portable kernels for small dense matrices
  - Performance-portable kernels are key to the scalability of this code
- MHD - Drekar
  - Usage through MueLU multigrid solvers

Other relevant collaborations

- ECP Collaboration
  - SNL ATDM Application SPARC
  - SNL ATDM Application EMPIRE
  - NREL/SNL ECP Application ExaWind (Nalu)
  - ECP/ATDM Kokkos project
  - ECP Codesign centers
    - ExaGraph
    - CEED