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Sandia National Laboratories

Trilinos/MueLu: Node-level Parallelism

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FASTMath meeting, October 1st, 2014, Chicago, IL
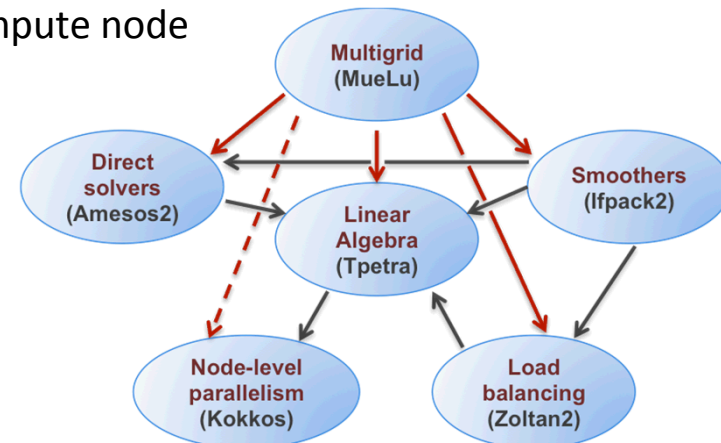
MueLu Multigrid Library

- Trilinos C++ multigrid library
  - Explicitly uses templated sparse linear algebra (Tpetra library)
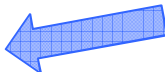 - Template types: local index, global index, scalar, compute node

- Aggregation-based
  - Group fine DOFs together to form coarse DOFs
  - Poisson, elasticity, convection-diffusion, Maxwell, Helmholtz

- Smoothers: SOR, Chebyshev, $\ell 1$ Gauss-Seidel, incomplete factorizations, additive Schwarz, ... (Ifpack2)

- Direct solvers: KLU2, SuperLU, ... direct solvers (Amesos2)

- Load balancing: RCB, multijagged (Zoltan2)

- Krylov acceleration (Belos)

Current Kokkos Integration Status

- MueLu leverages Kokkos indirectly through some (not all) sparse linear algebra operations in Tpetra

- Setup
  - ✗ SPGEMM
    - Galerkin product RAP ⟵ High priority
    - Prolongator smoothing
  - ✓ Sparse Matvec: eigenvalue estimates
  - ✗ Factorizations
    - Incomplete (smoothers) and direct (coarse)
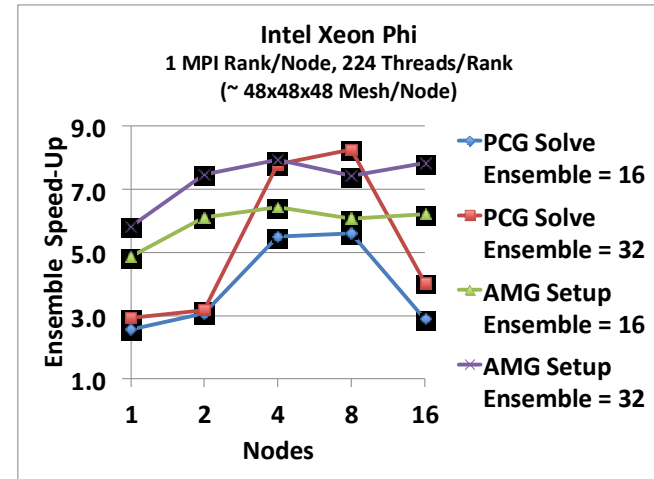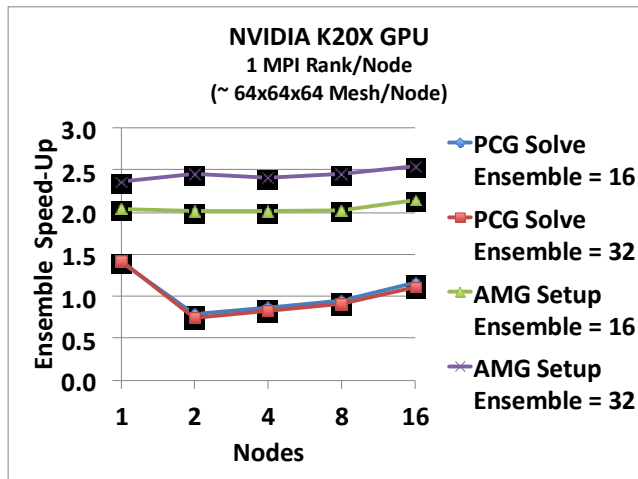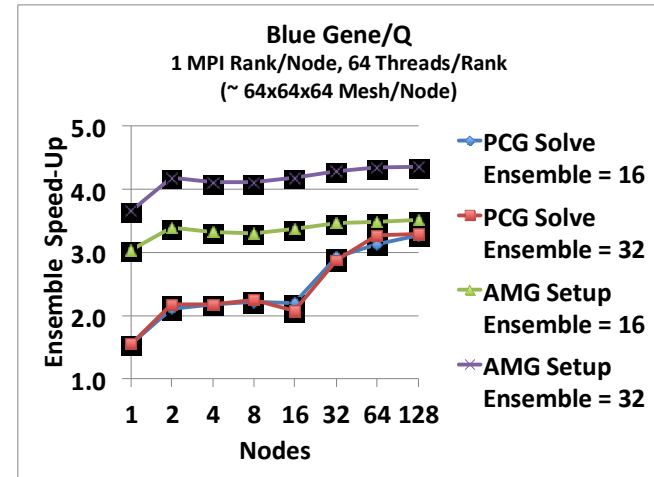 - ✗ Aggregation: graph operations

Current Kokkos Integration Status

- MueLu leverages Kokkos indirectly through some (not all) sparse linear algebra operations in Tpetra

- Application
  - ✓ Sparse Matvec
    - Interpolation and restriction operators
    - Residual calculation
    - Smoothers
    - Krylov
  - ✗ Triangular solves
    - Incomplete factorization smoothers
    - Coarse direct solve

AMG-Preconditioned CG (non-POD scalar type)

- MueLu apply demonstrated on various node types (non-optimal coarse grid solve)
- Setup done on host via Kokkos UVM mechanism

*plots courtesy E. Phipps (SNL)

Research Directions

- Kokkos kernels in AMG
  - SPGEMM
  - Aggregation
  - Gauss-Seidel smoothers
  - Incomplete factorization setup (?)