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Trilinos ShyLU node updates

Trilinos User Group (TUG) meeting

Albuquerque, New Mexico, USA

October 22, 2034

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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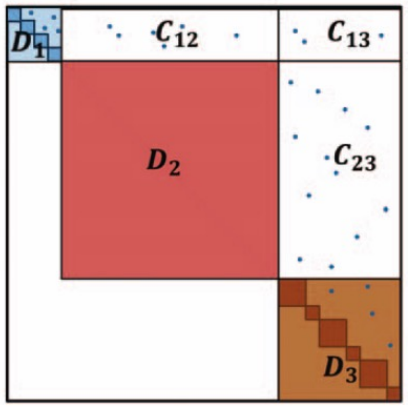
ShyLU :

- ShyLU-DD : domain decomposition preconditioners
  - Core : Schur complement method (scheduled to be deprecated)
  - BDDC : Balancing Domain Decomposition by constraints (has been deprecated)
  - **FROSch** : Multi-level Additive Schwarz (actively developed)
    - **Coming soon**: robust coarse-space for heterogeneous problems
      - Spectral adaptive coarse-space (J. Knepper, A. Heinlein, I. Yamazaki)
      - Algebraic multi-scale coarse-space (F. Cumaru, A. Heinlein)
    - For Albany icesheet on Perlmutter.
    - *Fast and Robust Overlapping Schwarz (FROSch) Preconditioners in Trilinos*
      (A. Heinlein), TUG'23

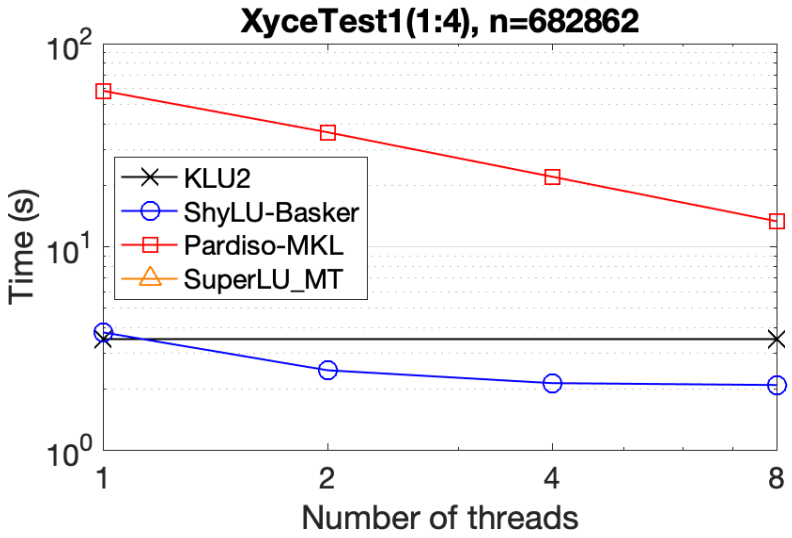
- **ShyLU-node** : local subdomain solvers for ShyLU-DD
  - **Basker** : sparse-direct (BTF)
    - Xyce
  - **Tacho** : sparse direct (Kokkos)
    - Sierra-SD/SM, Plato
  - **FastILU** : ILU/SpTRSV (iterative)
    - Aria
  - HTS : multi-threaded sparse-triangular solve

ShyLU-Basker

"Basker: A Threaded Sparse LU Factorization Utilizing Hierarchical Parallelism and Data Layouts"
by J. Booth, S. Rajamanickam, H. Thornquist



- Multi-threaded sparse-direct solver
  - Threaded version of KLU (targeting Circuit matrices)
    - General, algebraic, sparse direct
    - Column-based sparse LU (very sparse, not-supernodal)
    - Block Triangular Form (BTF)
      - Each small block is factorized in parallel
      - Each larger block is factorized using multiple threads based on nested-dissection
    - Transpose-solve (N. Ellingwood)
  - Works well when the matrix has BTF structure
    - Some Circuit matrices from **Xyce** (H. Thornquist)
  - *May* work well, even without BTF, e.g., very sparse matrix (newer circuit)
    - *Working on scalability of threaded-factorization (of big diagonal block)*



Tacho

"Tacho: Memory-Scalable Task Parallel Sparse Cholesky Factorization"
by K. Kim, E. Harlod, S. Rajamanican

- Kokkos-based sparse-direct solver (multi-frontal)
  - Originally, Cholesky for solving SPD problems
    based on Kokkos tasking
  - Currently, different problems (Cholesky, LDLt, and symmetric LU)
    based on level-set (no tasks) for portability
- Runs on a GPU (NVIDIA, or AMD), or on CPU cores
  - ***Plato*** *Optimization-Based Design*
    (S. Hardesty, D. Ridzal) at TUG'23
  - *Revolutionary Speedups in* ***SIERRA Structural Dynamics*** *Enhance Mission Impact*
    (J. Vo) at TUG'22
  - *Working on NVIDIA H100 and AMD Mi300 (C. Dohrmann)*

FastILU

"A fine-grained parallel ILU factorization" by E. Chow, A. Patel

- Iterative variant to approximate ILU(k) & SpTRSV based on Kokkos
  - Lots of compute, but very parallel
    - Iteratively compute each element of ILU(k), or each element of SpTRSV solution, in parallel
    - Computational cost of each iteration ≈ ILU(k) or SpTRSV
  - Effective if good approximation with a small number of iterations
    - *Performance of **Aria** Running on ATS-2 (J. Clausen) at TUG'22*
  - Other variants (threshold-based, block), or standard ILU and SpTRSV, in Kokkos-Kernels (J. Foucar)

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Thank you!!

- They are accessible through Amesos2 or Ifpack2, and FROSch
  - *Smoother interface between ShyLU_node & Amesos2 (matrix conversion)*