

# Trilinos User Group Meeting Solvers Update





#### PRESENTED BY

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#### Trilinos Solvers Overview

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- Comprehensive suite of solvers that covers entire spectrum of solver needs
  - Direct linear solvers for highly ill-conditioned, unsymmetric, problems (Xyce)
  - Dense LU solver for distributed memory complex LU (Eiger/GEMMA)
  - Schur complement solvers for distributed-memory direct solvers (Xyce)
  - Iterative linear solvers that cover broad suite of applications (SIERRA, Xyce, Charon, EMPIRE, SPARC)
  - Multigrid methods for broad suite of applications (Fluid dynamics, Charon, EMPIRE, SPARC)
  - Multilevel domain decomposition methods (SIERRA-SD, SIERRA-SM)
  - Incomplete factorization preconditioners (Smoother for multigrid methods)

### 3 Overview

- Major developments in the last year
  - UVM Removal in solver stack
  - HIP Support in Solver stack (Next talk by Brian Kelly, Luc Berger-Vergiat, and Ichi Yamazaki)

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- Multiprecision solvers (Two Talks after this one by Jennifer Loe)
- Funding for Trilinos Solvers
  - ASC ATDM Program
  - ECP Sake project
  - ASC IC Solvers
  - FASTMath SciDAC Institute
  - DFG SPP, Germany (FROSch)

- Default orthogonalization for Belos solvers has been changed from **DGKS to ICGS**, resulting in performance improvements for many application codes due to reduced global communications.
- Development of a Kokkos-based implementation of the multivector and operator abstractions.
- Improved testing for the next-generation linear algebra and preconditioner stack (Tpetra, Ifpack2, etc.). This illustrated a couple minor issues in some of the solvers (Minres, BiCGStab, etc.) that were fixed.
- Single-reduce, pipelined, and s-step variants of GMRES, and CG, are now registered and available through Belos solver factory by default (PEEKS)
- A novel polynomial preconditioner is deployed in Belos. This preconditioner is particularly useful for highly unstructured/irregular matrices. The preconditioner has been integrated into the Sphynx parallel partitioner developed by the Exagraph co-design project.

#### What to look forward to:

- Improvements to the Belos solver framework to consolidate commonly used utilities (orthogonalization manager, etc.) and capabilities across the current solvers. This will have a substantial impact on usability, maintainability, and extensibility of the solver framework.
- Modifications of the solver framework to enable the integration of multi-precision linear solvers.

- 5 Amesos2 / ShyLU-Basker Direct Solvers
  - Supernodal sparse Triangular Solver for L, U matrices from SuperLU/Cholmod in Kokkos Kernels
    - Yamazaki, Ichitaro, Sivasankaran Rajamanickam, and Nathan Ellingwood. "Performance portable supernode-based sparse triangular solver for manycore architectures." 49th International Conference on Parallel Processing-ICPP. 2020.
  - Supernodal sparse-triangular solve of Kokkos-Kernels is interfaced from Amesos2 SuperLU/Cholmod (FastMath)
  - ShyLU-Basker had been updated to improve its robustness and threaded performance, looking to further improve performance (Xyce)

## FROSch

- Increased use of FROSch in applications (<u>https://shylu-frosch.github.io/projects/</u>)
  - Active work with MALI Icesheet application

#### Accomplishments and Application Impact

- Usage of FROSch for complex multi physics applications, such as fluid-structure interaction and the coupled land ice problem
- Parallel scalability of three-level FROSch preconditioners to 220 000 cores using the Theta supercomputer

#### New Features

- Monolithic Schwarz preconditioners for block systems
- Multilevel extension of FROSch preconditioners
- Thyra interface
- FROSch Demo: <u>https://github.com/searhein/frosch-demo/</u>
- (Near) Future work
  - Adaptive/spectral coarse spaces
  - Nonlinear Schwarz preconditioners