



Getting Started With Trilinos

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I. Welcome to EuroTUG 2023



European Trilinos User Group Meeting 2023

Delft University of Technology, June 28-30, 2023

[Link to registration](#)

What is EuroTUG?

- EuroTUG Meeting = European Trilinos User Group Meeting
- Meeting series for Europe-based users and developers of the TRILINOS projects:
 - learn about recent developments in TRILINOS
 - report on their use cases and experiences with TRILINOS
 - interact with the TRILINOS leadership and core developers
 - form a European network of TRILINOS users and developers

Acknowledgement:

EuroTUG 2023 acknowledges the support of the following institutions:

- TU Delft Institute for Computational Science and Engineering (DCSE)
- Delft High Performance Computing Centre (DHPC)



Schedule:

- June 28, 2023 (today): Tutorial “Trilinos for Beginners”
- June 29 - 30, 2023: User & Developer Presentations

Detailed schedule on the EuroTUG website: <https://eurotug.github.io>

Organizers:

- Dr. Alexander Heinlein, TU Delft, FROSch developer
- Dr. Matthias Mayr, University of the Bundeswehr Munich, MUELU developer



External support

- Mike Heroux, SNL
- Siva Rajamanickam, SNL
- Luc Berger-Vergiat, SNL
- Nathan Roberts, SNL
- Damien Lebrun-Grandie, ORNL

Wifi

- Please use eduroam if possible
- If you do not have access to eduroam, please send an SMS with the code *ETUGM* to +316 3525 0006

Breaks, Lunch, Dinner

- All the breaks (including the lunch) breaks will be in the Aula Conference Centre
- **Dinner Wednesday:** We will go to a Pizza place (Pavarotti Delft) next to the train station. If you want, you can join us.
- **Dinner Thursday:** (self-paid) conference dinner at 19.00 pm:
Eetcafé De Verbeelding, Verwersdijk 128, 2611 NL Delft

Photos

- Please sign on the list of participants that you are Ok with us taking photos during the meeting
- We will take a group photo at the beginning of the lunch break on Thursday

II. Introduction to Trilinos

Disclaimer

The following slides will give a brief overview over the software package TRILINOS. It is far from complete, but on the final slides, some *references to additional introductory material and tutorials will be given.*

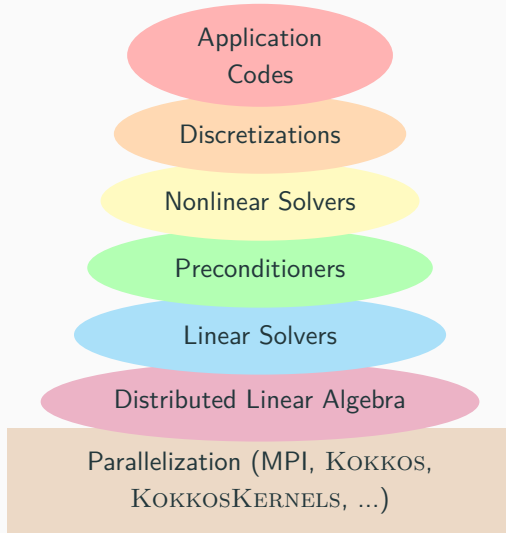


An Open-Source Library of Software for Scientific Computing

Mission statement¹: *“The TRILINOS Project is an effort to facilitate the design, development, integration, and ongoing support of mathematical software libraries and enabling technologies within an object-oriented software framework for the solution of large-scale, complex multi-physics engineering and scientific problems on new and emerging high-performance computing (HPC) architectures”.*



Layers of a Trilinos-based application



Wide range of functionality (organized in 5 *product areas*)

| | |
|---|---|
| Data services | Vectors, matrices, graphs and similar data containers, and related operations |
| Linear and eigen-problem solvers | For large, distributed systems of equations |
| Nonlinear solvers and analysis tools | Includes basic nonlinear approaches, continuation methods and similar |
| Discretizations | Tools for the discretization of integral and differential equations |
| Framework | Tools for building, testing, and integrating Trilinos capabilities |

Performance portability for various parallel programming paradigms

TRILINOS is targeted for all major parallel architectures, including

- distributed-memory using the Message Passing Interface (MPI),
- multicore using a variety of common approaches,
- accelerators using common and emerging approaches, and
- vectorization.

Performance portability is achieved through the KOKKOS programming model².

*“... as long as a given algorithm and problem size contain enough latent parallelism, **the same Trilinos source code** can be compiled and execution on **any reasonable combination of distributed, multicore, accelerator and vectorizing computing devices.**”* — Trilinos Website

Overview of Trilinos packages

TRILINOS is a collection of more than 50 software packages:

- Each TRILINOS package is a *self-contained, independent piece of software with its own set of requirements, its own development team³ and group of users.*
- However, there are often certain *dependencies between different TRILINOS packages.* Some TRILINOS packages also *depend on third party libraries (TPLs).*
- Generally, a *certain degree of interoperability* of the different TRILINOS packages is provided.

Contents of trilinos/packages:

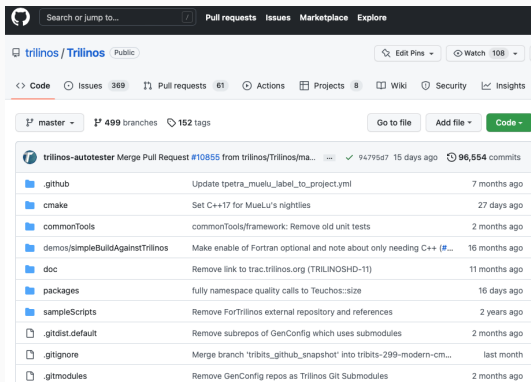
| | | | | | | |
|----------|-----------|----------------|------------|---------|------------------------------|----------|
| adelus | epetra | isorropia | nox | rol | stratimikos | triutils |
| amosos | epetraext | kokkos | pamgen | rtop | teko | xpetra |
| amosos2 | fei | kokkos-kernels | panzer | rythmos | tempus | zoltan |
| anasazi | framework | komplex | percept | sacado | teuchos | zoltan2 |
| aztecoo | galeri | minitensor | phalanx | seacas | thyra | |
| belos | ifpack | ml | pike | shards | tpetra | |
| common | ifpack2 | moertel | piro | shylu | TriKota | |
| compadre | intrepid | muelu | pliris | stk | trilinoscouplings | |
| domi | intrepid2 | new_package | PyTrilinos | stokhos | Trilinos_DLLExportMacro.h.in | |

| | MPI (EPETRA-based) | MPI+X (TPETRA-based) |
|--|--------------------------------|-----------------------------------|
| Linear algebra | Epetra & EpetraExt | Tpetra |
| Direct sparse solvers | Amesos | Amesos2 |
| Iterative solvers | AztecOO | Belos |
| Preconditioners: <ul style="list-style-type: none"> • One-level (incomplete) factorization • Multigrid • Domain decomposition | Ipack ML | Ipack2 MueLu ShyLU |
| Eigenproblem solvers | | Anasazi |
| Nonlinear solvers | NOX & LOCA | |
| Partitioning | Isorropia & Zoltan | Zoltan2 |
| Example problems | Galeri | |
| Performance portability | | Kokkos & KokkosKernels |
| Interoperability | Stratimikos & Thyra | |
| Tools | Teuchos | |
| ⋮ | ⋮ | ⋮ |

- Packages, that do not depend on EPETRA or TPETRA work in both software stacks, e.g. GALERI, NOX & LOCA, TEUCHOS
- More details on <https://trilinos.github.io>.

Source code repository

- GitHub:
<https://github.com/trilinos/Trilinos>
- Default branch: master
- Development branch: develop

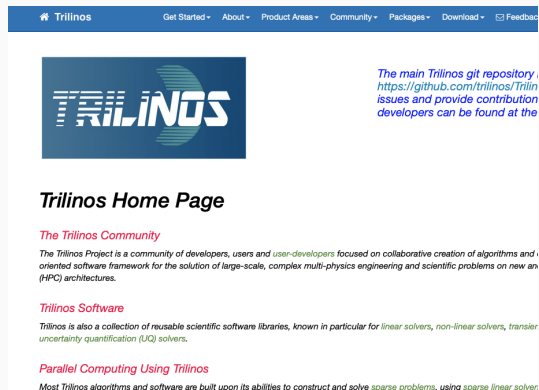


The screenshot shows the GitHub interface for the Trilinos repository. At the top, there is a search bar and navigation links for Pull requests, Issues, Marketplace, and Explore. Below this, the repository name 'trilinos / Trilinos' is displayed with a 'Public' badge. Navigation tabs for Code, Issues (369), Pull requests (61), Actions, Projects (8), Wiki, Security, and Insights are visible. The current branch is 'master', with 499 branches and 152 tags. A 'Code' button is highlighted. Below the repository information, a table lists recent commits and pull requests. The most recent entry is a merge pull request #10855 from 'trilinos/Trilinos/main' merged 15 days ago, with 96,554 commits. The table lists various folders and files with their respective commit messages and dates.

| File/Folder | Commit Message | Time Ago |
|----------------------------------|---|---------------|
| .github | Update tpetra_muelu_label_to_project.yml | 7 months ago |
| cmake | Set C++17 for MueLu's nightlies | 27 days ago |
| commonTools | commonTools/framework: Remove old unit tests | 2 months ago |
| demos/simpleBuildAgainstTrilinos | Make enable of Fortran optional and note about only needing C++ (#... | 16 months ago |
| doc | Remove link to trac.trilinos.org (TRILINOSH-11) | 11 months ago |
| packages | fully namespace quality calls to Teuchos::size | 16 days ago |
| sampleScripts | Remove ForTrilinos external repository and references | 2 years ago |
| .gitdist.default | Remove subrepos of GenConfig which uses submodules | 2 months ago |
| .gitignore | Merge branch 'tribits_github_snapshot' into tribits-299-modern-cm... | last month |
| .gitmodules | Remove GenConfig repos as Trilinos Git Submodules | 2 months ago |

Website

- Link: <https://trilinos.github.io>
- Provides general information
- Details on all packages
- Links to Doxygen source code documentation



The screenshot shows the Trilinos website home page. The top navigation bar includes 'Trilinos' and links for 'Get Started', 'About', 'Product Areas', 'Community', 'Packages', 'Download', and 'Feedback'. The main content area features the Trilinos logo on the left and a text block on the right stating: 'The main Trilinos git repository, https://github.com/trilinos/Trilinos issues and provide contribution developers can be found at the'. Below the logo, the heading 'Trilinos Home Page' is followed by the sub-heading 'The Trilinos Community'. The text describes the project as a community of developers, users, and user-developers focused on collaborative creation of algorithms and oriented software framework for the solution of large-scale, complex multi-physics engineering and scientific problems on new (HPC) architectures. Below this, the sub-heading 'Trilinos Software' is followed by text describing the collection of reusable scientific software libraries, known in particular for linear solvers, non-linear solvers, transfer uncertainty quantification (UQ) solvers. The sub-heading 'Parallel Computing Using Trilinos' is followed by text stating that most Trilinos algorithms and software are built upon its abilities to construct and solve sparse problems, using sparse linear solver.