Component-Based Application Code Development, Part 1:
The *AgileComponents* Strategy and Albany Code

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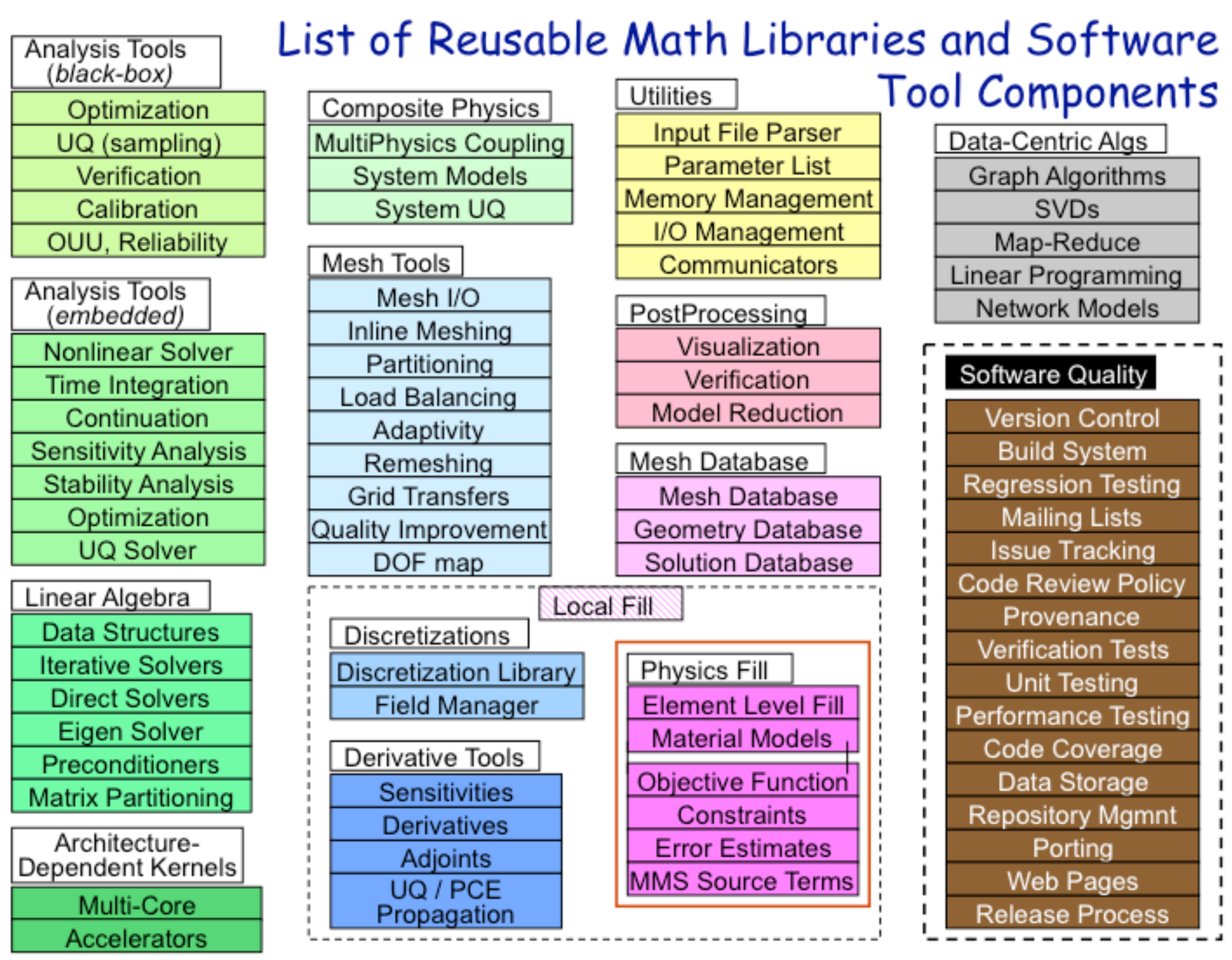
Overview

The goal of this poster is to foster discussions on a collaboration model between Climate Scientists and Computational Scientists.

The Computational Science organization at Sandia has largely adopted a strategy, "AgileComponents" [1], that was designed to maximize the long-term impact to our diverse set of customers. For application codes, this strategy involves leveraging computational mathematics libraries, expertise, and funding streams. A manifestation of the AgileComponents approach is the Albany finite element code, which is now playing a role in DOE climate modeling. Will climate model developers (1) embrace the broad use of components and (2) see real benefits of this leverage?

AgileComponents Strategy: Create, use, and improve a common base of modular, independent-yet-interoperable, software components.

"Components" = ☑ Libraries ☑ Software Quality Tools
☑ Interfaces ☑ Demonstration Applications



Albany [2] is an application code built primarily from Trilinos [3] math libraries.

Albany plays the Demonstration Application role in the AgileComponents Strategy.

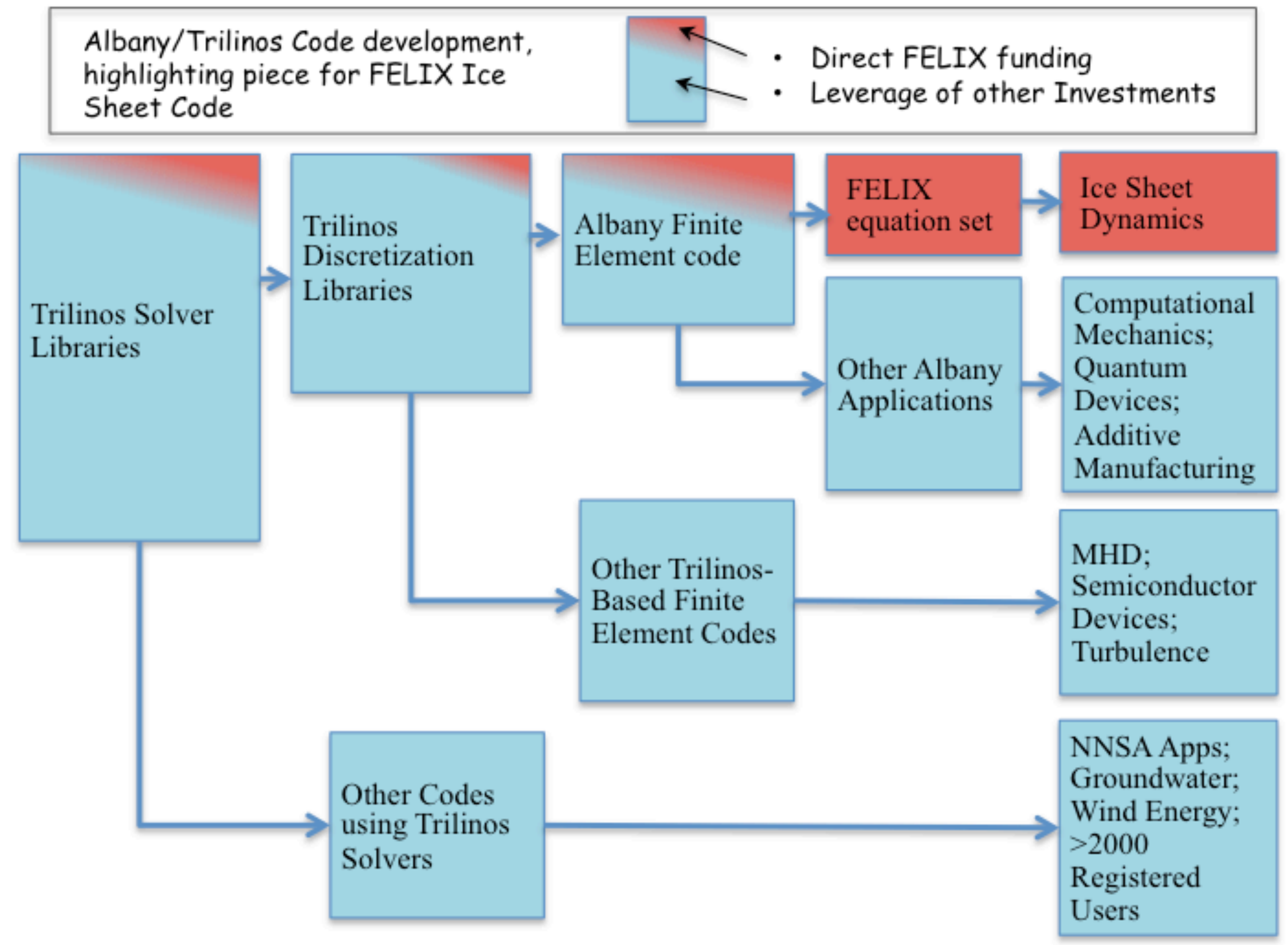
Demonstration Application role:

- Develop abstract interfaces
- Incubator for new libraries
- Demonstrate inter-operability
- Library installation and integration testing
- Library ripening: usability, performance
- Prototype Software Tools, E.g.,
  - *git, github, cmake, ctest, cdash*
- Research platform for new algorithms
  - "Meso-app": step between mini-app and production

Trilinos libraries used in Albany:

- Sacado
- Stokhos
- Intrepid
- Zoltan
- Belos
- Aztec
- ML
- Muelu
- Amesos
- Ifpack
- Anasazi
- Epetra
- Tpetra
- NOX
- LOCA
- Piro
- Rythmos
- ROL
- TriKota
- Thyra
- Teuchos
- STK
- Kokkos

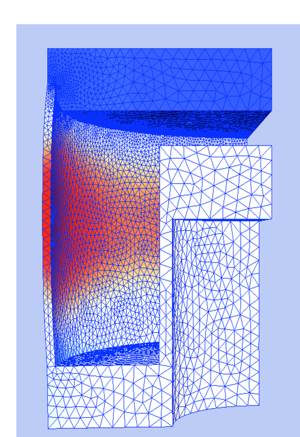
Leveraging of Investments to Develop Albany/FELIX



A schematic showing the leverage of the AgileComponents code strategy, highlighting the slice of the code base written specifically for the Albany/FELIX ice sheet application. This figure illustrates how large parts of the code base are also used by other applications -- several of which are listed in the right column -- which all contribute to the development costs, research drivers, and creation of expertise.

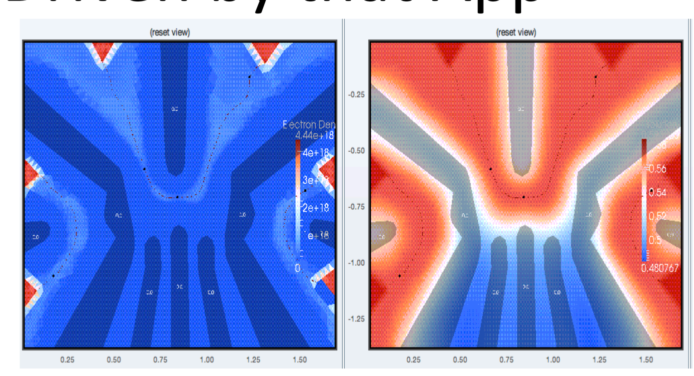
Gallery of Rapidly Developed Albany Applications

- the Component Development Driven by that App



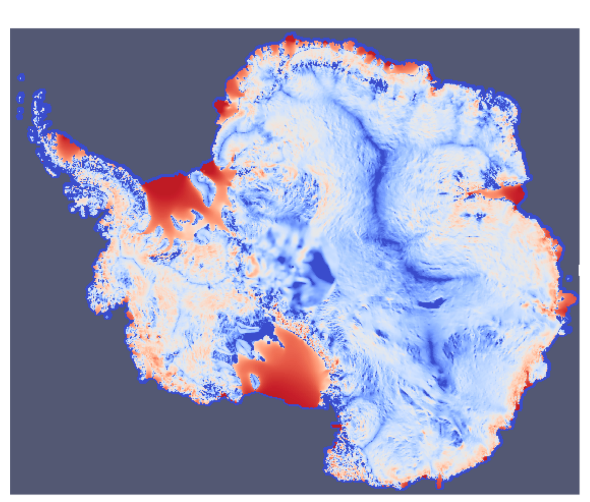
LCM: Computational Mechanics [4]

- Configure/Build system; mesh database; automatic differentiation; response functions; discretizations



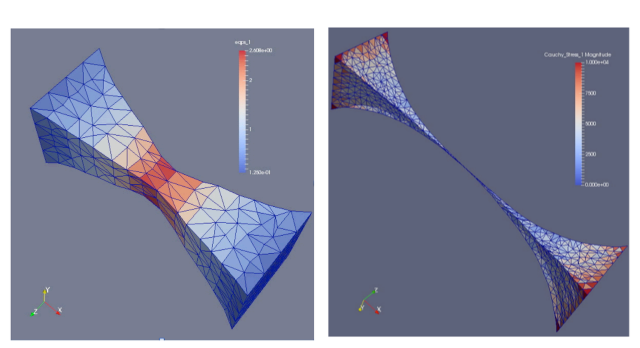
QCAD: Quantum Device Modeling [5]

- *In situ* Optimization; Tet elements; Neumann BCs; MultiLevel Prec; Multi-Physics coupling; eigensovler



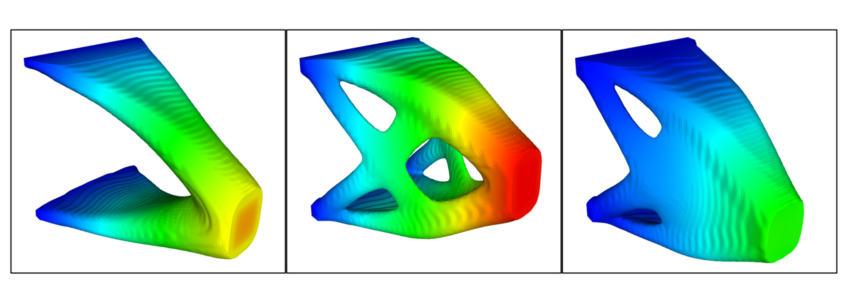
FELIX: Ice Sheet velocity [6]

- Adjoint-based inversion; semi-coarsening ML; Bayesian calibration; Albany as libAlbany.a; port to Kokkos



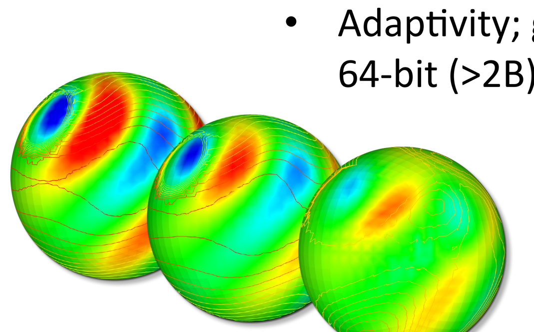
PAALS: Mesh Adaptive Loop [7]

- Adaptivity; github; documentation; 64-bit (>2B) problem size



ATO: Topological Optimization for Additive Manufacturing [8]

- Multi-physics coupling; level-set equations



Aeras: Next-Gen Atmosphere Model [9]

- Performance-portable kernels; embedded UQ; explicit integrators; spectral elements

The Value Proposition for Using Component Libraries

1. Inclusion of the algorithmic capability into the climate code.
2. Access to the algorithmic expert for continued engagement, who can work in his/her own familiar code base.
   - From this foundation, fractional funding streams and even consultations can have large impact.
3. Automatic, free upgrades in capability as the library development continues through other funding sources and using developments motivated by other applications.
4. A decreased code base that must be supported, and ported to new architectures.
5. Encourages more modular code design, for improved agility and maintainability.
6. Broadening of the network of people thinking about your application.
7. Ability to leverage algorithm and inter-disciplinary funding streams to impact climate science application development.

The Value Proposition for Coding Algorithm Ideas Directly in Climate App

1. Inclusion of the algorithmic capability into the climate code.
2. Application expert has complete control of code base

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