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In-situ Meshing to Enable Advanced Analysis Workflows on Next Generation Platforms

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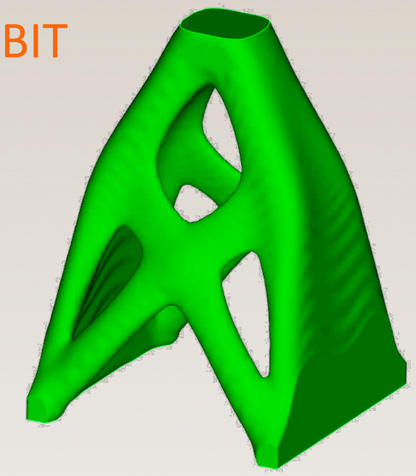
Goal: To enable in-situ meshing by integrating interoperable software components for advanced analysis workflows such as mesh sensitivity analysis, uncertainty quantification, and optimization.

Software Architecture

CUBIT



- CUBIT supports offline geometry creation and geometry import in multiple formats including ACIS
- Supports various geometry modification operations
- Supports boundary conditions via blocks, sidesets, & nodesets
- Exports geometry in STL format

ATDM Apps

- Build ATDM App input deck
- Specify the STL file path to read geometry
- Specify the meshing parameters such as mesh scheme, mesh size, number of process, threads per process, etc.
- Specify the solver parameters
- Specify analysis output format (default is Exodus)

```
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  <Parameter name="Basis degree"                           type="int"    value="1"          />
  <Parameter name="STL file dir"                           type="string" value="/ascldap/users/wrquadr/ATDM/
  <Parameter name="STL file name"                          type="string" value="brick_all_sideset.stl" />
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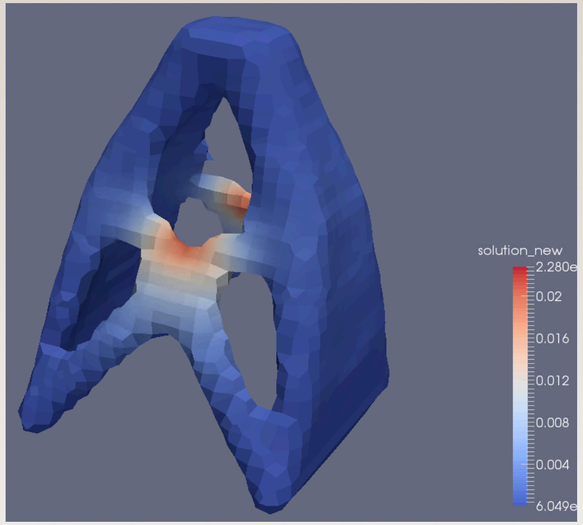
PARAVIEW



- PARAVIEW is a data analysis and visualization application
- Uses qualitative and quantitative techniques to visualize solution field of LSO

ACIS → STL

EMPIRE, AERO, LSO → EXO

STK

- Provides infrastructure that assists in the development of computational engineering software
- Supports parallel unstructured meshes for finite element and finite volume analysis applications
- Supports reading/writing parallel mesh files
- Supports geometric proximity search and other utilities

TRILINOS

PANZER

Panzer_Sculpt_Mesh

- PANZER provides a common API for all ATDM Apps
- PANZER translates Sculpt mesh using STK::Classic

CAMAL

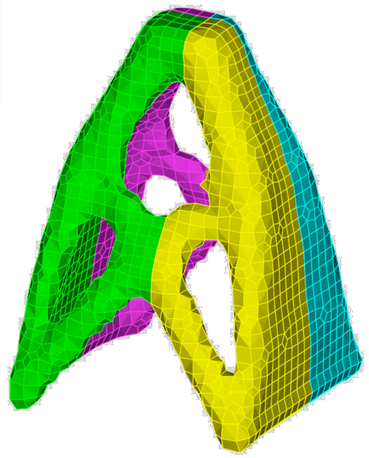
Sculpt_Interface

SCULPT

Linux_Libs

Diatom

STL



- CAMAL is a collection of meshing algorithms and post-meshing algorithms such as volume and surface smoothing
- CAMAL library has been integrated into Trilinos as a TPL
- Sculpt is a parallel hex meshing algorithm in CAMAL
- Linux_Libs provides Diatom import capability.
- Diatom is a geometry format that supports STL

KOKKOS

- Sculpt uses Kokkos for hybrid MPI + X (OpenMP, Pthreads, and CUDA for threading) programming model
- Kokkos provides performance portability on multiple advanced architecture machines
- Supports data parallelism on shared memory models by dispatching parallel functors manycore device
- Manages the layout of multidimensional arrays so that the functors have device optimal memory access patterns.

Conclusion:

Achieved in-situ meshing on a proxy ATDM app called LSO by integrating multiple components such as CUBIT/lib, CTH/Diatom, CAMAL/Sculpt, Trilinos/Panzer, Kokkos, and STK. This work should enable in-situ meshing in the ATDM Apps such as EMPIRE and AERO for advanced analysis workflows on the next generation platforms.

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