ESTO Computational Technologies Project
PYRAMID: Parallel Unstructured Adaptive Mesh Refinement Library

Modern... Simple... Efficient... Scalable...

**Technology Description**

An advanced software library supporting parallel unstructured adaptive mesh refinement for large-scale scientific and engineering simulations.

**State-of-the-Art Design**

- Efficient object-oriented design in Fortran 90/95 with MPI for message passing.
- Automatic mesh quality control, dynamic load balancing, mesh migration, partitioning, integrated mathematics and data structure management routines, all in parallel.
- Scalable to hundreds of processors and millions of elements using triangular (2-dim) and tetrahedral (3-dim) elements.
- Power, completeness, and ease of use.

**Parallel Adaptive Process**

Initially the generally random input mesh must be repartitioned and redistributed after loading from disk. The application calculation and local error-estimation steps occur followed by a logical AMR process that decides how new elements will be created.

Load balancing techniques are used to ensure that the best location for the coarsest elements is determined by using algorithms to minimize data movement and boundary communication.

A physical refinement stage will create new elements from the coarsest elements in the proper load balanced location with quality control.

**Multi-Million Element Adaptive Refinement**

Colors show processors that contain elements that are load balanced across partitions on the parallel machine.

**Performance Modeling on Clusters**

Significant computational power is required for finite element analysis of large models so we use clusters, often with high speed networks, for our software development.

Pyramid runs on massively parallel computers as well as clusters.

**A Minimal Pyramid Program**

Users provide the initial mesh and per-element error indicators and Pyramid handles all of the parallelism issues.

**Current and Future Collaborations**

Partnership with others influences library development.

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