SIERRA & MiniFE

- **What are SIERRA's primary performance characteristics?**
- **What does MiniFE do?**

Alan Williams
Mini-app workshop
August 24, 2010

Sandia
National
Laboratories

What are SIERRA's primary performance characteristics?

- **SIERRA is a suite of unstructured-mesh finite-element analysis applications**
- **SIERRA is big: (7 applications, 2-3 million lines of code)**
- **Being consolidated to 2 major application areas:**
  - **Thermal/fluid (heat transfer, fluid dynamics, turbulent flow, radiation)**
  - **Solid mechanics (quasi-statics, explicit transient dynamics)**

- **Quasi-statics**
  - **Involves nonlinear CG preconditioned by linear-solve (almost exclusively uses Kendall Pierson's FETI-DP solver)**
- **Explicit transient dynamics**
  - **Ideally, performance is dominated by element-loop force and stress calculations (gradient operator, tensor divergence, etc)**
  - **In practice, often dominated by contact, element-death and remeshing operations**
    - Very problem-dependent!

- **Application developers are expressing interest in threading and GPUs.**

Sandia
National
Laboratories

What are SIERRA's primary performance characteristics?

- ## Thermal/fluid
    - **Implicit Galerkin finite-elements**
    - **Heat-transfer capability can be as simple as solving the conduction equation, and for certain (simple) problems can be dominated by unpreconditioned (linear) conjugate gradients. (MiniFE!!)**

    - **More "interesting" problems involve adaptive mesh refinement, contact, radiation, etc.**
        - Very performance-intensive, can swamp the linear-solver in many cases.

    - **Solution often includes several coupled equations, not just temperature**

    - **Often includes terms that make the matrix non-symmetric, and linear-solve performance lives or dies by the preconditioner.**
    - **GMRES/ILUT (Aztec) is a workhorse, recently they are experimenting with the ML preconditioner to get better parallel scaling.**

What does MiniFE do?

- **MiniFE (evolved from Mike's HPCCG) does two major computations:**
    1. finite-element assembly of a global linear-system from the conduction equation on a brick-shaped domain of hex-8 elements.
    2. Solve the linear-system using unpreconditioned conjugate gradients
- **Good proxy for the "simple" thermal application**

- **Excellent test-bed for experimenting with:**
    - Shared-memory (threaded) programming
    - Hybrid (MPI+threads) parallelism
    - GPU (Nvidia/CUDA) programming

- **Has optional compile-time support for:**
    - Intel TBB threading library
    - Trilinos/TPI thread-pool library
    - Nvidia/CUDA
    - Optionally store data in STK-mesh
- **More details, and performance results in a presentation from SIAM PP10 …**

Sandia National Laboratories