SIERRA & MiniFE

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

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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.

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 …