Computational Seismology at LLNL: A National Lab Perspective

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Overview of LLNL Seismology

- LLNL is a DOE-funded applied science Lab
  - Working on problems of national security interest
  - Heavily driven by programmatic requirements
- Seismology Programs
  - Ground Based Nuclear Explosion Monitoring (GNEM) Program
    - Largest program supporting seismology
    - 15 Ph.D. seismologists
  - Hazards Mitigation Center
    - Strong motion prediction & modeling
  - Southern Nevada Programs
    - Yucca Mountain Program
    - Test Site Readiness
- Livermore Computing
  - Some of the most powerful computers in the world

Computational Seismology in the GNEM Program - 1

- Forward calculations of high-frequency seismograms in 3D Earth models (*Rodgers*, *Myers*)
  - Focus on local (< 50 km) & regional (< 2000 km) distances
    - Large-scale computing
    - 3D model manipulation
- Estimation of 3D Earth models (*Pasyanos*)
  - Surface wave group velocity tomography
  - Markov Chain Monte Carlo
    - Relies on multiple data sets
    - Large-scale computing
- Waveform correlation methods (*Harris*)
  - Coherent signal processing

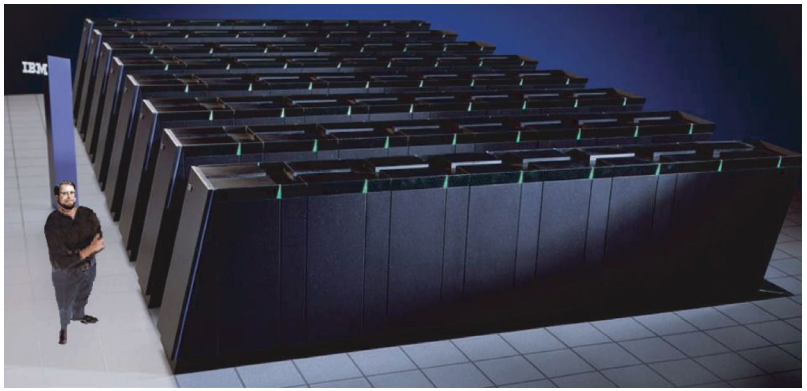
Computational Seismology in the GNEM Program - 2

- Many “conventional” applications
  - Ray tracing/travel times
  - Event location
    - Single & multiple events
  - Travel time & surface wave tomography
  - Synthetic seismograms
    - Reflectivity, WKBJ and normal mode
  - Regional phase amplitude measurements
    - P/S discriminants
    - Coda magnitudes
  - Surface wave dispersion
  - Waveform inversion
    - Crustal/Lithospheric structure estimation
    - Source parameter estimation
  - Receiver functions
  - Hydroacoustic and coupled seismic/hydro

Scientific Information Management

- GNEM Research Database
  - ORACLE DB, SQL/Plus, various tools
- Contains …
  - 60 Terabytes
  - ~ 60,000,000 waveforms from 10,000's stations
  - Provides data in "research ready" form
- Unifies data-processing efforts
  - Resolves format issues
  - Measurement tools read from and written to DB
    - Regional phase amplitude processing
    - Phase picking and event location
- GNEM LINUX Cluster
  - 10 nodes (20 CPUs), soon to be 25 nodes

Livermore Computing



BlueGene/L, 70 Tflops/s (#1/500)
65536 nodes, 131072 CPUs

MCR, 11 TFlop/sec (#19/500)
1152 nodes, 2304 CPUs

Thunder, 22 Tflop/sec (#5/500)
1024 nodes, 4096 CPUs

- Access to LC is open for LLNL researchers: allocations are prioritized.
- Access for non-LLNL researchers is possible, but difficult.
- Getting allocation with sufficient cycles is key.
- Visualization also supported.

LLNL Goals

- Short-Term
  - Facilitate the use of “conventional” tools
    - Synthetic seismograms
    - Waveform inversion
  - Expand the use of 3D travel time and waveform codes
    - Facilitate the specification of models
    - Store metadata and output for runs
- Long-Term
  - Make use of powerful computers for LLNL programmatic priorities
  - Develop and enhance parallelized applications
    - 3D travel time and waveform calculations
    - Grand-scale high-resolution stochastic tomography
    - Parallel signal processing
    - Data mining

LLNL Opportunities

- Possibilities exist for collaboration with LLNL via CIG
  - Must serve mission and be great science (need Lab “by-in”)
  - LLNL has much to offer
- Vehicles for collaboration
  - Joint Proposals
    - DOE/AFRL NEM BAA process
      - Nuclear Explosion monitoring focus
      - Current round due July 26
    - DOE/Office of Science
      - Basic science and computational focus
      - Typically due in January
  - Visiting Scientist
    - Sabbatical Leave
    - Participating Guest status
- Development of a new elastic finite difference code
  - Possible for CIG to guide development

Thank you

Other Efforts

- Strong Motion Efforts
  - Bay Area fault ruptures (*Larsen, Rodgers*)
    - Hayward Fault
    - 1906 San Francisco Earthquake Project
  - Southern Nevada (*Larsen, Hutchings, Foxall, Rodgers*)
    - Yucca Mountain Program
    - Test Site Readiness
    - Efforts rely on 3D model(s) and multiple runs on large-scale computers
  - Theoretical and Related Efforts
    - Poroelasticity (*Berryman*)
    - Hydrodynamic Modeling
      - Shock physics
      - Discrete element method