

Workshop on Computing for Earth System Science

Jeroen Tromp
Princeton University



Domain Science: Computational Seismology

- Almost 20 years of open source software development
- Forward simulations: modeling seismic wave propagation generated by explosions, earthquakes, and “noise”
- Adjoint simulations: using seismic waves to constrain Earth structure
- Tools used from MHz frequencies for medical imaging and nondestructive testing to mHz frequencies for Earth’s free oscillations: 9 decades in frequency
- Peripheral software for preprocessing (timeseries analysis, windowing, making measurements, etc.) and postprocessing (quasi-Newton optimization) just as important as the solvers



Inversions Require Proximity to Data

- The IRIS Data Management Center is located in Seattle
- It takes months to transfer waveform data from the IRIS DMC to an HPC facility such as Oak Ridge
- Need to “mirror” the IRIS database and tools at dedicated HPC center(s)



Exchange of Earth Models

- There is no standard for the exchange of Earth models
- It is very difficult to take a seismic tomographic model and use it for geodynamic simulations
- This inhibits Earth System Science
- It takes enormous amounts of time and effort to develop and maintain a standard
- There is little “glory” for the developers of the standard



Academic Software Development Challenges

- Hardware evolution requires continual investment in code development and optimization
- Human resources turnover every few years
- Need dedicated professional software engineers
- Need dedicated financial resources
- Very difficult to sustain software over the long term
- No professional software development environment
- Need unit testing (e.g., Travis, Jenkins, BuildBot) , standards, documentation, examples, test cases, nightly builds



Research Software Engineers

- Very difficult to find
- Very difficult to retain
- Often not sufficiently appreciated by domain scientists and university administrators
- Need a stimulating, collaborative, respectful environment
- Need to define appealing career trajectories
- These human resources have become just as important as the computational resources
- Can alleviate academic software development challenges



Previous & Current Efforts

- About 10 years ago there was a discussion involving NSF, DOE (Oak Ridge and Livermore), and CIG to discuss the possibility of generating an “NCAR-like” facility for solid Earth geophysics
- Idea was to locate a dedicated team of about 7 professionals at an existing DOE HPC facility
- CIG could grow from a software-only enterprise to true, hands-on support organization providing education, training, software development, computational resources, and human resources
- SCOPED: Ongoing attempt by Carl Tape, Ebru Bozdag, et al. to establish a Cyberinfrastructure that delivers data, computation, and service to the seismological community (Collaboration with TACC)

