The EQSIM Computational Framework for Fault-to-Structure Earthquake Simulations – a DOE Exascale Computing Project Application Development

DOE - NRC Natural Phenomenon Hazards Workshop

David McCallen
Lawrence Berkeley National Laboratory
and the University of Nevada, Reno

Large earthquakes present a major worldwide risk and are a significant natural phenomenon hazard across the DOE mission space ranging from DOE's own inventory of one-of-a-kind, mission critical facilities to all major US energy systems (electric/gas distribution systems, renewable energy production facilities, nuclear power plants etc.). Beyond the DOE enterprise, addressing earthquake risk, from the standpoint of life safety and damage/economic impact, is a major societal challenge for all seismically prone regions of the world. Because of the complexities of earthquake processes, empirically based methods have been employed to yield estimates of future earthquake ground motions, however this approach has significant limitations in terms of the ability to represent the complex spatial variability and site-specific nature of strong ground motions.

The continued rapid advancements occurring in high performance computing, data collection, and data exploitation can help transform earthquake hazard and risk assessments. As computational power increases, the reliance on simplifying idealizations, approximations and sparse empirical data can diminish, and attention can be focused on understanding the fundamental physics uncertainties in earthquake processes. Regional-scale ground motion simulations are becoming computationally feasible, and simulation models that connect the domains of seismology, geotechnical and structural engineering are becoming within grasp. The EQSIM application development project is focused on creating an unprecedented computational toolset and workflow for earthquake hazard and risk assessment. EQSIM is developing a simulation framework for executing fault-to-structure simulations on the next generation of exaflop computers that will be coming on-line at DOE National Laboratories in the 2022 time frame. EQSIM simulations will provide unique new information on earthquake hazard and risk, and the simulation technology can ultimately help reduce the current substantial uncertainties in predicting the effects of major earthquakes.

This presentation will provide a comprehensive overview of recent developments on the EQSIM framework including advanced algorithm development, workflow for simulations at billions of grid zones, and preparation for implementation on DOE's exascale computer platforms.