TP4: Computational Simulation and Data Visualization

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Simulation and data visualisation software are the primary means by which the seismic resilience of infrastructure components and systems are quantified and communicated to end users and the general public. The aim of this Technology Platform is to provide computational workflows which enable the connection of all multi-disciplinary research activities across QuakeCoRE via a 'heterogeneous software ecosystem' and thus provide a pipeline by which new research results at any point can be understood in terms of their wider impacts in earthquake resilience.

For the purpose of operational and strategic planning, the platform is seperated into three research thrust areas of: (1) ground motion simulation; (2) seismic response modelling of infrastructure; and (3) seismic loss assessment, all of which have objectives toward reducing the barriers to entry and time to solution via the principles of open-source, scalable, and flexible software development.

Further details can be found in the sections below and related sub-pages.

Key research thrust areas

There are three key thrust areas in QuakeCoRE's computational infrastructure efforts (The specifics for each of the thrust areas are outlined below in their respective pages):

1. **Ground motion simulation:** Includes the development of a computational pathway for handling ground motion simulation calculations, the necessary input model information, post-processing of results and visualisation.
    - Ground motion simulation workflow: Discusses developments the QuakeCoRE ground motion simulation workflow for performing hybrid broadband ground motion simulations of NZ earthquake ruptures using multiple wave propagation tools and NeSI HPC resources
    - SeisFinder: Discusses the SeisFinder interface, which allows access to ground motion simulation information for use in engineering applications

2. **Seismic response modelling of infrastructure:** Includes both detailed modelling of individual infrastructure components (e.g. individual structural and geotechnical systems), as well as spatially-distributed infrastructure systems.
    - **OpenSees Development:** The Open System for Earthquake Engineering Simulation (OpenSees) is the principal collaborative software for detailed modelling of individual infrastructure used by QuakeCoRE. You can find specific initiatives by clicking on the link above.
    - Further information can be found in the 2016 QuakeCoRE Annual Meeting Poster for this topic.

3. **Seismic loss assessment:** Includes both detailed 'structure-specific', as well as 'regional' loss assessment.
    - OpenSLAT - an open-source software for building specific loss assessment. Further information on work to date can be seen in this 2016 QuakeCoRE Annual Meeting Poster.
    - SP3 - a product of Haselton Baker Risk group - is a commercial structure-specific loss assessment product. While commercial, efforts will be made for other TP4 products to produce outputs that can be used within SP3.
    - RiskScape - a regional loss assessment platform developed and maintained by GNS Science and NIWA. QuakeCoRE TP4 efforts are focused on ensuring compatibility of ground motion simulation and seismic response modelling of infrastructure workflows to providing input information into Riskscape. See these links for: General information on RiskScape; and detailed information at the RiskScape Wiki.
    - PAGER - a macro-impact assessment provided by the USGS.
    - Regional liquefaction and landslide models based on geospatial information

Overarching objectives

The two key objectives for this platform are:

'Reducing barriers to entry': Simplifying the access to data and computational software workflows so that it is easier to use for researchers unfamiliar with specific nuances. This will lead to an increase in the usage of high quality data and computational tools by QuakeCoRE researchers, both improving research quality and connectivity between disciplines.

'Reducing time to solution': Through optimizing database storage and computational codes, as well as pre- and post-processing workflows, we will allow researchers to speed up their research. Improved timeliness will allow for the solution of both previously un-managable problems, as well as improved multi-disciplinary research interactions.

Principles

The underlying principles to attain the overarching objectives are:

Open Source: The software should be open source to maintain flexibility, enhance collaboration, and not be dependent on external software organisations. This also recognises that NZ researchers represent a small portion of the global human resource in this field and the use of OS software enables a greater leverage of international initiatives.

Scalable: The software should be able to be scaled to make use of HPC facilities, particularly through NeSI.

Flexible: The outputs of the different software modules should be able to easily read by other software modules within the QuakeCoRE ecosystem.

Personnel

The QuakeCore (and aligned) staff for Technology Platform 4 (Simulation and Data Visualization) (some of who are also involved in TP 3 (Multi-disciplinary community datasets)) are:

Sung Bae, IT architect

Sharmila Savarimuthu, software engineer

Viktor Polak, software engineer

Daniel Lagrava (Aligned software developer)

Sharmila Savarimuthu (Aligned software developer)

Jonney Huang (Aligned software developer)

Jason Motha (Aligned software developer)

Michael Gauland (Aligned software developer)

Key performance indicators:

KPI	Start Date	Due Date	Q2 report
TP4.1: Implement emod3d and specfem ground motion simulation software on NeSI HPC resources.	1/01/2016	1/01/2017	Completed
TP4.2: Develop a streamlined workflow (incl. visualization) for ground motion simulation calculations to minimize the barrier to entry in new users running a large number of ground motion simulations.	1/01/2016	1/01/2018	On track
TP4.3: Develop automated simulation of ground motions from NZ earthquakes in real-time.	1/01/2017	1/07/2018	On track
TP4.4: Optimize OpenSees FE software on NeSI HPC resources and train the QuakeCoRE community to develop a critical mass of capable OpenSees analysts.	1/01/2016	1/01/2018	On track
TP4.5: Develop centralized pre- and post-processing functionality for OpenSees calculations to reduce barriers to users to streamline their analyses.	1/07/2016	1/01/2018	On track
TP4.6: Examine the parallelization of the OpenSees source code and look to improve its HPC scalability to enable large computational models to be run efficiently.	1/01/2017	1/01/2019	On track
TP4.7: Implement structure-specific and regional loss estimation software into a computational workflow with ground motion and OpenSees simulations.	1/01/2017	31/12/2020	Not started
TP4.8: Implement multi-scale loss estimation methods which combine the details of current structure-specific methodologies at the regional level.	1/07/2017	31/12/2020	Not started
TP4.9: Parallelize loss estimation software so that multi-scale loss estimation methods are computational feasible.	1/01/2018	31/12/2020	Not started

2018 RfP Information

No applications or Expressions of Interest (EOI) are being sought via the RfP. The Technology Platform Leaders are responsible for delivering a long-term coordinated Technology Platform Programme; investigators are encouraged to engage with the Technology Platform Leaders to see where they may contribute to the Technology Platform Programme.