QuakeCoRE
NZ Centre for Earthquake Resilience

QuakeCoRE OpenSees Monthly Webconference 19 October 2016

UC University of Canterbury
The University of Auckland New Zealand
Resilient Organisations
GNS Science
Massey University
Te Whare Wānanga o te Upoko o te Ika a Māui Victoria University of Wellington
The University of Waikato Te Whare Wānanga o Waikato
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Monthly Webconferences

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Objectives/Purpose:

- Provide a place where researchers can share the OpenSees-related work they are doing with the QuakeCoRE research community
- Provide a medium through which to hold presentations about OpenSees topics of interest, and to
- Generally facilitate collaboration and sharing between students and faculty working with OpenSees

Typical Agenda (will vary a bit week-to-week)**:**

- Updates on ongoing QuakeCoRE OpenSees development
- Student presentations on past/current/future OpenSees research (shorter)
- Seminars on OpenSees topics of general interest (longer)
- Community questions/discussion sessions

QuakeCoRE and OpenSees

QuakeCoRE
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QuakeCoRE is a national network of leading New Zealand earthquake resilience researchers intended to:

- Leverage strengths across the country and internationally
- Facilitate collaborative integrated multidisciplinary research that will support the development of an earthquake-resilient NZ

Flagship Programs:

- FP1: Ground Motion Simulation & Validation
- FP2: Liquefaction Impacts on Infrastructure
- FP3: Heritage, Safety & Economics: Addressing Earthquake-Prone Buildings
- FP4: Next-Generation Infrastructure
- FP5: Pathways To Resilience
- FP6: Spatially Distributed Infrastructure

QuakeCoRE and OpenSees

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Technology Platforms:

- TP1: Experimental Laboratory Facilities
- TP2: Field Testing & Monitoring
- TP3: Open-source Community Datasets
- TP4: Computational Simulation and Data Visualization

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Technology Platform 4:

- Ground motion simulation
- Seismic response modelling of infrastructure
- Seismic performance and loss assessment

QuakeCoRE and OpenSees

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Role of QuakeCoRE with OpenSees:

- Optimize implementation of OpenSees on NeSI HPC resources
- Development of pre/post-processing tools to streamline utilization of OpenSees by QuakeCoRE researchers
  - Mesh generation tools
  - 'Code blocks' for common or typical simulation types
  - Post-processing tools
  - Results visualization

Workshop Survey Results

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Summary – Who comprises the QuakeCoRE OpenSees research community?

- Largely composed (80%) of users with little or no experience with OpenSees
- Predominantly structural analysis
- The computational scope of most of the work is moderately demanding, with parametric studies comprising the main source of computational demand
- No consensus pre/post-processing tools or strategies in use throughout the community – more of a mix of different things
- Desire for improvement/assistance nearly equally in each of:
  - Pre-processing
  - Analysis tools
  - Post-processing
  - Visualization

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Update: OpenSees Parallel Workflow

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OpenSees Parallel Workflow

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One of the initial TP4-related tasks for OpenSees is related to workflow optimization for parallel analysis of very large models:

- Two options for parallel analysis using OpenSees
  - OpenSeesSP – single interpreter → very large models (many DOF)
  - OpenSeesMP – multiple interpreter → parameter studies (and very large models with manual domain decomposition)

- Currently, it appears that OpenSeesSP does not scale particularly well for the types of problems that have been analyzed with this parallel tool. Why?
  - Inefficient communication between processes
  - Master process (where single interpreter in running) is overloaded
  - Optimal size of decomposition has been reached
  - Too much communication due to choice of implicit integrator

OpenSees Parallel Workflow

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OpenSeesSP Initial Profiling:

- Initial profiling has been carried out for OpenSeesSP using a power7 node with 32 cores (up to 128 virtual cores). The selected profiling tool is TAU (http://www.cs.uoregon.edu/research/tau/home.php)
- The test problem is a version of the Heathcote Valley simulations being carried out by Seokho Jeong at UC. This test problem was chosen as it is able to run in a reasonable amount of time (~15 min) on several cores.
- Execution times (note that performance is affected by instrumented code):

Number of Cores	Execution Time (s)
8	6219
16	3785
32	2805

- Scaling from 8 to 16 is reasonable, but scaling from 16 to 32 is poor

OpenSees Parallel Workflow

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OpenSeesSP Initial Profiling:

- The functions that use the most time for 8 cores:

OpenSees Parallel Workflow

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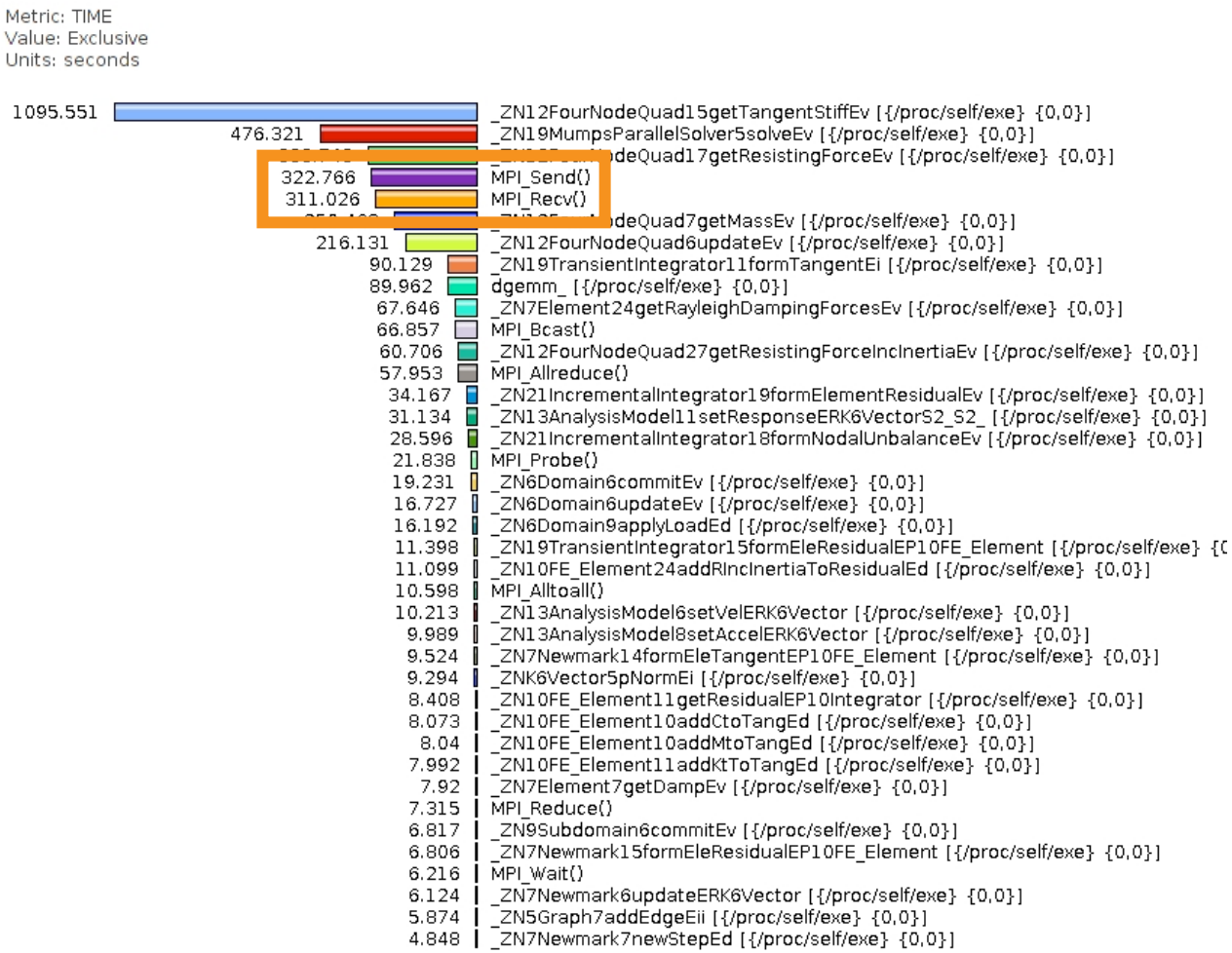
OpenSeesSP Initial Profiling:

- The functions that use the most time for 16 cores:



OpenSees Parallel Workflow

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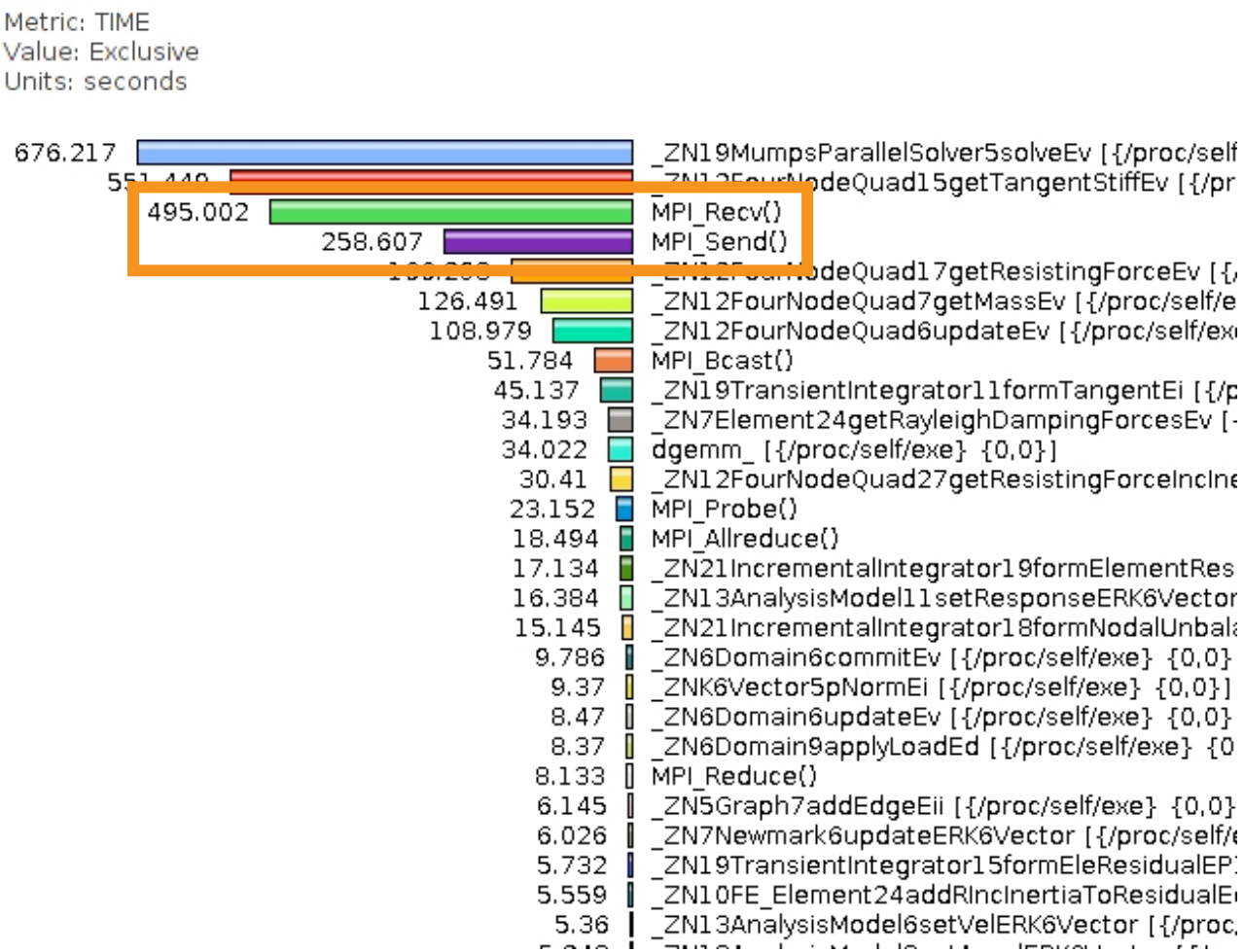
OpenSeesSP Initial Profiling:

- The functions that use the most time for 32 cores:



OpenSees Parallel Workflow

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OpenSeesSP Initial Profiling:

- The portion of the execution time occupied by the MPI send and receive functions increases with the number of cores

Number of Cores	Execution Time (s)	MPI send/recv (s)	MPI send/recv (%)
8	6219	423.74	6.81%
16	3785	633.79	16.74%
32	2805	753.61	26.87%

- The increase in percentage is much larger than would be expected.

OpenSees Parallel Workflow

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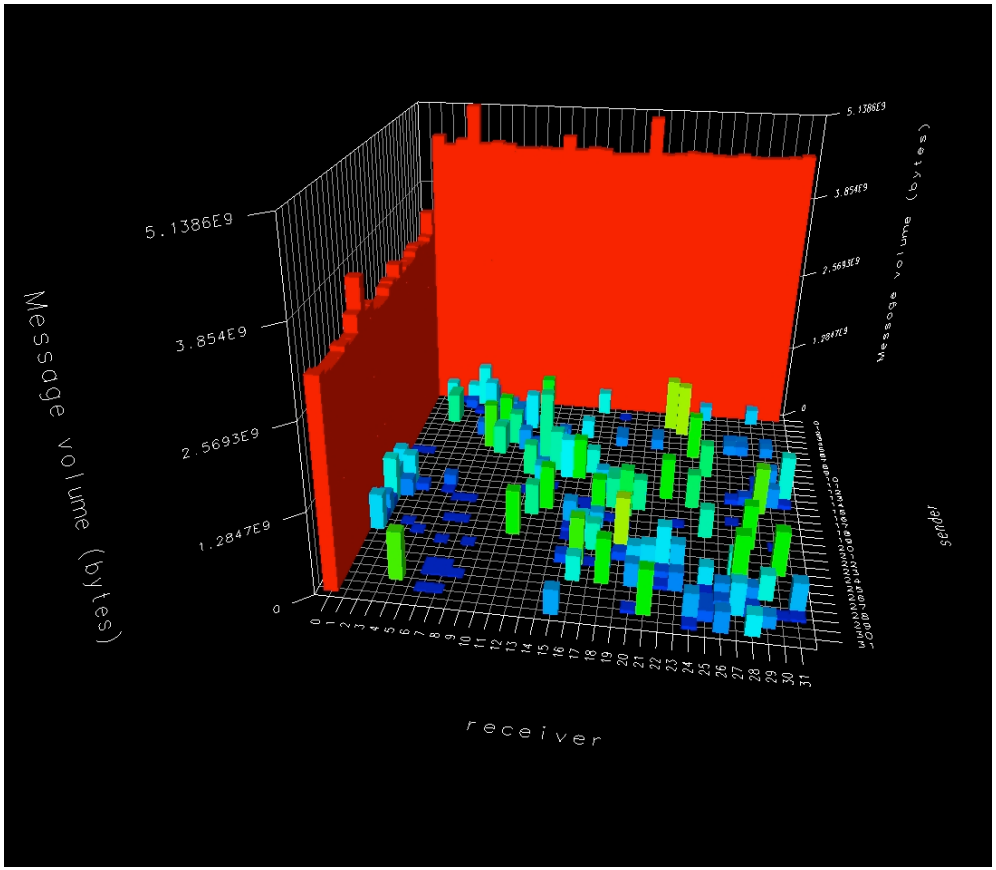
OpenSeesSP Initial Profiling:

- The communication matrix below shows that most of the communication occurs between process 0 and the others. The other inter-process communications are irrelevant to the total communication time



OpenSees Parallel Workflow

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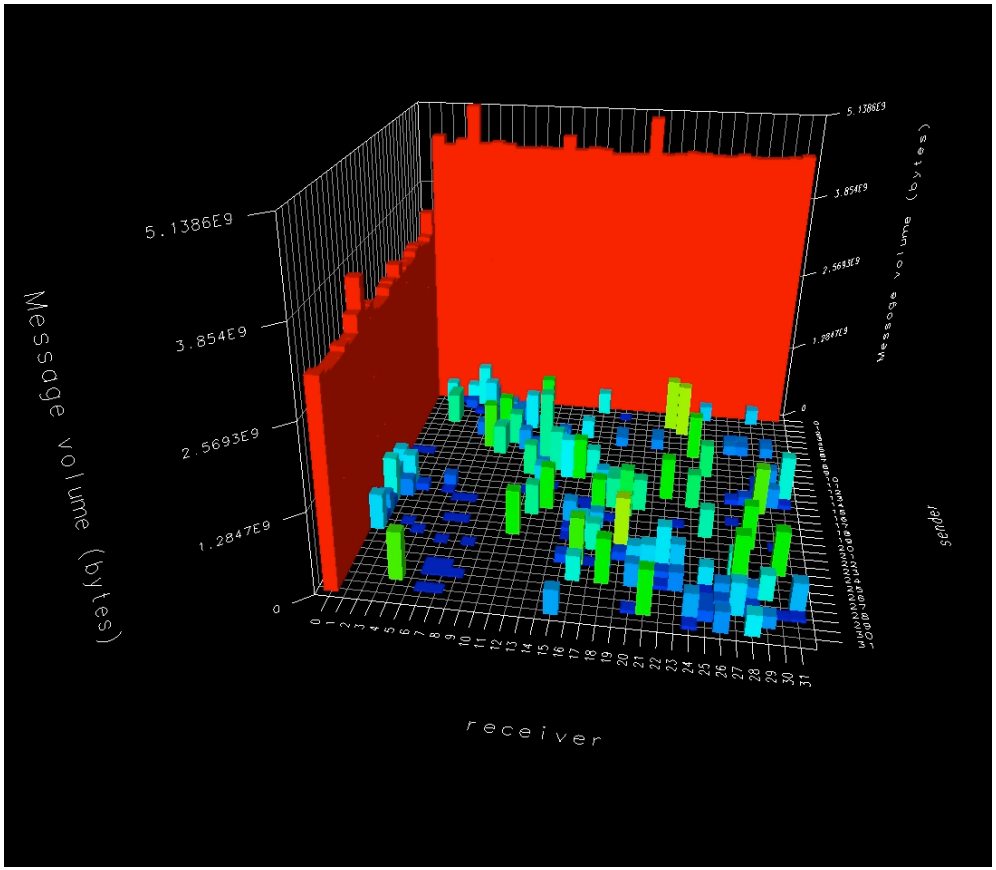
OpenSeesSP Initial Profiling:

- By inspecting the code, we have found that the MPI blocking communication is performed in a point-to-point manner, where process 0 sequentially sends and receives from the others rather than using a collective communication.



OpenSees Parallel Workflow

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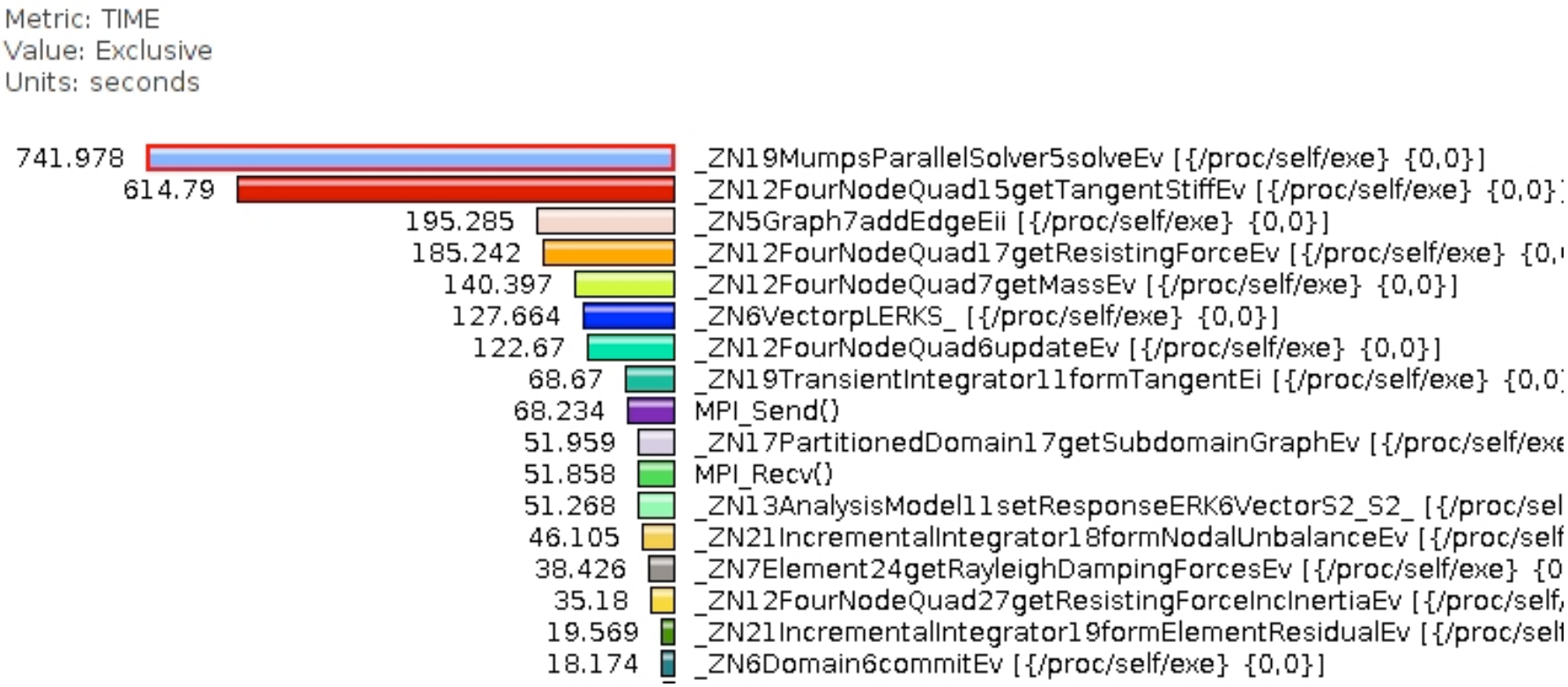
OpenSeesSP Initial Profiling:

- To illustrate how this may affect the performance, we can compare what processes 0, 2, and 31 are spending their time on during the analysis:



Process 0

OpenSees Parallel Workflow

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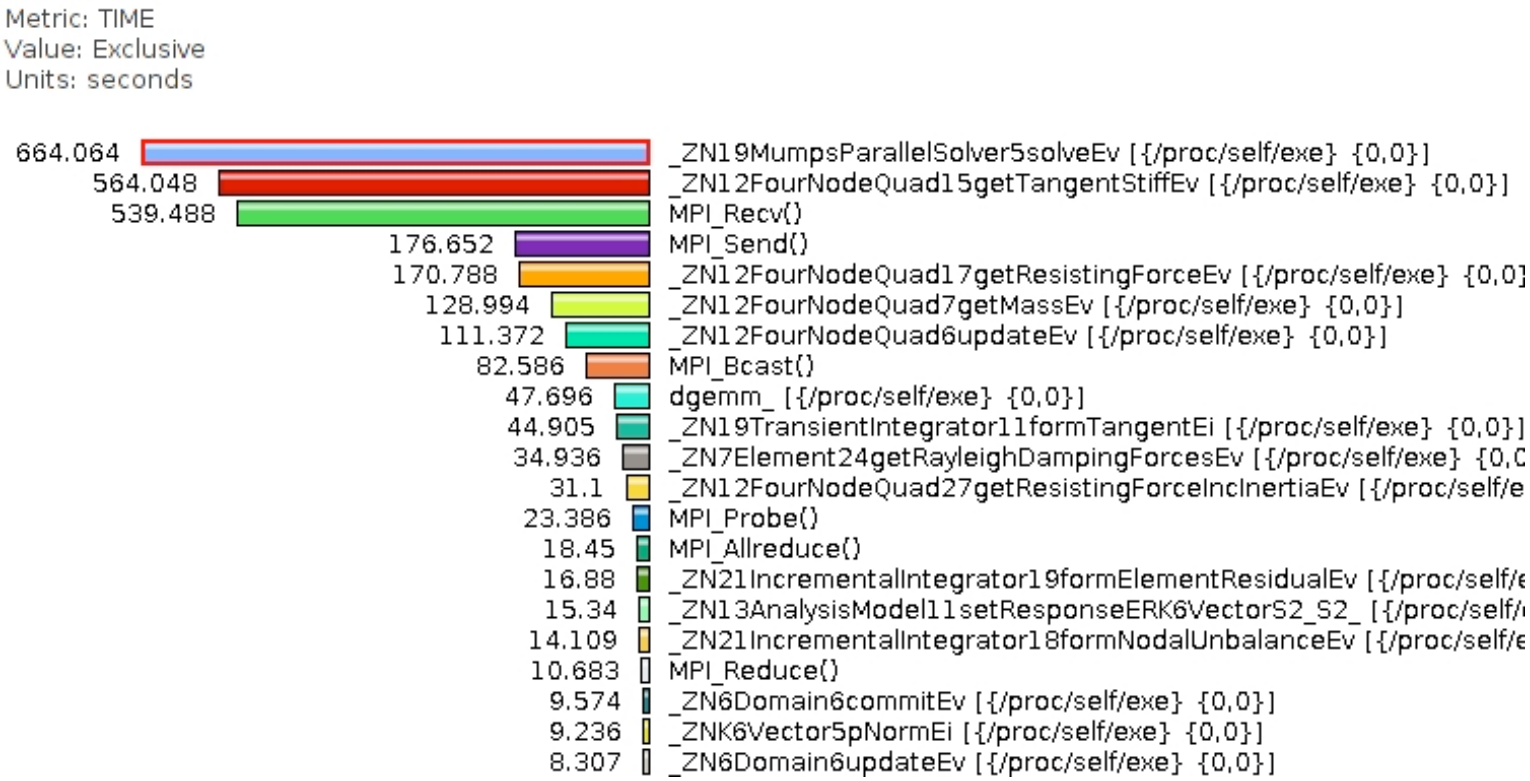

Process 2

OpenSees Parallel Workflow

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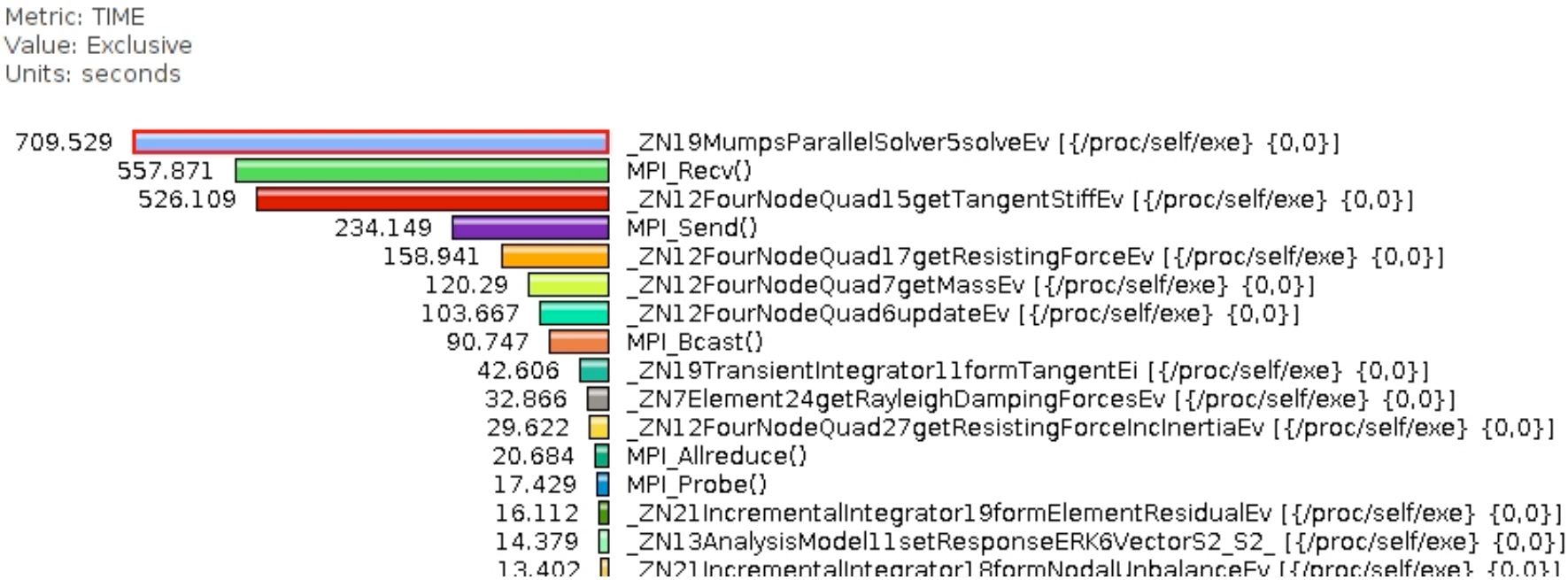

Process 31

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Thank you!

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