OpenSees

Introduction to OpenSees
Parallel Classes and Applications

Frank McKenna
UC Berkeley

OpenSees Parallel Workshop
Berkeley, CA

NEES

NEESit

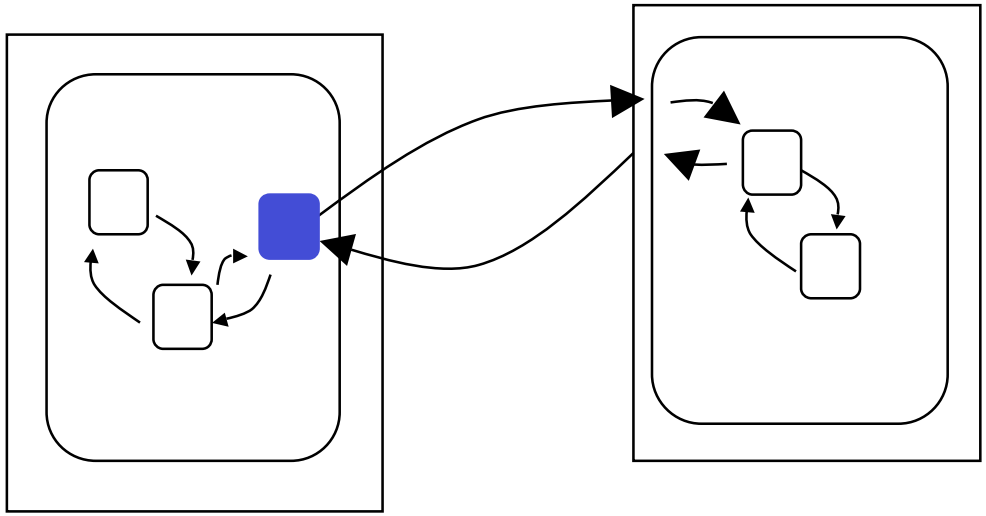
NSF

What is OpenSees?

- OpenSees is an Open-Source Software Framework written in C++ for developing nonlinear Finite Element Applications for both sequential and **PARALLEL** environments.
- The OpenSees framework provides classes for the Actor programming model.

The Actor Model

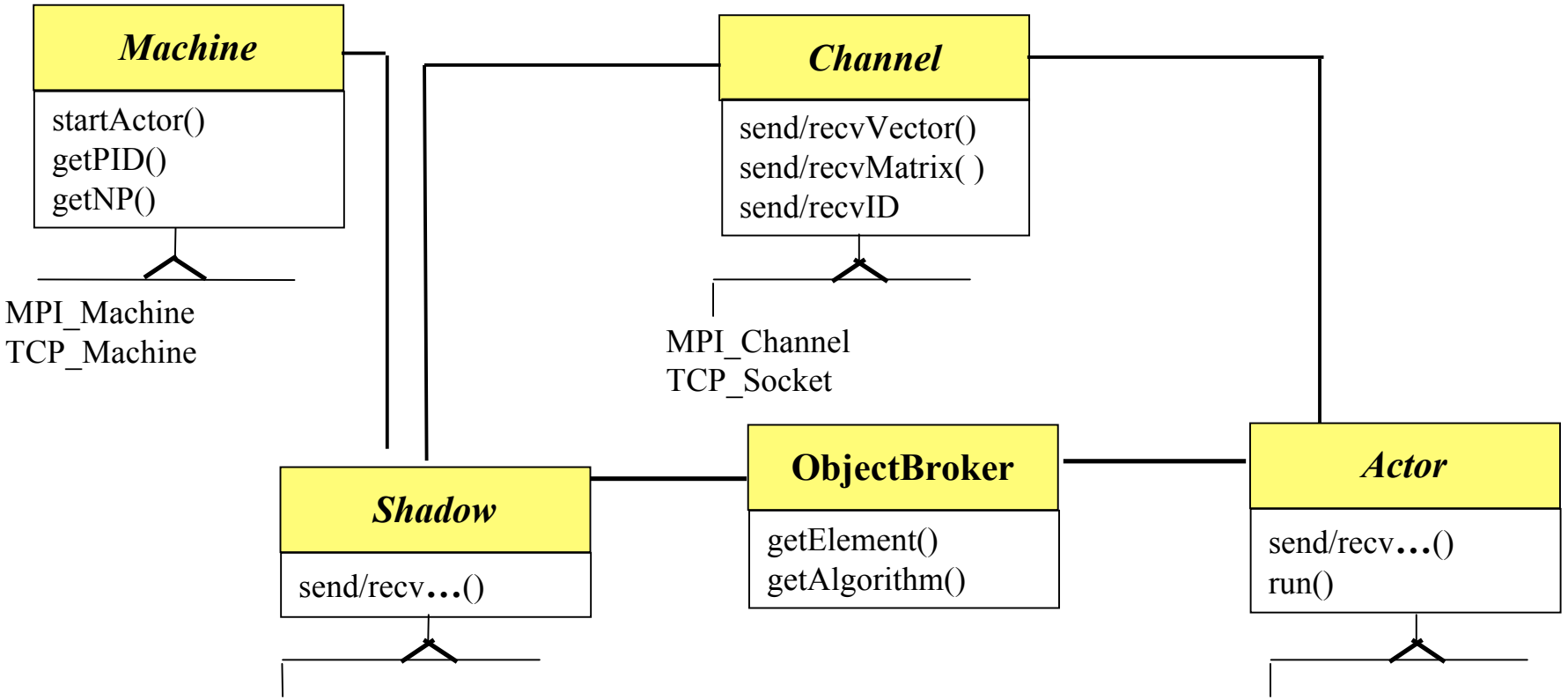
- It is a parallel version of the object-oriented model.
- In response to an incoming message, Actors can perform local work, create more Actors to perform the work, and can send return messages.
- A Shadow object represents a remote actor object locally, methods from the local process intended for a remote Actor go through the local Shadow object.



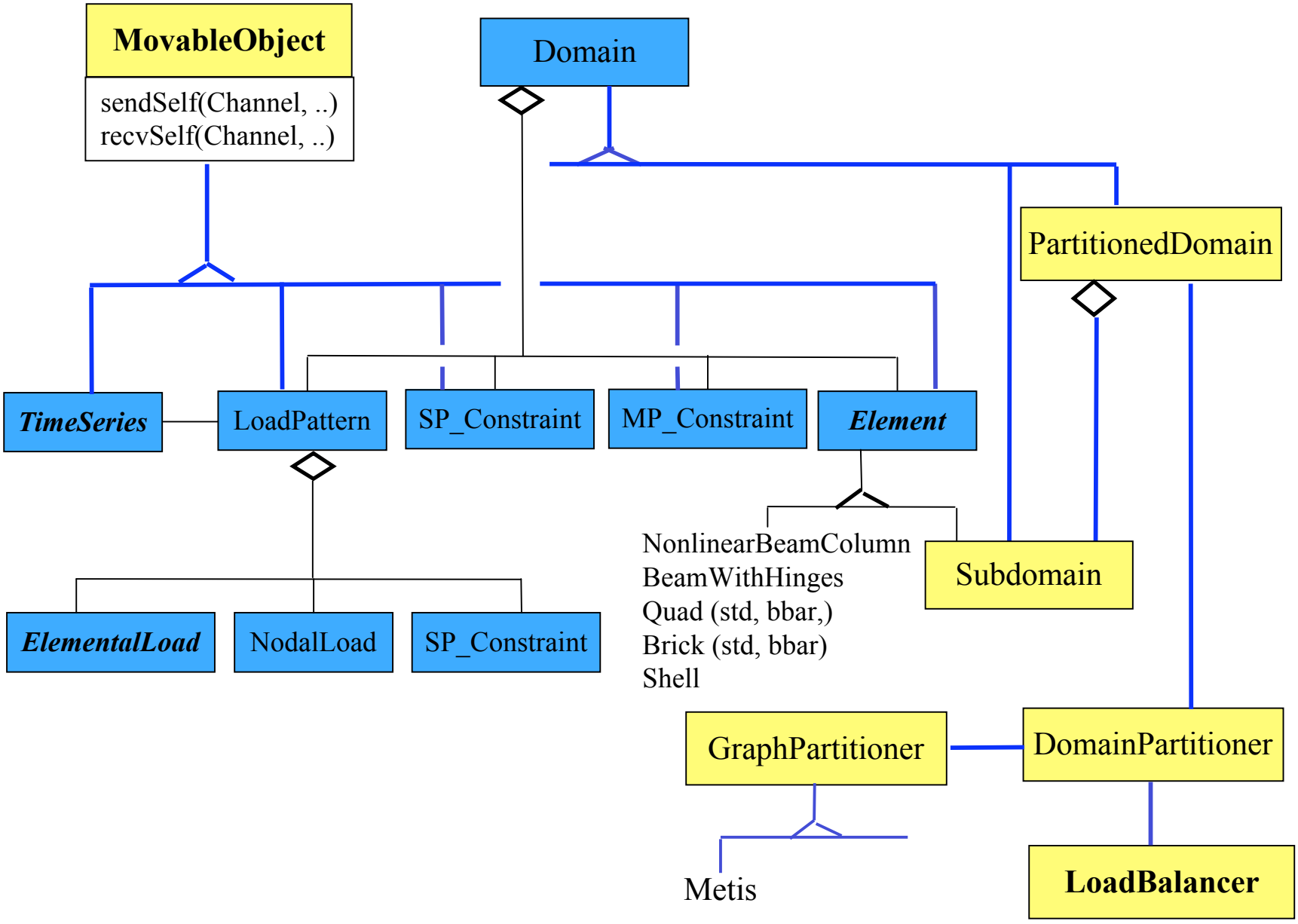
- It does not preclude message passing or thread programming within the objects.

Classes for Parallel Processing

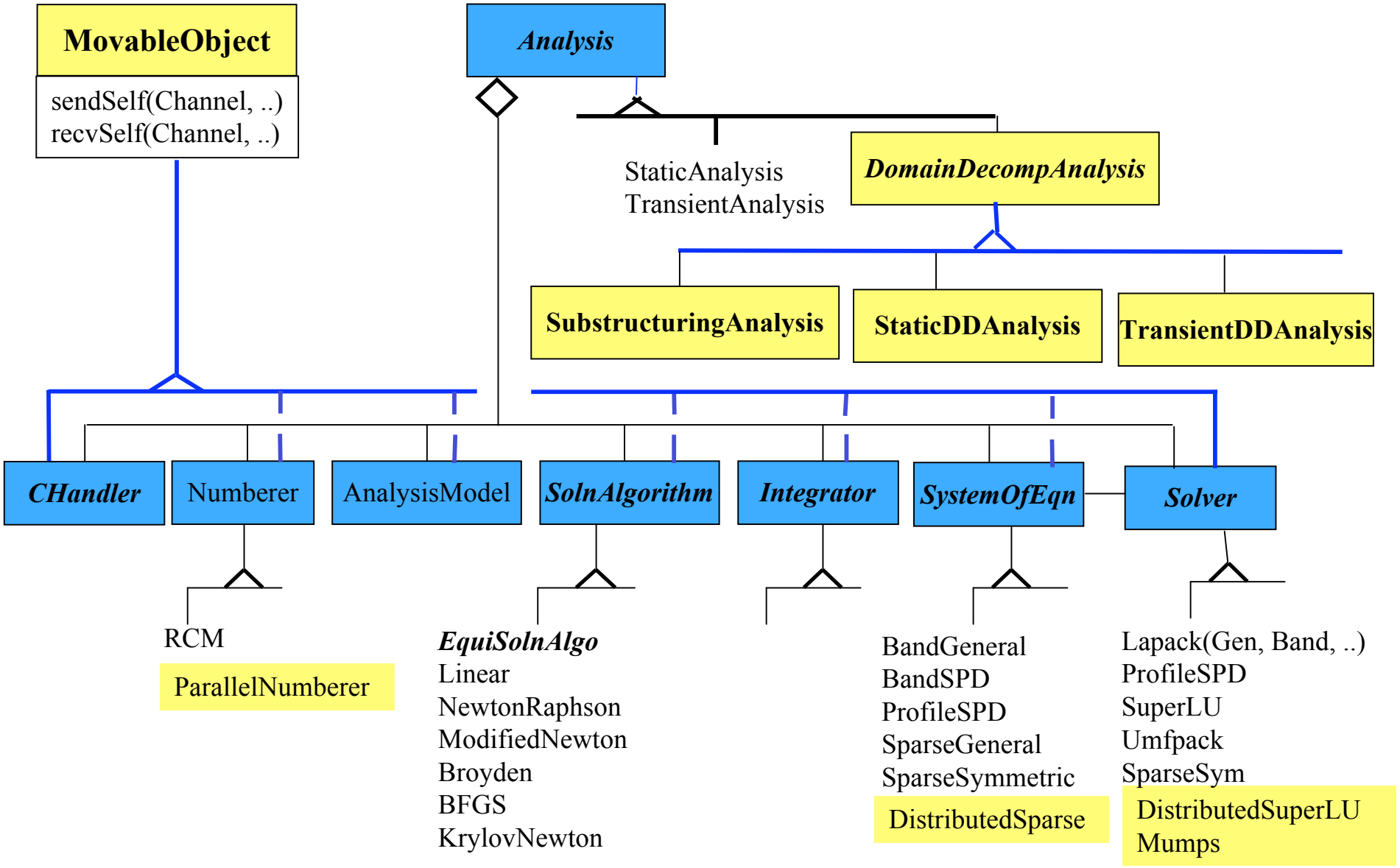
- The OpenSees framework was designed for parallel and distributed processing from the outset.
- Classes are provided for the Actor Model.
- This does not rule out the use of message passing or threads within the objects of an Actor.



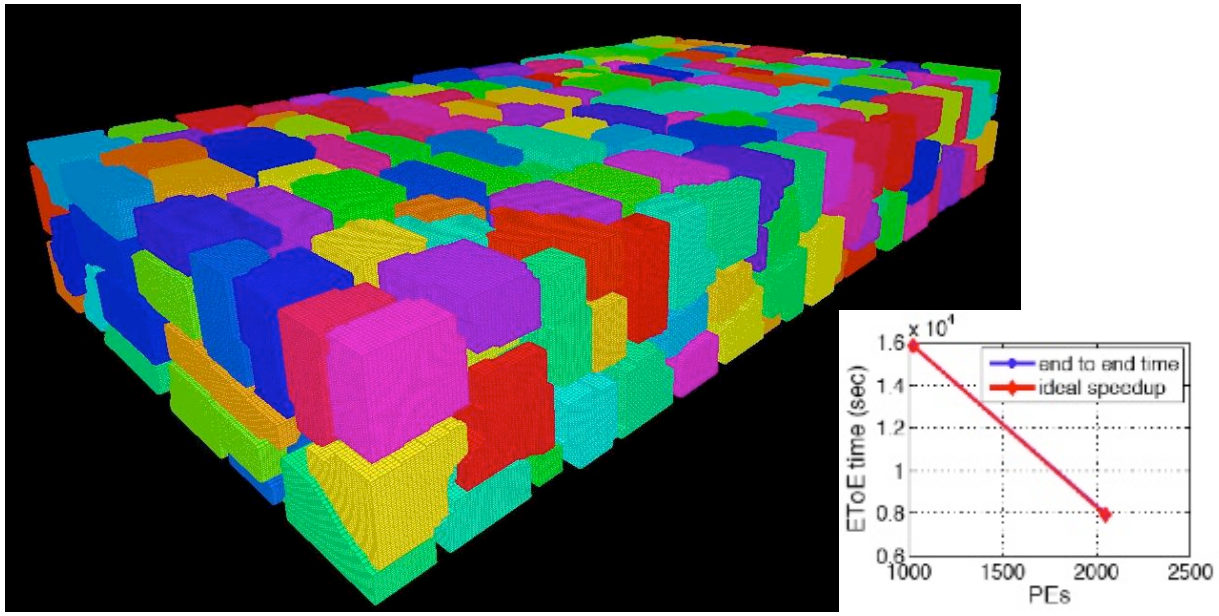
Domain Classes

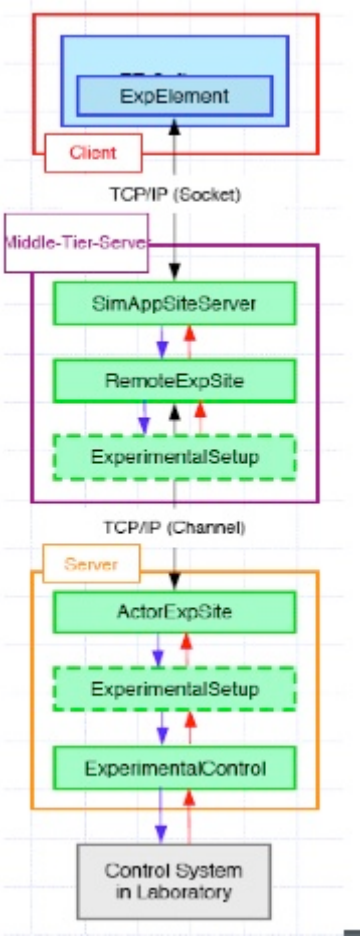


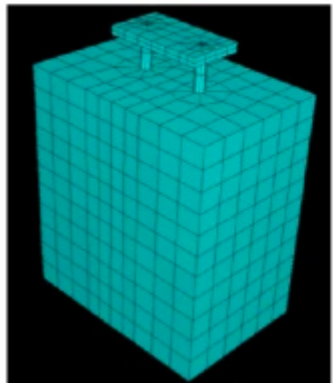
Analysis Classes

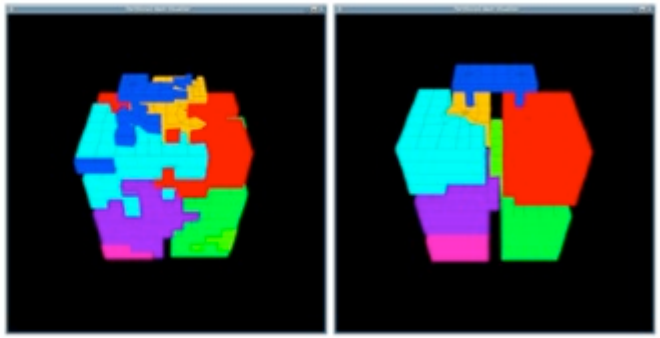


Example Parallel Applications





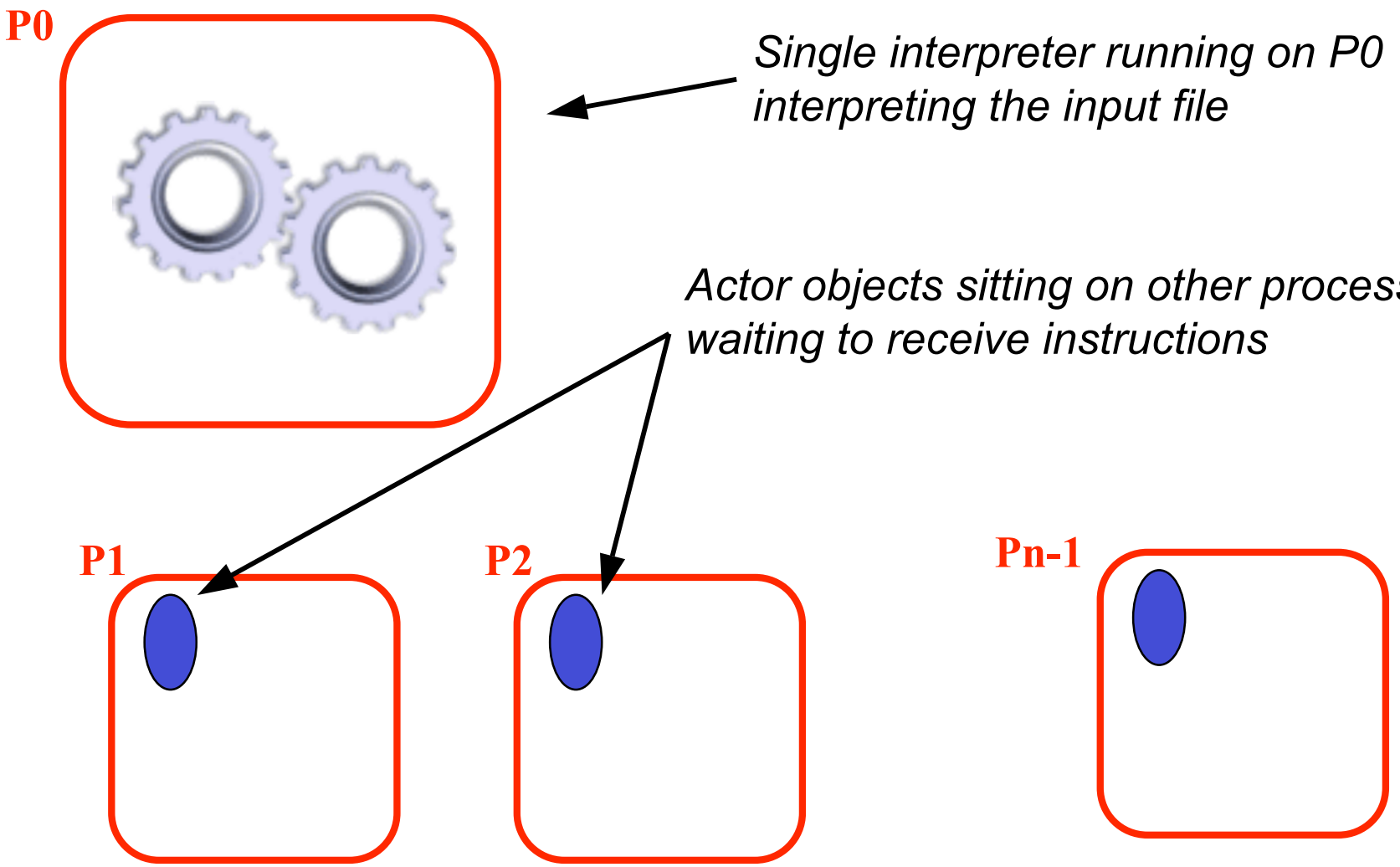




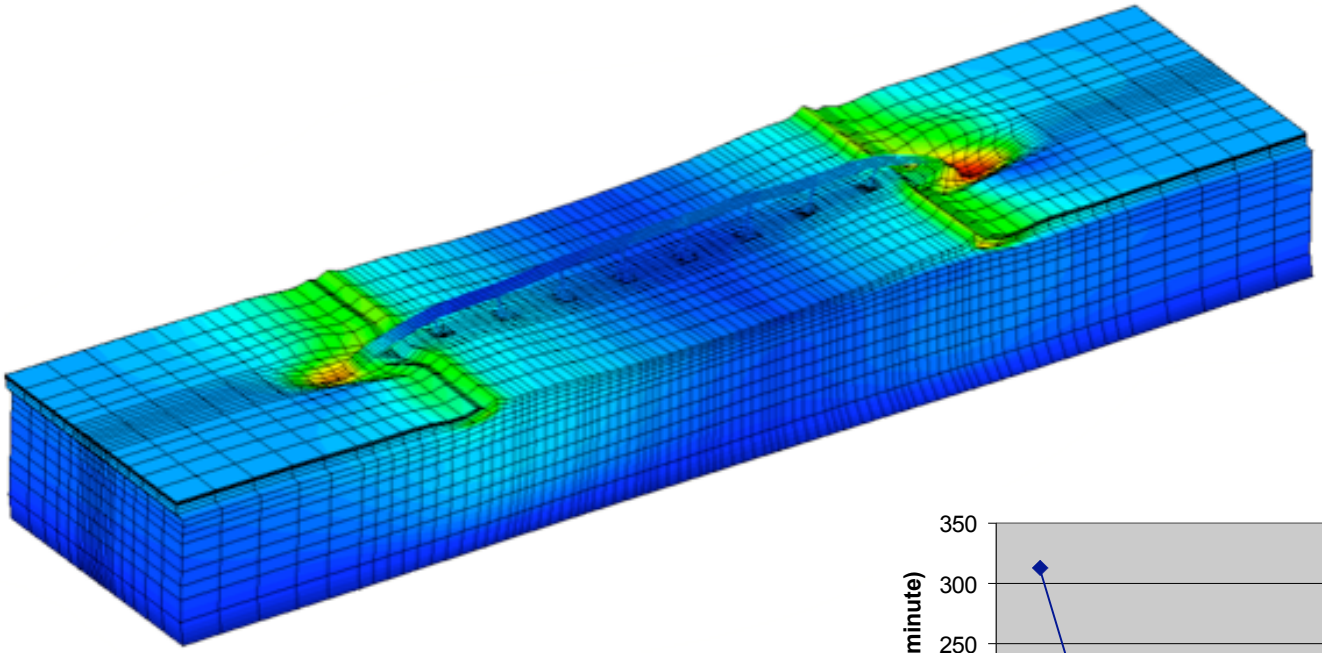
Parallel OpenSees Interpreters

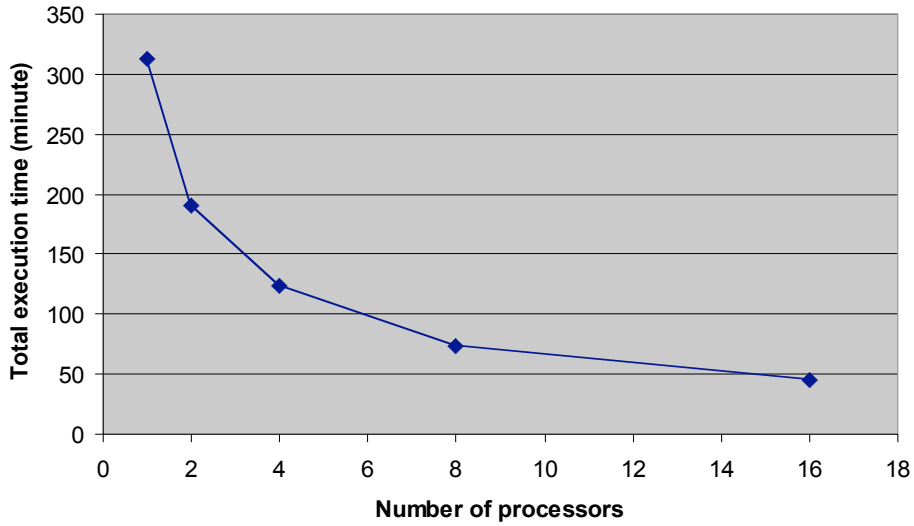
- Two Interpreters have been created for users:
  - OpenSeesSP: An application for large models which will parse and execute the exact same script as the sequential application. The difference being the element state determination and equation solving are done in parallel.
  - OpenSeesMP: An application for **BOTH** large models and parameter studies.

OpenSeesSP:
An application for Large Models

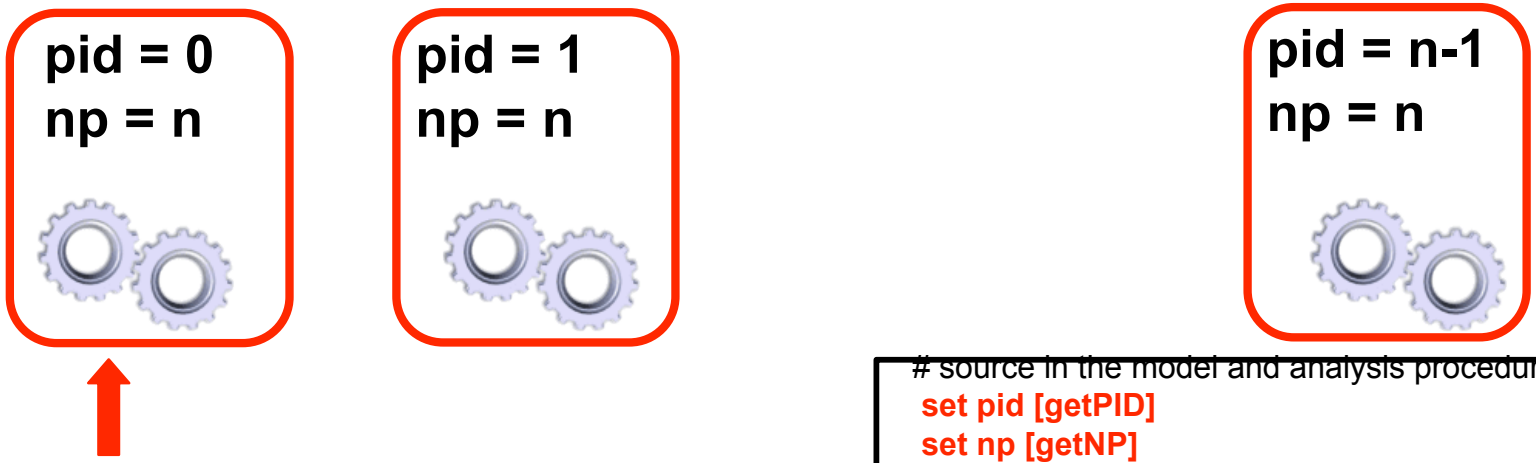


Example Usage: Humboldt Bay Bridge Model





OpenSeesMP: An application for Large Models and Parameter Studies



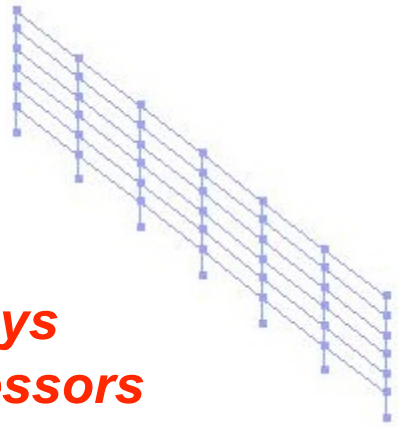
Each process is running an interpreter and can determine it's unique process number and the total number of processes in computation

Based on this script can do different things

```
# source in the model and analysis procedures
set pid [getPID]
set np [getNP]

# build model based on np and pid
source modelP.tcl
doModel {$pid $np}

# perform gravity analysis
system ParallelMumps
constraints Transformation
numberer ParallelPlain
test NormDispIncr 1.0e-12 10 3
algorithm Newton
integrator LoadControl 0.1

analysis Static

set ok [analyze 10]
return $ok
```

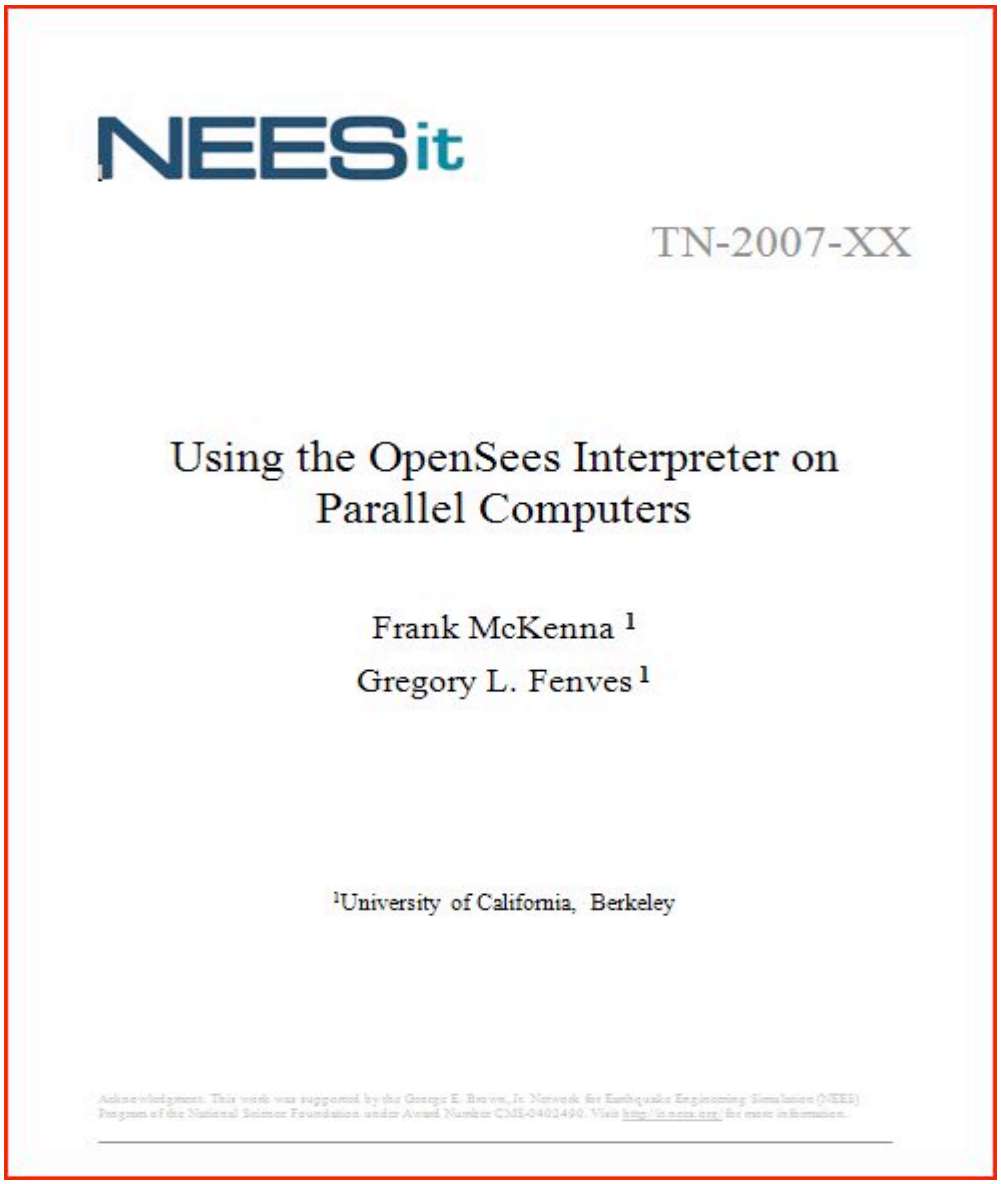
Steel Building Study

```
set pid [getPID]
set np [getNP]
set recordsFileID [open "peerRecords.txt" r]
set count 0;

foreach gMotion [split [read $recordsFileID] ¥n] {
  if {[expr $count % $np] == $pid} {

  source model.tcl
  source analysis.tcl

  set ok [doGravity]

  loadConst -time 0.0

  set gMotionList [split $gMotion "/"]
  set gMotionDir [lindex $gMotionList end-1]
  set gMotionNameInclAT2 [lindex $gMotionList end]
  set gMotionName [string range $gMotionNameInclAT2 0 end-4 ]

  set Gaccel "PeerDatabase $gMotionDir $gMotionName -accel 384.4 -dT dT -nPts nPts"
  pattern UniformExcitation 2 1 -accel $Gaccel

  recorder EnvelopeNode -file $gMotionDir$gMotionName.out -node 3 4 -dof 1 2 3 disp

  doDynamic [expr $dT*$nPts] $dT

   wipe
  }

  incr count 1;
}
```



7200 records
2 min a record
240 hours or 10 days
Ran on 2000 processors
on teragrid in less than 15 min.

Documentation



NEESit

TN-2007-XX

Using the OpenSees Interpreter on Parallel Computers

Frank McKenna [1]
Gregory L. Fenves [1]

[1]University of California, Berkeley

Acknowledgment. This work was supported by the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) Program of the National Science Foundation under Award Number CMS-0402490. Visit http://it.nees.org/ for more information.

Any Questions?