

Parallel & Distributed Processing With OpenSees

Frank McKenna
UC Berkeley

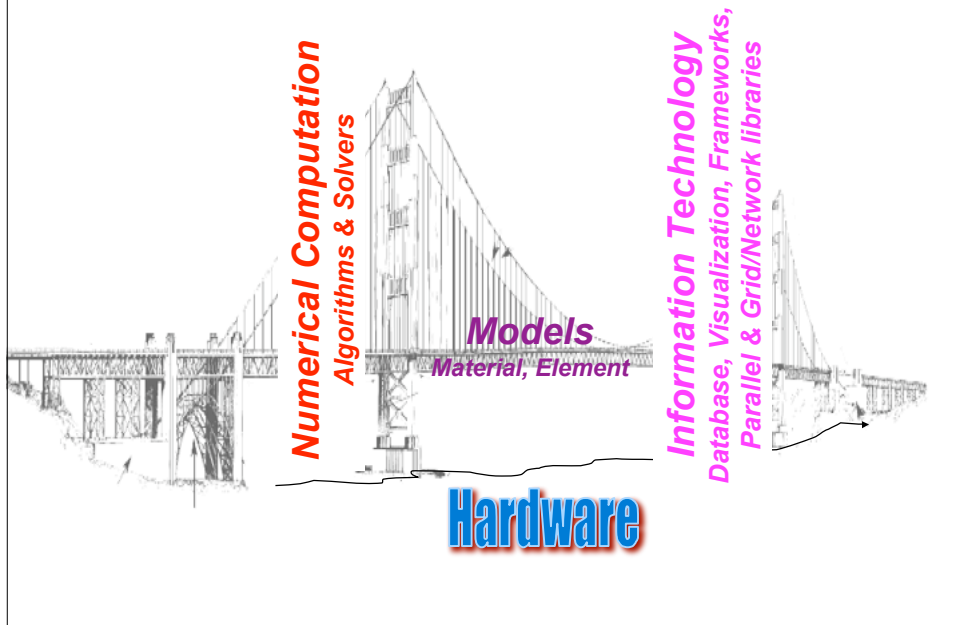
OpenSeesDays Shanghai 2011



Overview

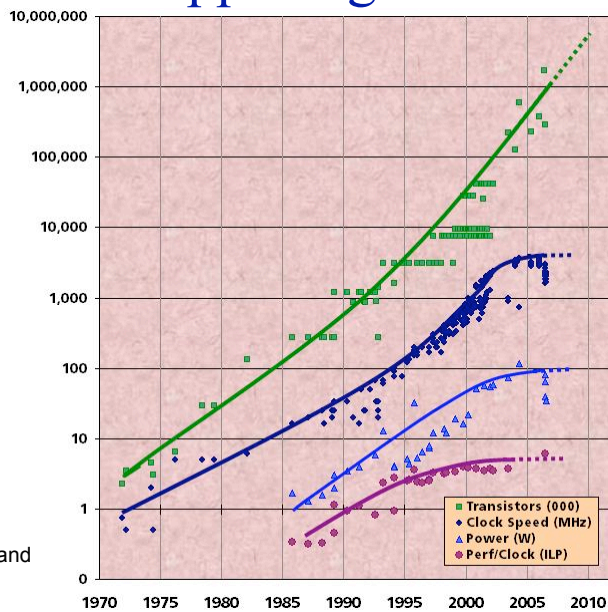
- Hardware Trends
- Parallel Computing & OpenSees
- Cloud Computing & OpenSees

Building Blocks for Simulation



Revolution is Happening Now

- Chip density is continuing increase ~2x every 1.5-2 years (Moore's law)
 - Clock speed is not
 - Number of processor cores may double instead
 - There is little or no more hidden parallelism (ILP) to be found
 - Parallelism must be managed by
- Source: Intel, Microsoft (Sutter) and Stanford (Olukotun, Hammond)



Teraflops Research Chip

http://techresearch.intel.com/articles/Tera-Scale/1449.htm

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Home > Research > Tera-Scale

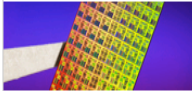
Teraflops Research Chip

"Our researchers have achieved a wonderful and key milestone in terms of being able to drive multi-core and parallel computing performance forward."
- Justin Rattner, Intel Chief Technology Officer

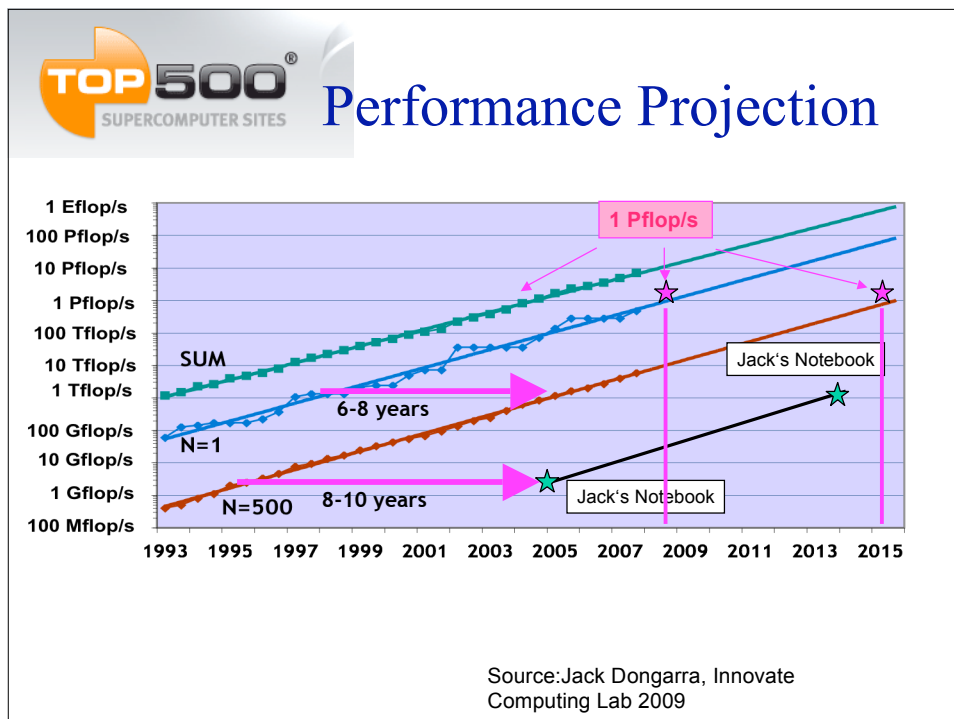
Advancing Multi-Core Technology into the Tera-scale Era [back to top](#)

The Teraflops Research Chip is the latest development from the Intel® Tera-scale Computing Research Program. This chip is Intel's first silicon tera-scale research prototype. It is the first programmable chip to deliver more than one trillion floating point operations per second (1 Teraflops) of performance while consuming very little power. This research project focuses on exploring new, energy-efficient designs for future multi-core chips, as well as approaches to interconnect and core-to-core communications. The research chip implements 80 simple cores, each containing two programmable floating point engines—the most ever to be integrated on a single chip. Floating point

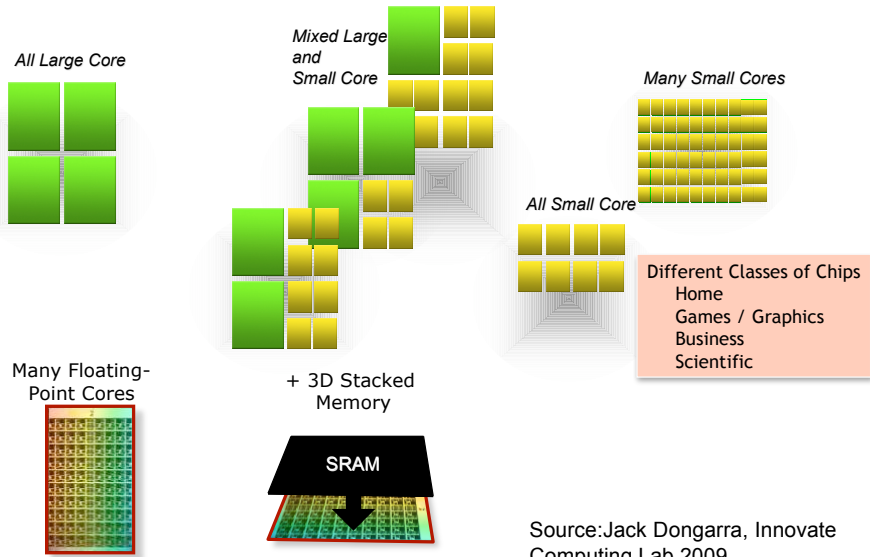
80-Core Programmable Processor First to Deliver Teraflops Performance



Intel Corporation researchers have developed the world's first programmable processor that delivers supercomputer-like performance from a single, 80-core chip not much larger than the size of a



Single Machine Architecture?



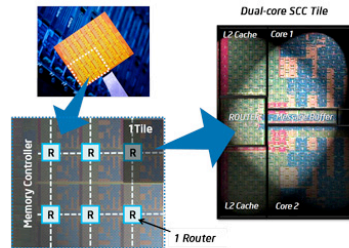
Source: Jack Dongarra, Innovate Computing Lab 2009

Intel's Cloud Processor

Inside the Single-chip Cloud Computer

The name "Single-chip Cloud Computer" reflects the fact that the architecture resembles a scalable cluster of computers such as you would find in a cloud, integrated into silicon. The research chip features:

- 24 "tiles" with two IA cores per tile
- A 24-router mesh network with 256 GB/s bisection bandwidth
- 4 integrated DDR3 memory controllers
- Hardware support for message-passing

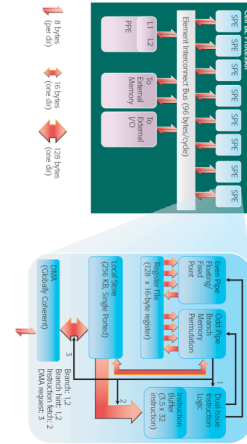


In a sense, the SCC is a microcosm of cloud datacenter. Each core can run a separate OS and software stack and act like an individual compute node that communicates with other compute nodes over a packet-based network.

One of the most important aspects of the SCC's network fabric architecture is that it supports "scale-out" message-passing programming models that have been proven to scale to 1000s of processors in cloud datacenters. The network can be 2 levels of

Cell Processor

- PlayStation 3 based on “Cell” Processor
- Each Cell contains a PowerPC and 8 self contained vector processing units (SPU’s).
- Power PC at 3.2 GHz
 - DGEMM at 5 Gflop/s
 - Altivec peak at 25.6 Gflop/s
 - Achieved 10 Gflop/s SGEMM
- 8 SPUs
 - 204.8 Gflop/s peak!
 - The catch is that this is for 32 bit floating point; (Single Precision SP)
 - And 64 bit floating point runs at 14.6 Gflop/s total for all 8 SPEs!!



Source: Jack Dongarra, Innovate Computing Lab 2009

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Bell's Law

Bell's Law of Computer Class formation

was discovered about 1972. It states that technology advances in semiconductors, storage, user interface and networking advance every decade enable a new, usually lower priced computing platform to form. Once formed, each class is maintained as a quite independent industry structure. This explains mainframes, minicomputers, workstations and Personal computers, the web, emerging web services, palm and mobile devices, and ubiquitous interconnected networks. We can expect home and body area networks to follow this path.

Gordon Bell, <http://research.microsoft.com/~GBell/Pubs.htm>

Grid Computing

BOINC

Open-source software for volunteer computing and grid computing.

language Search

Volunteer
Download · Help · Documentation

Use the idle time on your computer (Windows, Mac, or Linux) to cure diseases, study global warming, discover pulsars, and do many other types of scientific research. It's safe, secure, and easy:

1. Choose projects
2. Download and run BOINC software
3. Enter an email address and password.

Or, if you run several projects, try an account manager such as GridRepublic or BAM!

Computing power
Top 100 volunteers · Statistics

Active: 302,617 volunteers, 528,462 computers.
24-hour average: 2,749.72 TeraFLOPS.

KWSN Checklist is contributing 2,675 GFLOPS.
Country: United States; Team: The Knights Who Say NI!

Compute with BOINC
Documentation · Software updates

- Scientists: use BOINC to create a volunteer computing project giving you the comp
- Universities: use BOINC to create a Virtual Campus Supercomputing Center.
- Companies: use BOINC for desktop Grid computing.

The BOINC project

- Message boards
- Email lists
- Personnel and contributors
- Events
- Papers and talks
- Research projects
- Logos and graphics
- Bolt and Bossa

Values are in GigaFLOPS

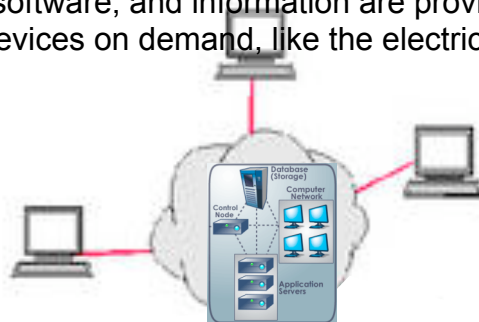
- Hel No data
- Sof 1 - 50
- API 51 - 100
- 101 - 500
- 501 - 1,000
- 1,001 - 5,000
- 5,001 - 10,000
- 10,001 - 20,000
- 20,001 - 50,000
- 50,001 - 100,000
- 100,001+

BOINC is supported by the National Science Foundation through PHY/0555655, and OCI-0721124. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

8443, SCI-0506411, Einstein@Home pulsar discovery
The recent discovery of a new pulsar by

Cloud Computing

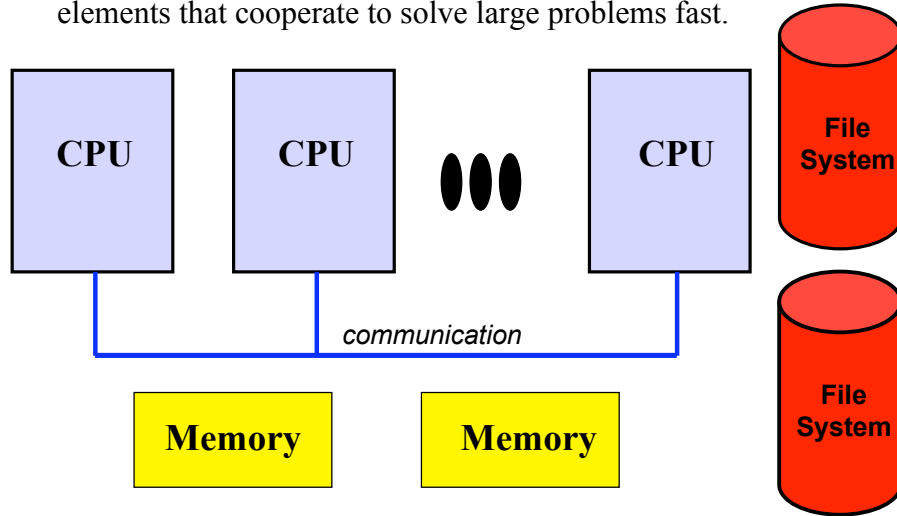
Cloud computing is internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, like the electricity grid. source: wikipedia



- Applications are run and data is stored on remote machines in the cloud.
- User accesses the applications and files using an internet based application, e.g. web browser for Google Docs and NEEShub.

What is a Parallel Computer?

- A *parallel computer* is a collection of processing elements that cooperate to solve large problems fast.



Why should you care?

- They will save you time
- They will allow you to solve larger problems.
- They are **here** whether you like it or not!

TOP 10 Sites for June 2010

For more information about the sites and systems in the list, click on the links or view the complete list.



Rank	Site	Computer
1	Oak Ridge National Laboratory United States	Jaguar - Cray XT5-HE Opteron Six Core 2.6 Ghz Cray Inc.
2	National Supercomputing Centre in Shenzhen (NSCS) China	Nebulae - Dawning TC3600 Blade, Intel X5650, NVidia Tesla C2050 G Dawning
3	DOE/NSA/LANL United States	Roadrunner - BladeCenter QS22L.S21 Cluster, PowerXCell 8i 3.2 Ghz Opteron DC 1.8 Ghz, Voltaire Infiniband IBM
4	National Institute for Computational Sciences/University of Tennessee United States	Kraken XT5 - Cray XT5-HE Opteron Six Core 2.6 Ghz Cray Inc.
5	Forschungszentrum Juelich (FZJ) Germany	SuperMUC - Intel Xeon E5440, NVIDIA G200, Infiniband SGI
6	NASA/Ames Research Center United States	Red Sky - Sun Blade x6275, Xeon X55xx 2.93 Ghz, Infiniband Sun Microsystems
7	National SuperComputer Center in Tianjin/NUDT China	Tianhe-1 - NUDT TH-1 Cluster, Xeon E5540/E5450, ATI Radeon HD 4 Infiniband NUDT
8	DOE/NSA/LANL United States	BlueGene/L - eServer Blue Gene Solution IBM
9	Argonne National Laboratory United States	Intrepid - Blue Gene/P Solution IBM
10	Sandia National Laboratories / National Renewable Energy Laboratory	Red Sky - Sun Blade x6275, Xeon X55xx 2.93 Ghz, Infiniband Sun Microsystems

BEFORE YOU GET ALL EXCITED

Speedup & Amdahl's Law

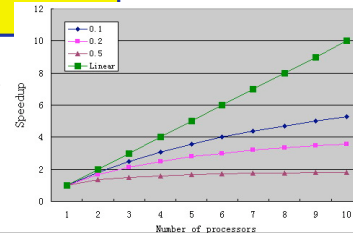
$$speedup_{PC}(p) = \frac{Time(1)}{Time(p)}$$



$$Speedup_{PC} = \frac{T_1}{\alpha T_1 + \frac{(1-\alpha)T_1}{n}} \rightarrow \frac{1}{\alpha} \text{ as } n \rightarrow \infty$$

Portion of sequential

of processors



Improving Real Performance

Peak Performance grows exponentially, a la Moore's Law

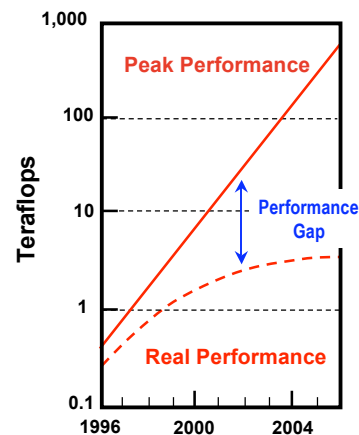
- In 1990's, peak performance increased 100x; in 2000's, it will increase 1000x

But efficiency (the performance relative to the hardware peak) has declined

- was 40-50% on the vector supercomputers of 1990s
- now as little as 5-10% on parallel supercomputers of today

Close the gap through ...

- Mathematical methods and algorithms that achieve high performance on a single processor and scale to thousands of processors
- More efficient programming models and tools for massively parallel supercomputers

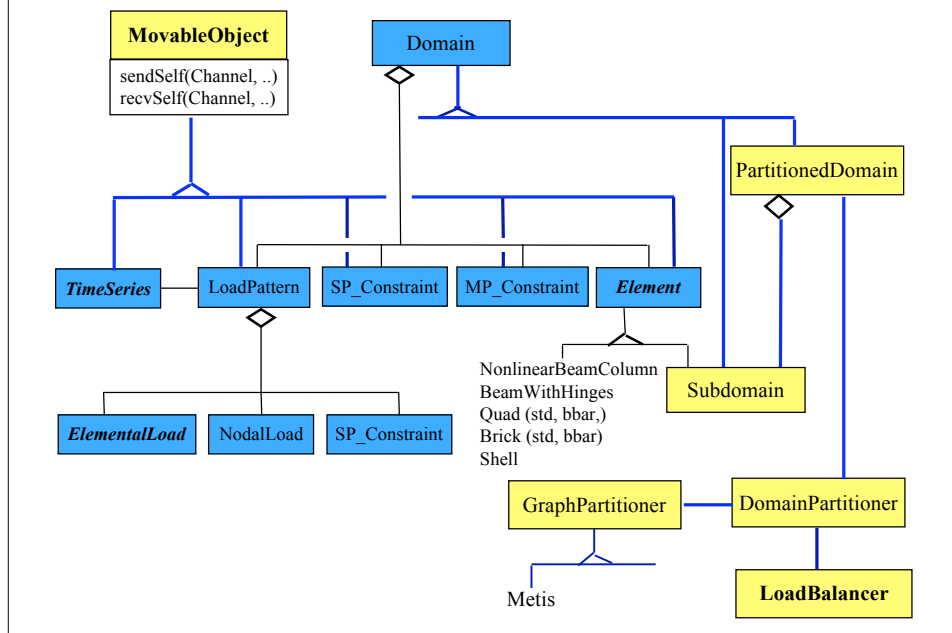


Source: Jim Demmell, CS267 Course Notes

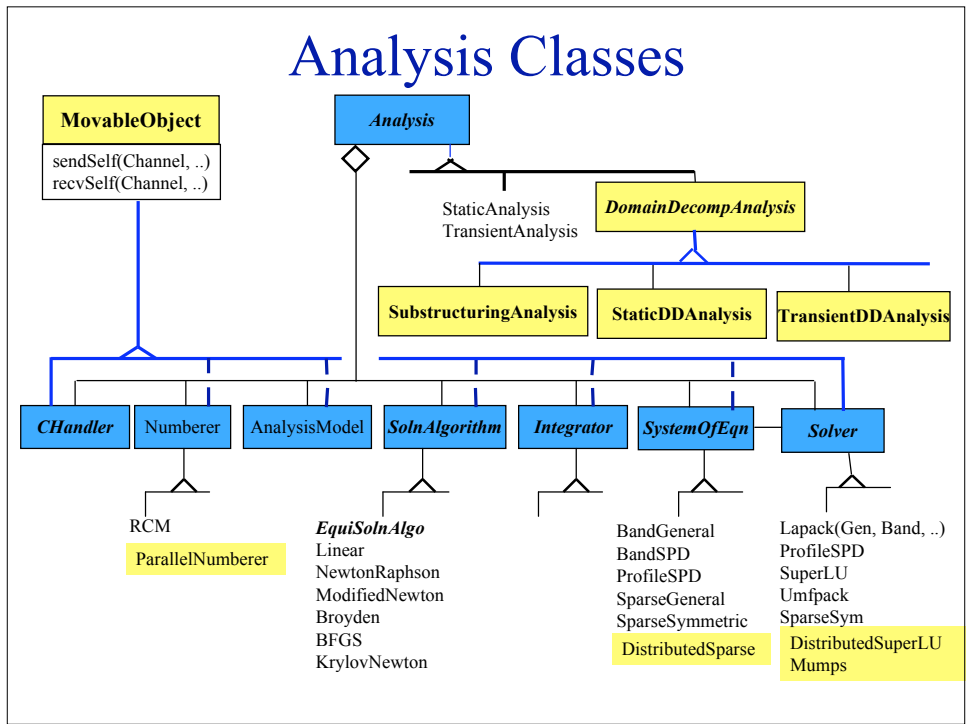
What is OpenSees?

- OpenSees is an Open-Source Software Framework written in C++ for developing nonlinear Finite Element Applications for both sequential and **PARALLEL** environments.

Domain Classes



Analysis Classes



The OpenSees Interpreters

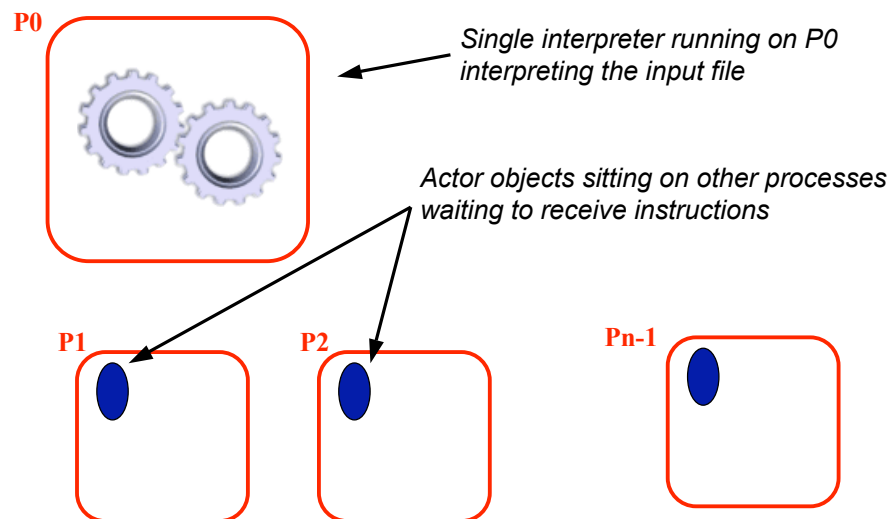
- OpenSees.exe, OpenSeesSP.exe and OpenSeesMP.exe are applications that extend the Tcl interpreter for finite element.

So What are OpenSeesSP.exe and OpenSeesMP.exe ?

Parallel OpenSees Interpreters

- 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



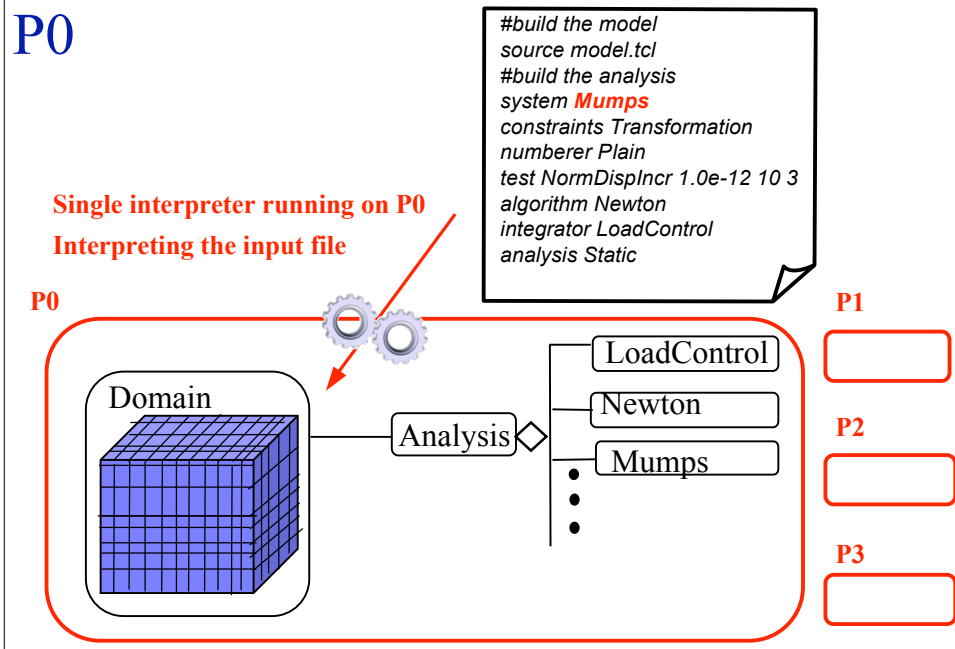
Modified Commands

- System command is modified to accept new parallel equation solvers

system Mumps

system Diagonal

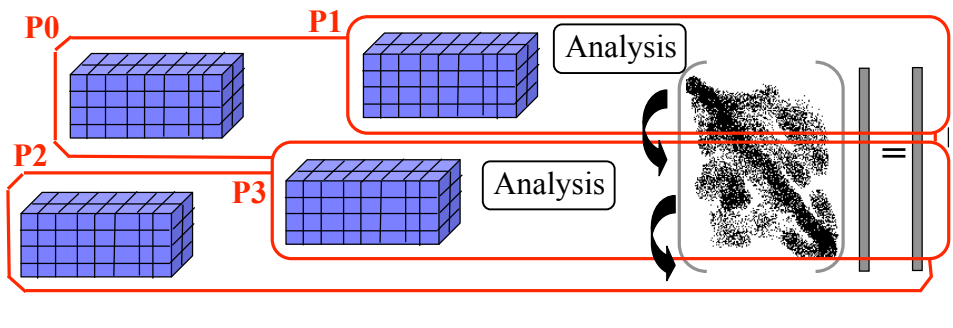
Model Built and Analysis Constructed in P0



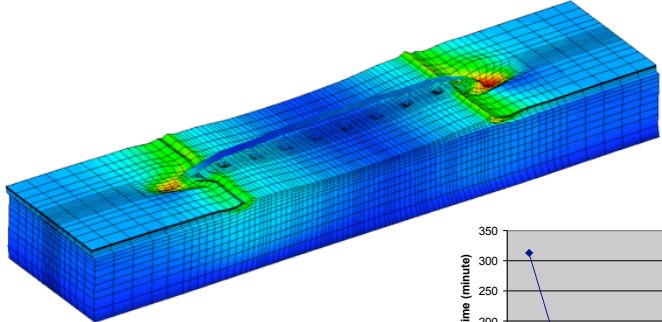
```

#build the model
source modelP.tcl
#build the analysis
system Mumps
constraints Transformation
numberer Plain
test NormDispIncr 1.0e-12 10 3
algorithm Newton
integrator LoadControl
analysis Static
analyze 10

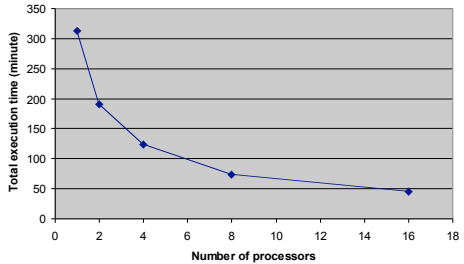
```



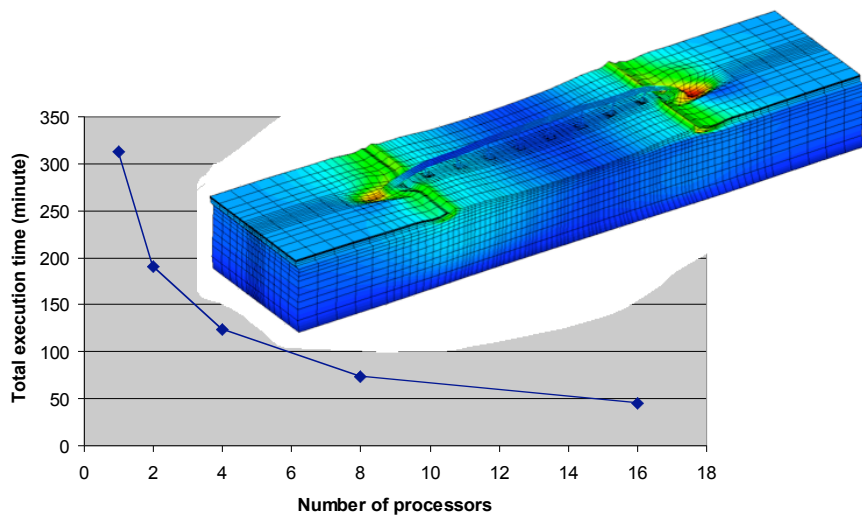
Example Usage: Humboldt Bay Bridge Model



100,000+ DOF Model
Implicit Integration
Mumps Direct Solver



Example Usage: Humboldt Bay Bridge Model



Run	el. size (m)	Elements	Nodes	DOFs
A	20	54,026	59,032	156,768
B	10	404,751	424,512	1,193,283
C	5	3,130,301	3,208,822	9,307,563
D	2.5	24,615,801	24,928,842	73,515,123

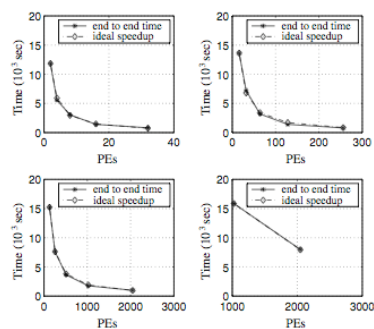
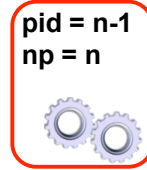
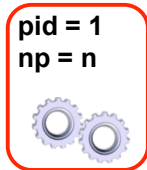
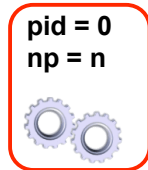


Fig. 18 Fixed-size, scalability plot at SDSC's DataStar. Upper row is runs A (*left*) and B (*right*), lower row is runs C (*left*) and D (*right*) (Table 3)

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 Mumps
constraints Transformation
numberer Parallel
test NormDisplncr 1.0e-12 10 3
algorithm Newton
integrator LoadControl 0.1

analysis Static

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

New Commands added to OpenSeesMP:

- A Number of new commands have been added:
 1. `getNP` returns number of processes in computation.
 2. `getPID` returns unique process id {0,1, .. NP-1}
 3. `send -pid pid? data` pid = { 0, 1, .., NP-1}
 4. `recv -pid pid? variableName` pid = {0,1 .., NP-1, ANY}
 5. `barrier`
 6. `domainChange`
- These commands have been added to ALL interpreters (OpenSees, OpenSeesSP, and OpenSeesMP)

Example

ex2.tcl

```

set pid [getPID]
set np [getNP]
if {$pid == 0} {
  puts "Random:"
  for {set i 1} {$i < $np} {incr i 1} {
    recv -pid ANY msg
    puts "$msg"
  }
} else {
  send -pid 0 "Hello from $pid"
}
barrier
if {$pid == 0} {
  puts "\nOrdered:"
  for {set i 1} {$i < $np} {incr i 1} {
    recv -pid $i msg
    puts "$msg"
  }
} else {
  send -pid 0 "Hello from $pid"
}

```

```

Terminal — bash — 80x32
bin> mpirun -np 10 OpenSeesMP ex2.tcl

OpenSees -- Open System For Earthquake Engineering Sim
Pacific Earthquake Engineering Research Center -- 1.7.
(c) Copyright 1999,2000 The Regents of the Univers
All Rights Reserved
(Copyright and Disclaimer @ http://www.berkeley.edu/OpenSe

Random:
Hello from 1
Hello from 3
Hello from 5
Hello from 6
Hello from 8
Hello from 2
Hello from 4
Hello from 7
Hello from 9
Ordered:
Hello from 1
Hello from 2
Hello from 3
Hello from 4
Hello from 5
Hello from 6
Hello from 7
Hello from 8
Hello from 9

```

```

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
  }

```

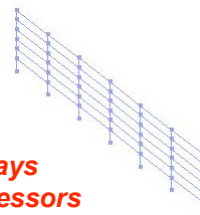
```

  incr count 1;
}

```

Steel Building Study

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



Concrete Building Study

```
set pid [getPID]
set np [getNP]
set count 0;
source parameters.tcl
source ReadSMDFileNewFormat.tcl;
foreach GMfile $iGMFile {
  foreach Factor1248 $iFactor1248 {

    if {[expr $count % $np] == $pid} {

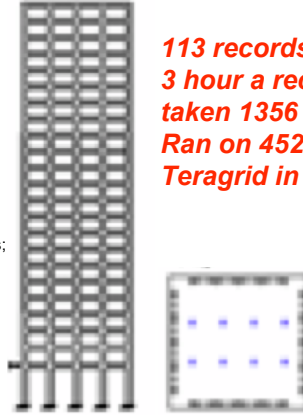
      set inFile $GMdir/$GMfile.AT2
      set outFile $GMdir/$GMfile.g3;
      ReadSMDFileNewFormat $inFile $outFile dt npts;

      wipe
      source GravityAnalysisScript.tcl

      loadConst -time 0.0;
      wipeAnalysis

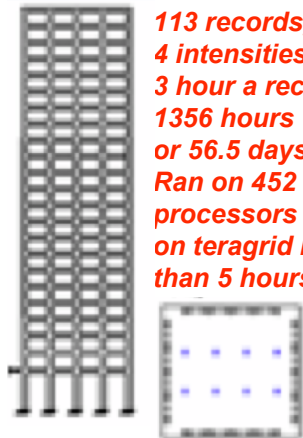
      source EQ_Recorder.tcl
      source EQAnalysisScript.tcl

      if {$ok == 0} {
        puts "Process $pid $GMfile x $Factor1248 FINISHED OK modelTime [getTime]"
      } else {
        puts "Process $pid $GMfile x $Factor1248 FINISHED FAIL modeTime [getTime] desiredTime $TmaxAnalysis]"
      }
      incr count 1
    }
  }
}
```



**113 records, 4 intensities
3 hour a record, would have
taken 1356 hours or 56.5 days
Ran on 452 processors of a
Teragrid in less than 5 hours.**

Concrete Building Study



**113 records,
4 intensities
3 hour a record
1356 hours
or 56.5 days
Ran on 452
processors
on teragrid in less
than 5 hours.**

Modified Commands

- Some existing commands have been modified to allow analysis of large models in parallel:

1. numberer

```
numberer ParallelPlain
```

```
numberer ParallelRCM
```

2. system

```
system Mumps <-ICNTL14 %?>
```

3. integrator

```
integrator ParallelDisplacementControl node? Dof? dU?
```

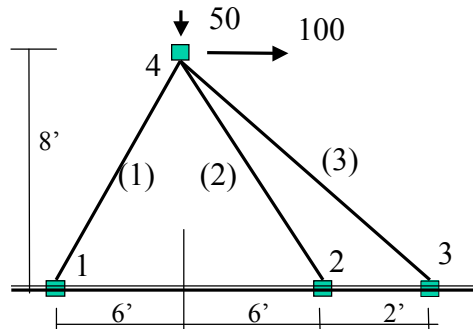
- Use these **ONLY IF PARALLEL MODEL**

Example Parallel Model:

ex4.tcl

```
set pid [getPID]
set np [getNP]
if {$np != 2} exit

model BasicBuilder -ndm 2 -ndf 2
uniaxialMaterial Elastic 1 3000
if {$pid == 0} {
  node 1 0.0 0.0
  node 4 72.0 96.0
  fix 1 1 1
  element truss 1 1 4 10.0 1
  pattern Plain 1 "Linear" {
    load 4 100 -50
  }
} else {
  node 2 144.0 0.0
  node 3 168.0 0.0
  node 4 72.0 96.0
  fix 2 1 1
  fix 3 1 1
  element truss 2 2 4 5.0 1
  element truss 3 3 4 5.0 1
}
}
```



	E	A
1	3000	10
2	3000	5
3	3000	5

Example Parallel Analysis:

```
#create the recorder
recorder Node -file node4.out.$pid -node 4 -dof 1 2 disp
```

```
#create the analysis
constraints Transformation
numberer ParallelPlain
system Mumps
test NormDispIncr 1.0e-6 6 2
algorithm Newton
integrator LoadControl 0.1
analysis Static
```

```
#perform the analysis
analyze 10
```

```
# print to screen node 4
print node 4
```

```
Terminal — bash — 86x31
bin> mpirun -np 2 OpenSeesMP ex4.tcl

OpenSees -- Open System For Earthquake Engineering Simulation
Pacific Earthquake Engineering Research Center -- 1.7.5

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Node: 4
Coordinates : 72 96
commitDisps: 0.530093 -0.177894
Velocities : 0 0
unbalanced Load: 100 -50
ID : 0 1

Process Terminating 0

Node: 4
Coordinates : 72 96
commitDisps: 0.530093 -0.177894
Velocities : 0 0
unbalanced Load: 0 0
ID : 0 1

Process Terminating 1
bin> diff node4.out.0 node4.out.1
bin> []
```

Parallel Displacement Control and domainChange!

ex5.tcl

```
source ex4.tcl

loadConst - time 0.0

if {$pid == 0} {
  pattern Plain 2 "Linear" {
    load 4 1 0
  }
}

domainChange

integrator ParallelDisplacementControl 4 1 0.1
analyze 10
```

```
Terminal — ba
Pacific Earthquake Engineering Research Center -- 1.
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Node: 4
Coordinates : 72 96
commitDisps: 0.530093 -0.177894
Velocities : 0 0
unbalanced Load: 100 -50
ID : 0 1

Node: 4
Coordinates : 72 96
commitDisps: 0.530093 -0.177894
Velocities : 0 0
unbalanced Load: 0 0
ID : 0 1

Node: 4
Coordinates : 72 96
commitDisps: 1.53009 -0.194007
Velocities : 0 0
unbalanced Load: 200.668 -50
ID : 0 1

Process Terminating 0

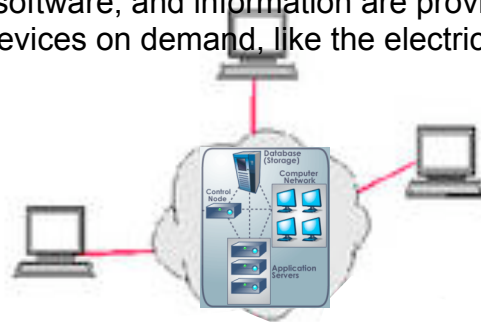
Node: 4
Coordinates : 72 96
commitDisps: 1.53009 -0.194007
Velocities : 0 0
unbalanced Load: 0 0
```

Things to Watch For

1. Deadlock (program hangs)
 - send/rcv messages
 - Opening files for writing & not closing them
2. Race Conditions (different results every time run problem)
 - parallel file system.
3. Load Imbalance
 - poor initial task assignment.

Cloud Computing

Cloud computing is internet-based computing , whereby shared resources, software, and information are provided to computers and other devices on demand. source: wikipedia



- Applications are run and data is stored on remote machines in the cloud.
- User accesses the applications and files using an internet based application, e.g. web browser for Google Docs and NEEShub.

Pros & Cons?

NEEShub



- The power behind NEES at <http://nees.org>
- Maintained and developed at Purdue by NEEScomm
- Built using proven HUBzero technology (nanoHUB > 100,000 users)
- A science gateway for education and research in earthquake engineering



Through a browser engineers can:

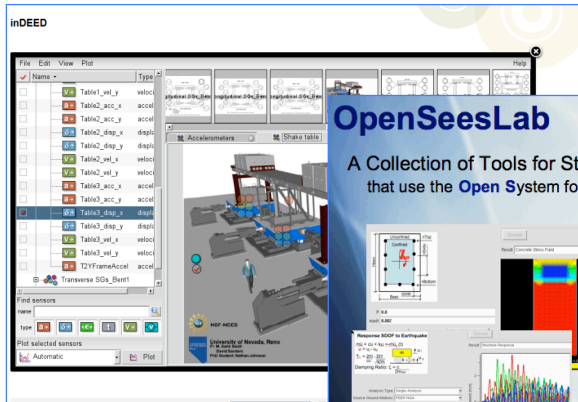
- Upload and view experimental data
- Browse online seminars and courses
- Launch sophisticated tools using remote computational resources (OpenSeesLab)

NEEShub (First Release July 2010)

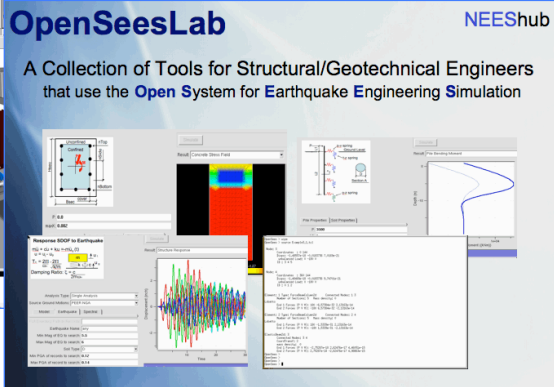
The screenshot shows the NEEShub website homepage as of July 2010. The browser address bar displays "https://neesub.org/home". The page features a navigation menu with links for "Home & Resources", "Learning & Outreach", "Project Workflows", "Sites", "Capabilities", and "Support". A central banner highlights the "Network for Earthquake Engineering Simulation (NEES)" as a shared national network of 14 experimental facilities, collaborative tools, a central data repository, and earthquake simulation software. Below the banner, there are several sections: "In the Spotlight" with links to "Visual Understanding Environment", "Virtual Laboratories - Nonlinear Two Story Building", and "Archorage Dealing Effects on Lateral Deformation"; "Use NEEShub to..." with links to "Access NEES projects - Project Workflows", "Real time data and other Tools", "Learn with earthquake data and simulators - NEES Academy", and "Share resources - Contribute Content"; "NEES Videos on YouTube" with a grid of video thumbnails; "Events and Activities" with a calendar for July 2010; "News and Announcements" with several news items including "National Science Foundation Sensational EO", "NEES Featured in NSF Sensational EO", "NEEScomm Update: June 2010", "Gulf Of Light MRI RAMP Submission", and "In light of the recent oil spill in the Gulf of Mexico, the National Science Foundation (NSF) has..."; and "Latest Earthquake Reports" with a list of recent seismic events including M 6.2, Vanuatu; M 5.1, New Britain region, Papua New Guinea; and M 5.3, Vanuatu.

NEEShub Tools and Resources

Documents, Learning Objects, Series & TOOLS



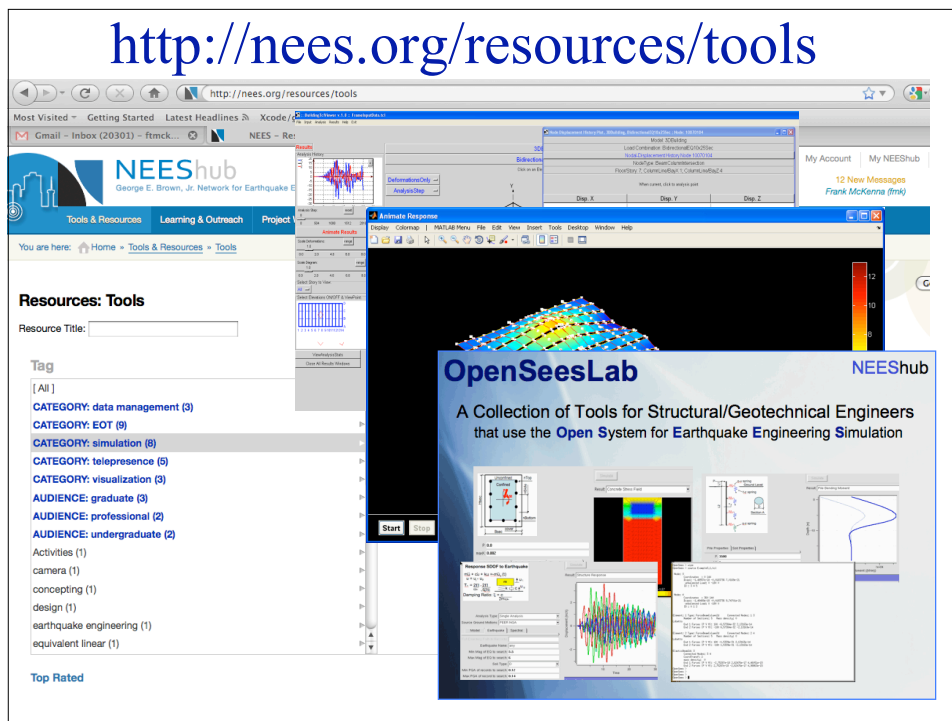
Simulation



OpenSeesLab NEEShub
A Collection of Tools for Structural/Geotechnical Engineers that use the **Open System** for **Earthquake Engineering Simulation**

Data Management

<http://nees.org/resources/tools>



Resources: Tools

Resource Title:

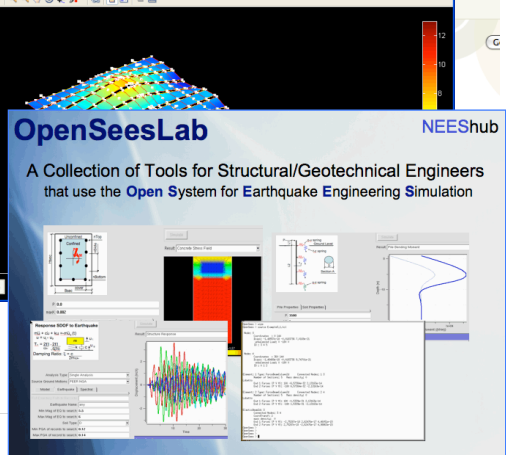
Tag: [All]

- CATEGORY: data management (3)
- CATEGORY: EOT (9)
- CATEGORY: simulation (8)
- CATEGORY: telepresence (5)
- CATEGORY: visualization (3)
- AUDIENCE: graduate (3)
- AUDIENCE: professional (2)
- AUDIENCE: undergraduate (2)

Activities (1)

- camera (1)
- concepting (1)
- design (1)
- earthquake engineering (1)
- equivalent linear (1)

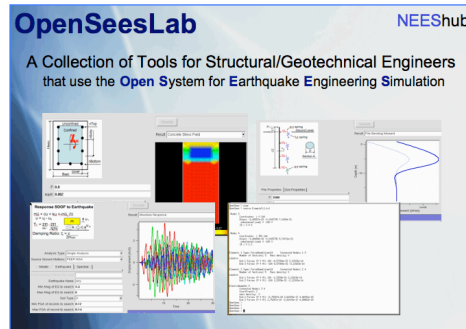
Top Rated



OpenSeesLab NEEShub
A Collection of Tools for Structural/Geotechnical Engineers that use the **Open System** for **Earthquake Engineering Simulation**

The OpenSeesLab tool:

<http://nees.org/resources/tools/openseeslab>



Is a suite of Simulation Tools powered by OpnSees for:

1. Submitting OpenSees scripts (input files) to HUB resources
2. Educating students and practicing engineers
3. Performing useful tasks

OpenSees Interpreter Tool

```
OpenSees -- Open System For Earthquake Engineering Simulation
Pacific Earthquake Engineering Research Center -- 2.2.1

(c) Copyright 1999,2000 The Regents of the University of California
All Rights Reserved
(Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)

OpenSees > tar xBf A_Example.tar
OpenSees > cd A_Example
OpenSees > source Ex8.tcl
couldn't read file "Ex8.tcl": no such file or directory
OpenSees > ls
A8.tcl
ExampleSP1.tcl
Node.out
analysis.tcl
model.tcl
peerRecords.txt
OpenSees > source A8.tcl
WARNING analysis Transient dt tFinal - no LinearSDE specified,
ProfileSPLinSDE default will be used

Node: 625
Coordinates : 1 1 1 0
Disps: 0.00977277 0.00977277 -0.00409793
Velocities : 0.0141832 0.0141832 -0.00878414
commitAccels: 0.128284 0.128284 0.228457
unbalanced Load: 0 0 0
ID : 0 1 2

Simulation Time 192
OpenSees > cd ..
OpenSees > tar cBf A_Example.tar A_Example
OpenSees >
```

File Transfer Tool

Application: File Transfer

Upload or download file or clipboard.

Upload Download

Popups must be enabled.

Cancel

Upload: From Your Machine to NEEShub

Download: From NEEShub to Your Machine

Lateral Pile Analysis

http://opensees.berkeley.edu/wiki/index.php/Laterally-Loaded_Pile_Foundation
Chris McGann U. Washington

Application: Lateral Pile Analysis

Simulate

Result: Pile Bending Moment

Depth (m)

Bending Moment ((kNm))

2 results Parameters... Clear

Simulation = #2

fixHead = no

NEEShub things to know:

1. Anyone can get an account (it's free!)
2. You can have 5 sessions running at once
3. The sessions stay alive until you kill them
4. With each session you get a new data directory, some tools by default will store their information there.
5. You have 1GB storage by default (it is expandable!)

Any Questions?