

Parallel & Distributed Processing With OpenSees

Frank McKenna
UC Berkeley

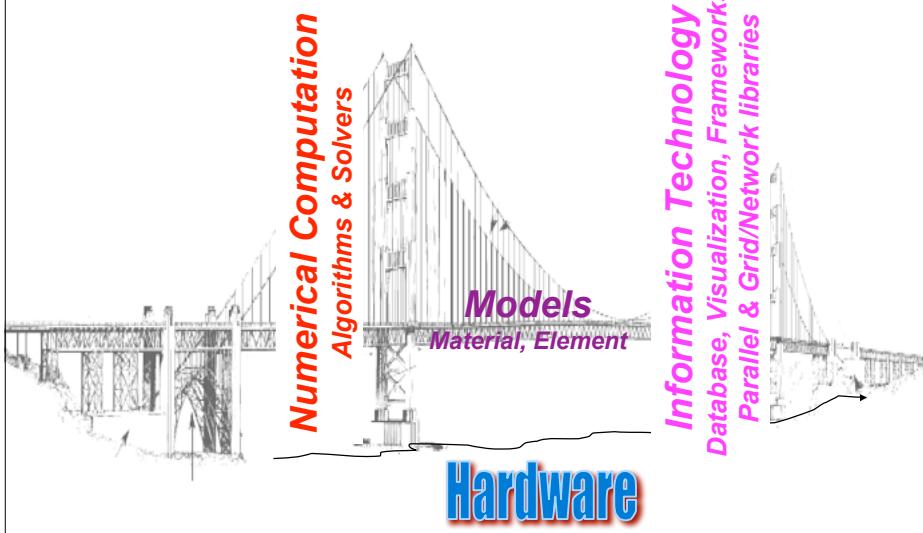
OpenSeesDays Shanghai 2011



Overview

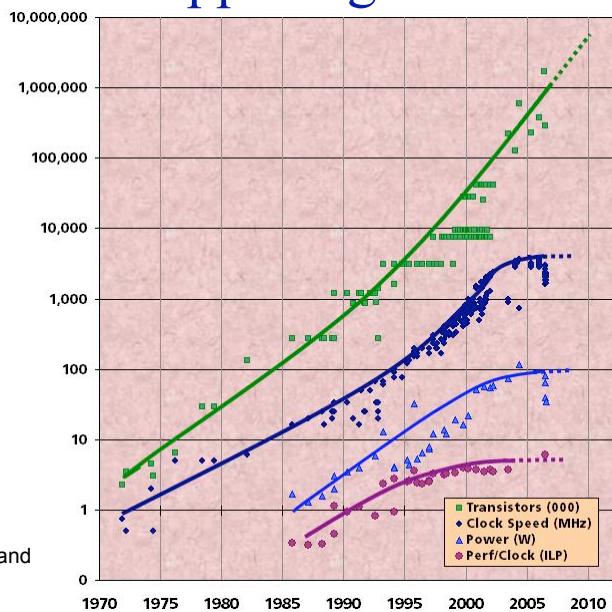
- Hardware Trends
- Parallel Computing & OpenSees
- Cloud Computing & OpenSees

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>

Getting Started Latest Headlines Xcode/gFortran Plugin... Apple Amazon eBay Yahoo! News

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Technology & Research

Architecture & Silicon Technology Platform Technology Eco-Technology Innovation Research Standards & Initiatives

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."

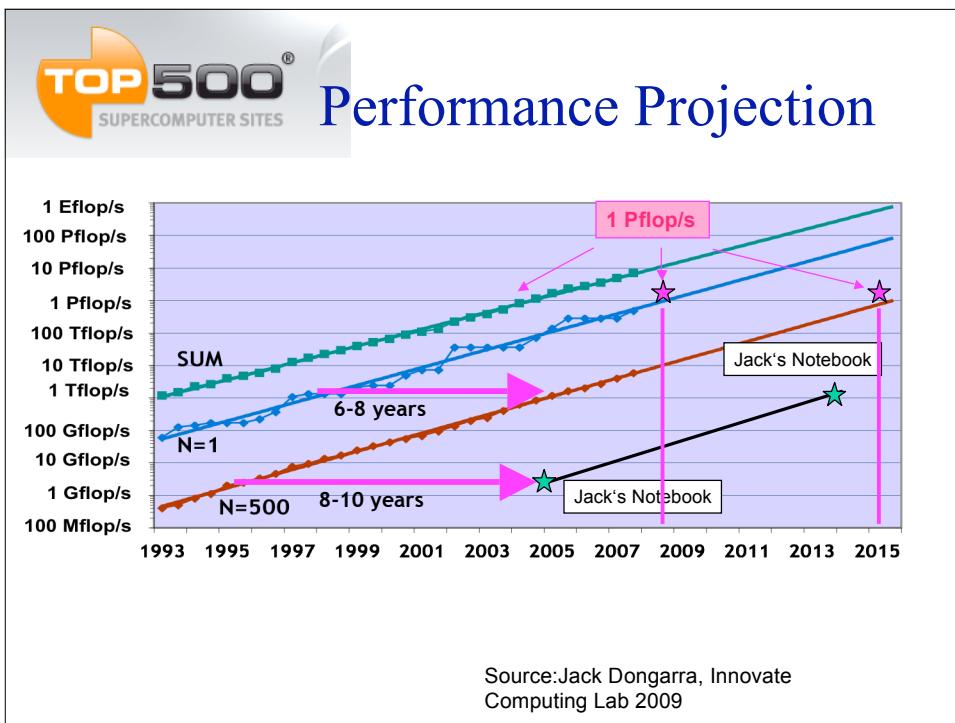
- Justin Rattner, Intel Chief Technology Officer

Advancing Multi-Core Technology into the Tera-scale Era back to top ^

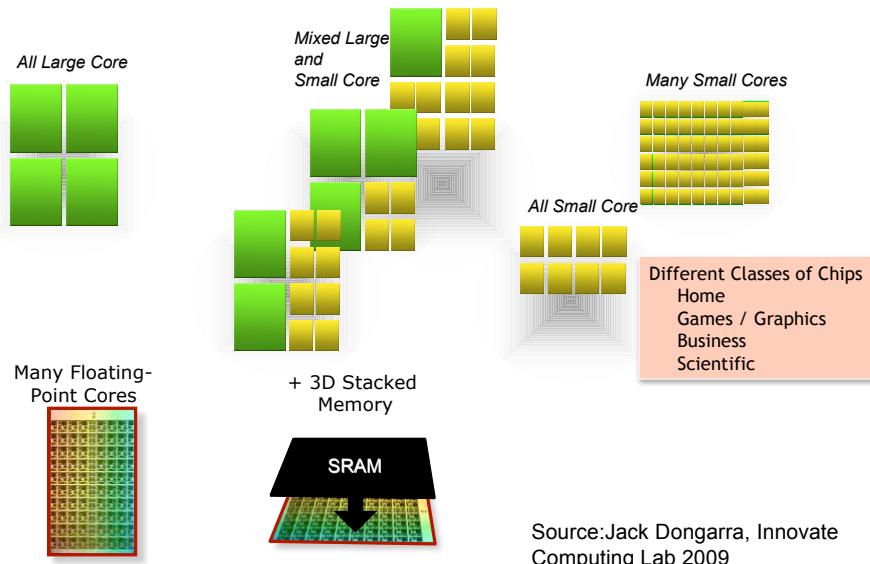
The Teraflops Research Chip is the latest development from the Intel® Tera-scale Computing Research Program. This chip is Intel's first silicon tera-scale research prototype. It is the first programmable chip to deliver more than one trillion floating point operations per second (1 Teraflop) of performance 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?

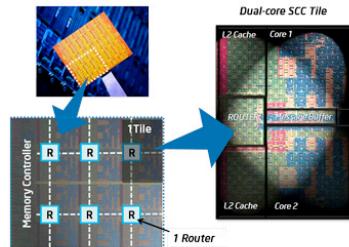


Intel's Cloud Processor

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

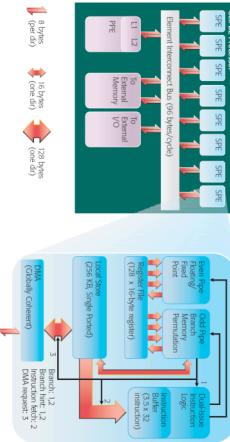


In a sense, the SCC is a microcosm of cloud datacenter. Each core can run a separate OS and software stack and act like an individual compute node that communicates with other compute nodes over a packet-based network.

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. Though each core has 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

9

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

Computing power Top 100 volunteers · Statistics

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

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

58.6%

1.8%

11.8%
Collatz Conjecture
10.6%
ONETCFence

Compute with BOINC Documentation · Software updates

Scientists: use BOINC to create a volunteer computing project giving you the compute power of millions of PCs. Universities: use BOINC to create a Virtual Campus Supercomputing Center. Companies: use BOINC for desktop Grid computing.

The BOINC project key

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

Values are in GigaFLOPS

Category	Value Range
Help	No data
Sof	<1
API	1 - 50
Events	51 - 100
Logos and graphics	101 - 500
Research projects	501 - 1,000
Papers and talks	1,001 - 5,000
Personnel and contributors	5,001 - 10,000
Email lists	10,001 - 20,000
Message boards	20,001 - 50,000
Bolt and Bossa	50,001 - 100,000
Help	100,001+

BOINC is supported by the National Science Foundation through PHY-0555655, CCF-0547124. 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

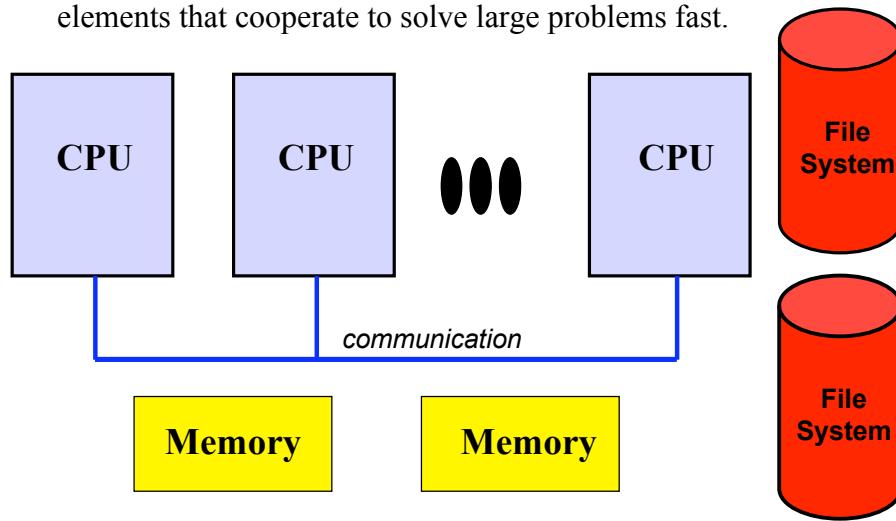
Cloud Computing

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

The diagram illustrates the architecture of cloud computing. At the center is a large grey cloud. Inside the cloud, there is a network of computer components: a 'Control Node' (represented by two server icons), a 'Database (Storage)' (represented by a server icon with a database symbol), a 'Computer Network' (represented by four computer monitors), and 'Application Servers' (represented by three server icons). Red lines connect this central cloud to three external devices: a laptop on the left, a desktop computer at the top, and another laptop on the right.

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	Neptune - Dawning TC3600 Blade, Intel X5650, Nvidia Tesla C2050 Dawning
3	DOE/INNSA/LANL United States	Roadrunner - Bladecenter QS22/LS21 Cluster, PowerXCell 8i 3.2 GHz Opteron 1.8 GHz, Voltaire Infiniband IBM
4	National Institute for Computational Sciences and University of Tennessee United States	Kraken XT5 - Cray XT5-HE Opteron Six Core 2.6 GHz Cray Inc.
5	Forschungszentrum Juelich (FZJ) Germany	SuperMUC - IBM Xeon X5650, X8400EX, Xeon HT QC 3.0/Xeon West Infiniband
6	NASA/Ames Research Center/ NASA Ames Research Center United States	SGI
7	National SuperComputer Center in Tianjin/NUDT China	Tianhe-1 - NUDT TH-1 Cluster, Xeon E5540/E5450, ATI Radeon HD 4890 Infiniband NUDT
8	DOE/INNSA/LLNL 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

WWW.Top500.org

A photograph of a silver laptop computer. The screen displays the 'WWW.Top500.org' logo, which consists of the words 'WWW.', 'Top500.', and '.org' stacked vertically in a green, blocky font.

BEFORE YOU GET ALL EXCITED

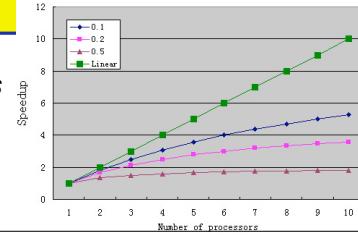
Speedup & Amdahl's Law

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



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

Portion of sequential *# of processors*



Improving Real Performance

Peak Performance grows exponentially, a la Moore's Law

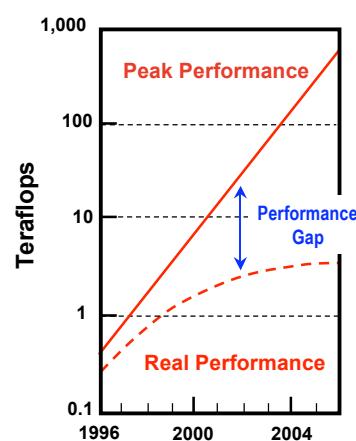
- In 1990's, peak performance increased 100x; in 2000's, it will increase 1000x

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

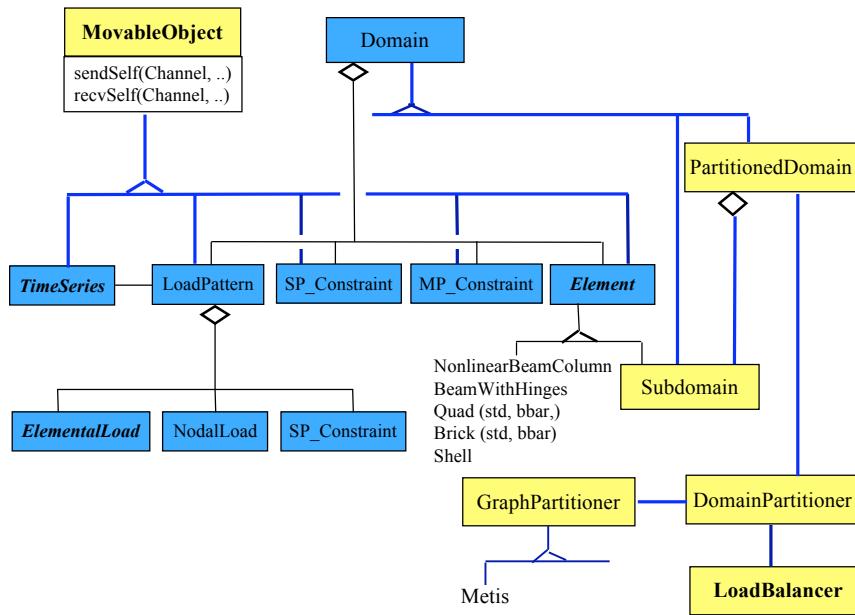


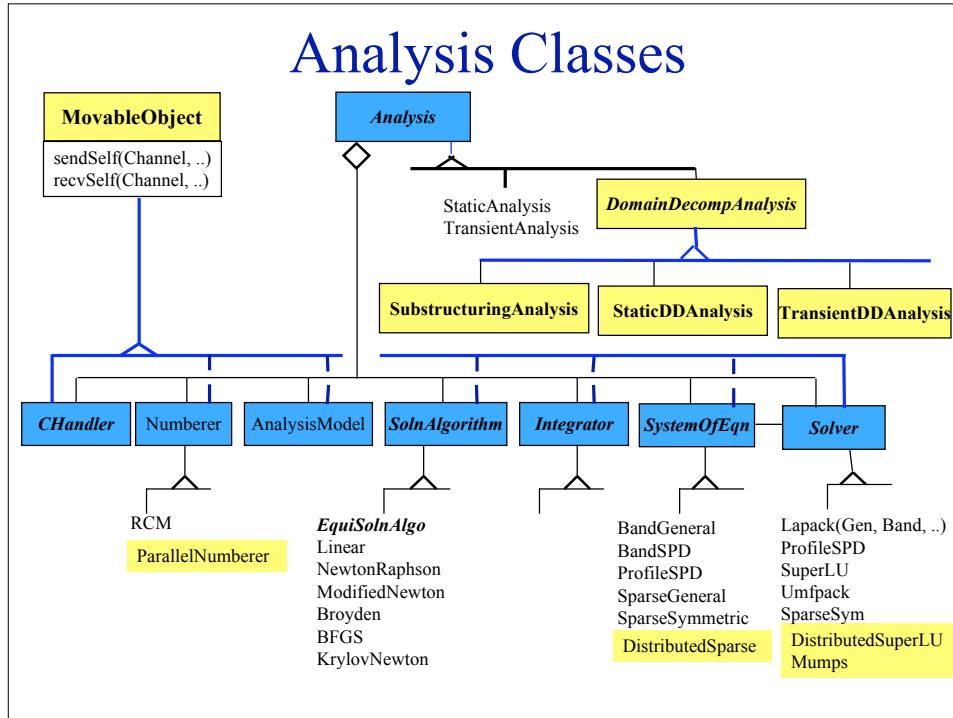
Source: Jim Demmel, CS267
Course Notes

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





The OpenSees Interpreters

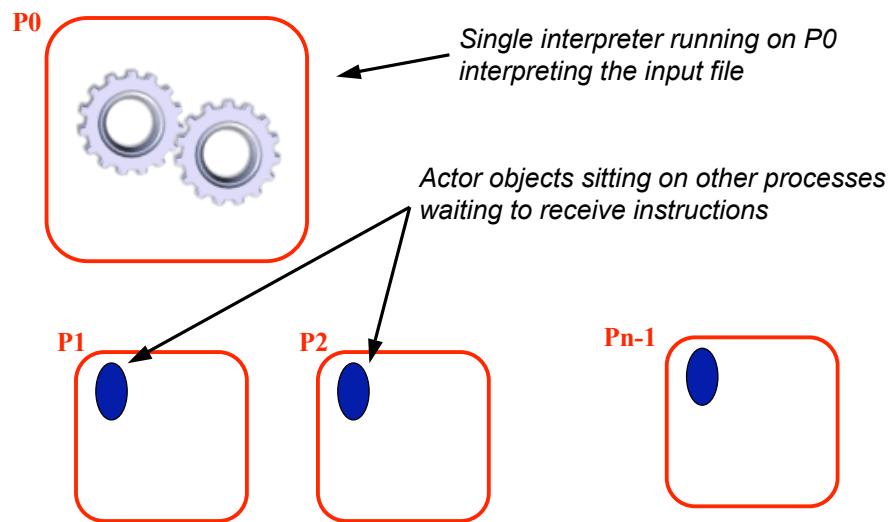
- OpenSees.exe, OpenSeesSP.exe and OpenSeesMP.exe are applications that extend the Tcl interpreter for finite element.

**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



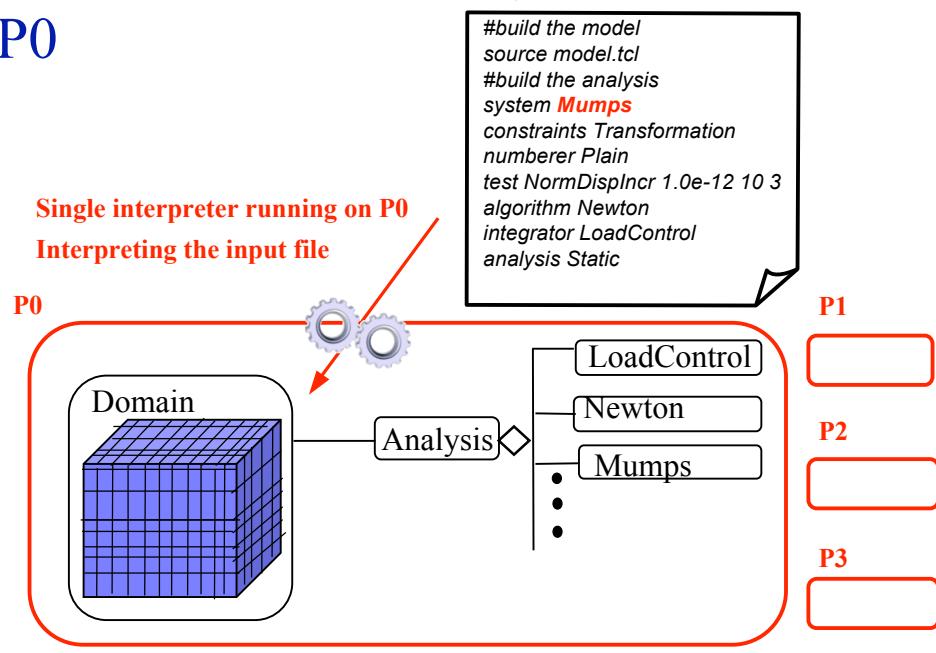
Modified Commands

- System command is modified to accept new parallel equation solvers

```
system Mumps
```

```
system Diagonal
```

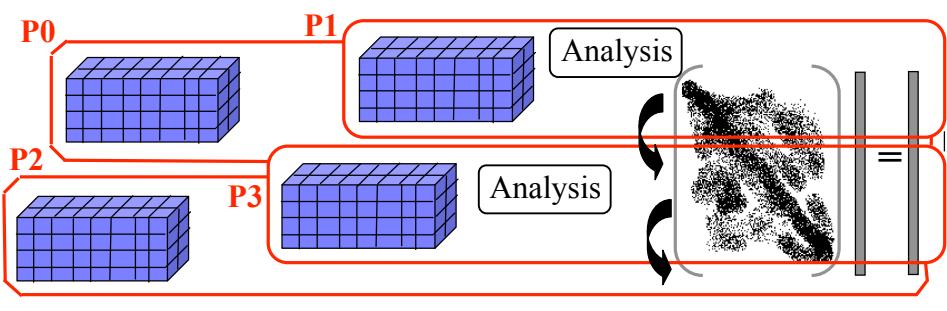
Model Built and Analysis Constructed in P0



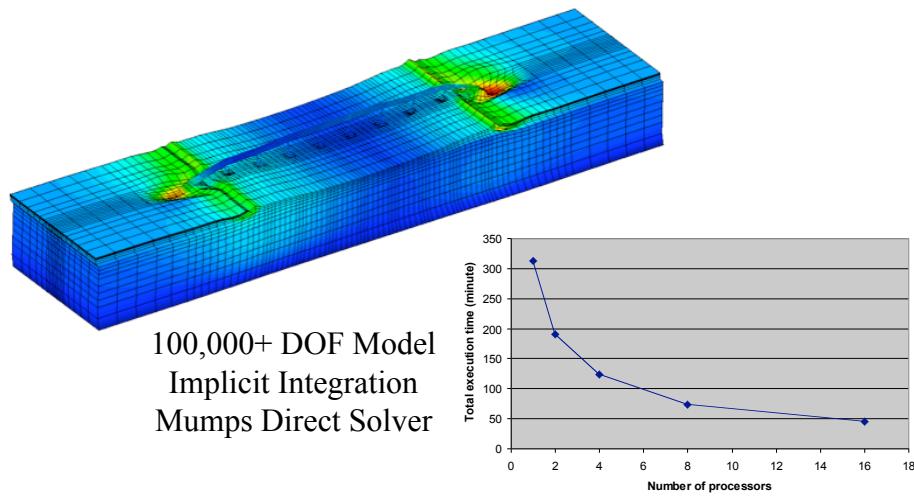
```

#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

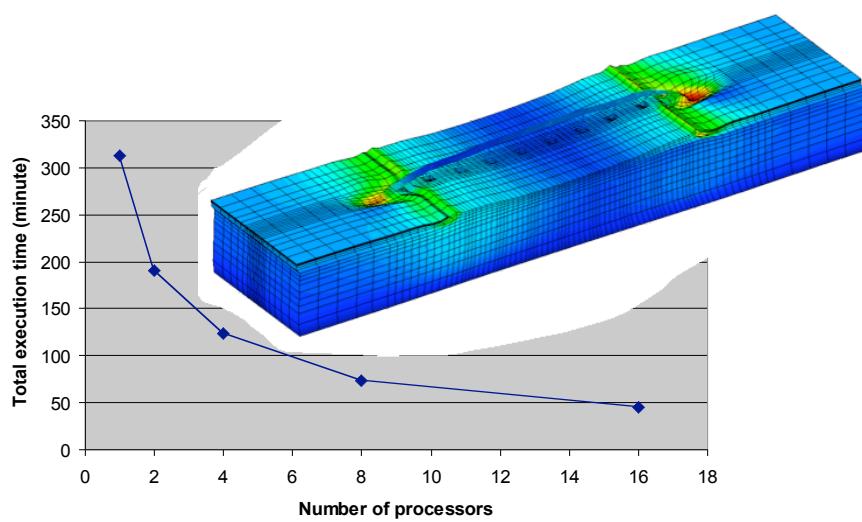
```



Example Usage: Humboldt Bay Bridge Model



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

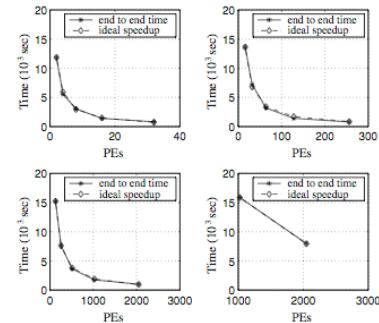
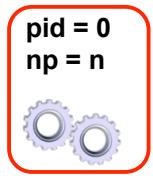


Fig. 18 Fixed-size, scalability plot at SDSC's DataStar. Upper row is runs A (left) and B (right), lower row is runs C (left) and D (right) (Table 3)

OpenSeesMP: An application for Large Models and Parameter Studies



Each process is running an interpreter and can determine its 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 NormDispIncr 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 pocess 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)

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"
}
```

Example

Terminal — bash — 80x32

```
bin> mpirun -np 10 OpenSeesMP ex2.tcl
```

OpenSees -- Open System For Earthquake Engineering Si
Pacific Earthquake Engineering Research Center -- 1.7.
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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

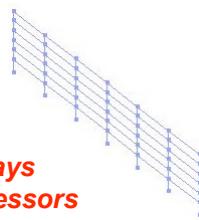
        doDynamic [expr $dT*$nPts] $dT

        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 $GMfile {
    foreach Factor1248 $Factor1248 {
        if {[expr $count % $np] == $pid} {

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

            wipe
            source GravityAnalysisScript.tcl

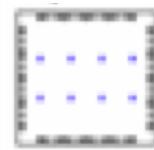
            loadConst -time 0.0;
            wipeAnalysis

            source EQ_Recorder.tcl
            source EQAnalysisScript.tcl

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

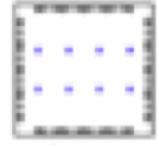


**113 records, 4 intensities
3 hour a record, would have
taken 1356 hours or 56.5 days
Ran on 452 processors of a
Teragrid in less than 5 hours.**



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:
 - numberer

numberer ParallelPlain

numberer ParallelRCM

- system

system Mumps <-ICNTL14 %?>

- integrator

integrator ParallelDisplacementControl node? Dof? dU?

- Use these **ONLY IF PARALLEL MODEL**

Example Parallel Model:

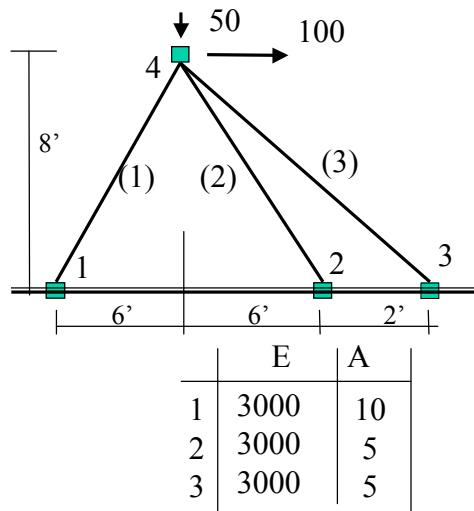
ex4.tcl

```

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
}

```



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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(Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)

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

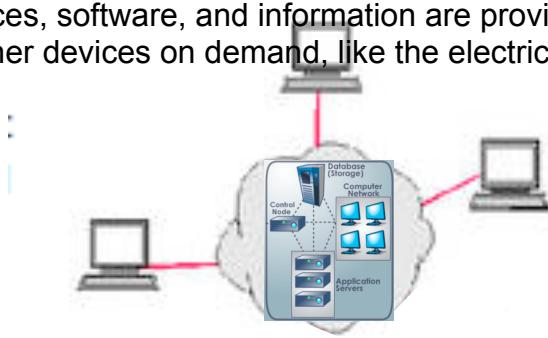
Node: 4
Coordinates : 72.96
commitDisps: 1.53009 -0.194007
Velocities : 0 0
unbalanced Load: 0 0
```

Things to Watch For

1. Deadlock (program hangs)
 - send/recv 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, 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.

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)

A screenshot of the NEEShub website homepage. The header includes the NEEShub logo and navigation links for "Tools & Resources", "Learning & Outreach", "Project Warehouse", "Sites", "Collaborate", and "Explore". The main content area features sections for "In the Spotlight", "Use NEEShub to...", "Events and Activities", "News and Announcements", and "Latest Earthquake Reports". The "In the Spotlight" section highlights "Visual Understanding Environment Map your ideas and concepts in this mapping tool - in Tools". The "Use NEEShub to..." section includes links for "Access NEES projects- Project Warehouse", "Run simulations and other Tools", "Learn with earthquake data and models- NEES Data & Models", and "Share research- Contribute Content". The "Events and Activities" section shows a calendar for June 2010. The "News and Announcements" section includes a "National Science Foundation Sensational 60" update and a "NEES FEATURED IN NY'S SENSATIONAL '60: The past 60 years have seen incredible developments in...". The "Latest Earthquake Reports" section lists several recent events, such as "M 6.2, Vanuatu" (July 22, 2010) and "M 5.1, New Britain region, Papua New Guinea" (July 22, 2010).

NEEShub Tools and Resources

Documents, Learning Objects, Series & TOOLS

The screenshot displays two main sections: "Data Management" and "Simulation".

Data Management: This section shows the inDEED software interface. It features a tree view of sensor data (e.g., Tel01.vel_x, Tel02.aco_y) and a 3D model of a building structure with various sensors attached. A legend indicates sensor types: velocity (green), acceleration (blue), and displacement (red).

Simulation: This section shows the OpenSeesLab interface. It includes a title card: "OpenSeesLab" and "NEEShub A Collection of Tools for Structural/Geotechnical Engineers that use the Open System for Earthquake Engineering Simulation". Below the title are several windows: "Results" showing a time history plot; "Deformations Only" showing a 3D model with color-coded displacement; "BiotResults" showing soil parameters; "Antenna Results" showing a plot of antenna response; and "Analysis Response" showing a plot of analysis results.

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

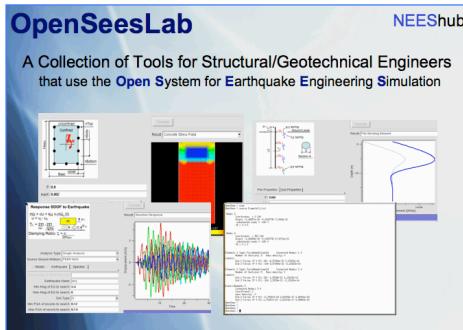
The screenshot shows the "Resources: Tools" search results page. The URL in the address bar is <http://nees.org/resources/tools>.

The left sidebar contains a search bar and a "Tag" filter section with categories like "data management", "EOT", "simulation", etc. Below this are sections for "Activities" and "Top Rated".

The main content area displays the "OpenSeesLab" tool card, which is identical to the one shown in the previous screenshot. It includes the title, description, and four representative software screenshots.

The OpenSeesLab tool:

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



Is a suite of Simulation Tools powered by OpenSees for:

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

OpenSees Interpreter Tool

 A screenshot of the OpenSees Interpreter Tool running in a Java Applet window titled 'hub'. The window shows the OpenSees logo at the top left and an 'Application:' dropdown set to 'OpenSees Interpreter'. Below the title bar is a menu bar with 'File', 'Edit', 'View', 'Analysis', 'Help', and 'About'. The main area displays a command-line interface for OpenSees. The text in the window reads:


```

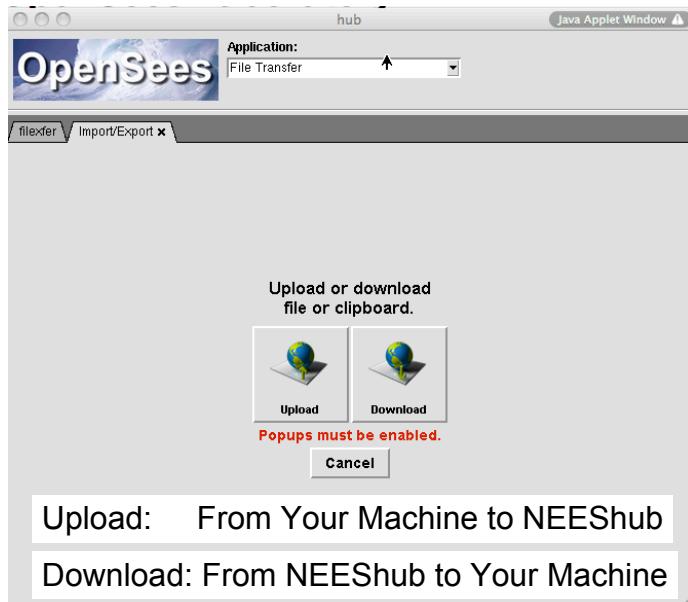
        OpenSees -- Open System For Earthquake Engineering Simulation
        Pacific Earthquake Engineering Research Center -- 2.2.1
        (c) Copyright 1999,2000 The Regents of the University of California
        All Rights Reserved
        (Copyright and Disclaimer @ http://www.berkeley.edu/OpenSees/copyright.html)

        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
        R8.tcl
        ExampleSP1.tcl
        Node.out
        analysis.tcl
        model.tcl
        peerRecords.txt
        OpenSees > source R8.tcl
        WARNING analysis Transient dt tFinal - no LinearSOE specified,
        ProfileSPDLinSOE default will be used

        Node: 525
        Coordinates : 1 1 10
        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 : 1 1 2

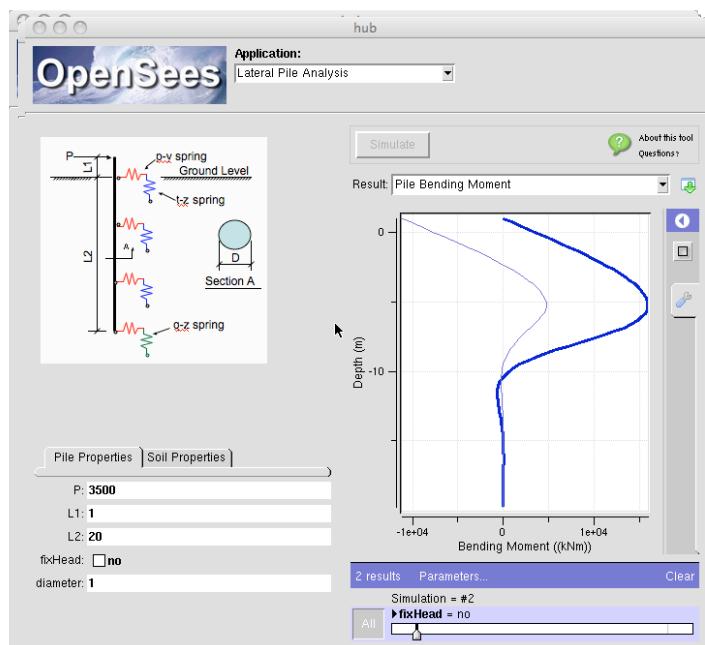
        Simulation Time 192
        OpenSees > cd ..
        OpenSees > tar cBf A_Example.tar A_Example
        OpenSees >
    
```

File Transfer Tool



Lateral Pile Analysis

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



NEEHub 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?