Cloud Computing With OpenSees

Frank McKenna

2012 PEER Annual Meeting

OpenSees is Sponsored by:

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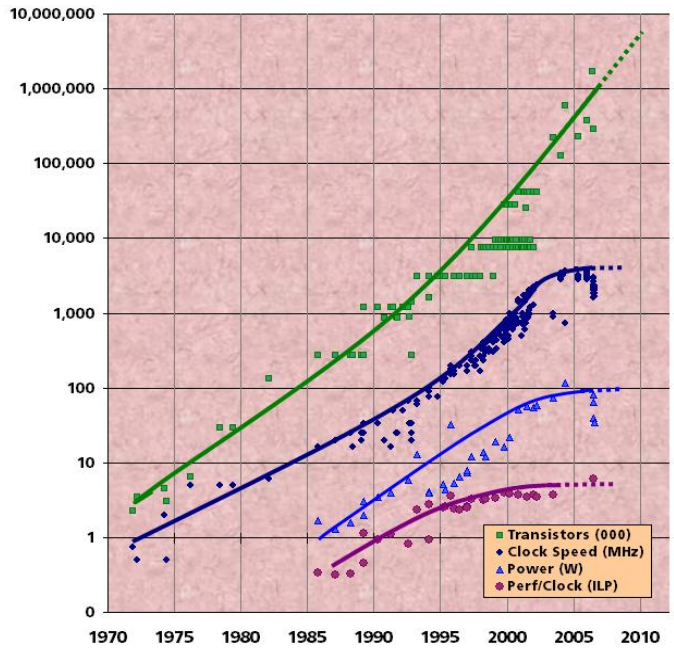
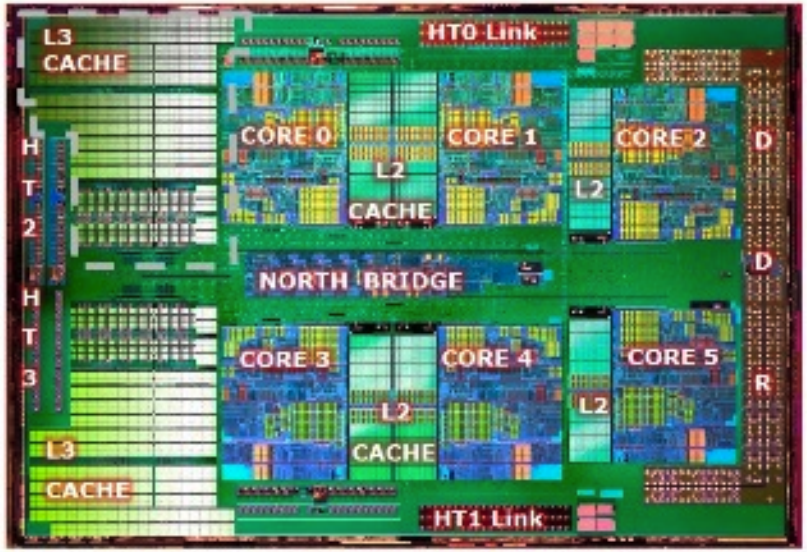
Technology is Changing



Intel Processor Speed	
XeonE7Server	72Gflop
i7Desktop	55GFlop
i7Mobile	30GFlop
i5Desktop	40GFlop
i5Mobile	22GFlop
Core2 Quad	48GFlop
Core2 Duo	25GFlop

CHIP/Socket



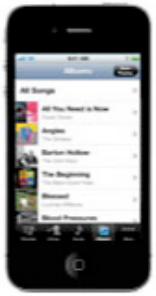
Game consoles (Wii, Xbox Playstation) have more raw numerical processing power than your desktop!

Game Console Speed	
Nintendo Wii	61Gflop
Xbox360	355Gflop
Sony PS3	2018Gflop

Cloud Computing (according to Steve)

Some people think the cloud is just
A hard drive in the sky!

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



"..PC and Mac Demoted to a Device"

More Specifically

- Cloud computing is a general term for anything that involves delivering hosted services over the Internet.
- A cloud service has **3** distinct characteristics that differentiate it from traditional desktop computing.
  1. **It is sold on demand**, typically by the minute or the hour
  2. **It is elastic** -- a user can have as much or as little of a service as they want at any given time;
  3. **The service is fully managed by the provider** (the consumer needs nothing but a personal computer and Internet access)
- A cloud can be private or public.
  - A public cloud sells services to anyone on the Internet. (Currently, Amazon Web Services is the largest public cloud provider.)
  - A private cloud is a proprietary network or a data center that supplies hosted services to a limited number of people.

You are Probably Using it Already

- gmail & google docs are actually cloud services provided by google.

Windows Azure

rackspace
the open cloud company

IBM

amazon
web services™

Did Thomas Watson have it Correct?

"I think there is a world market for maybe 5 computers", 1943

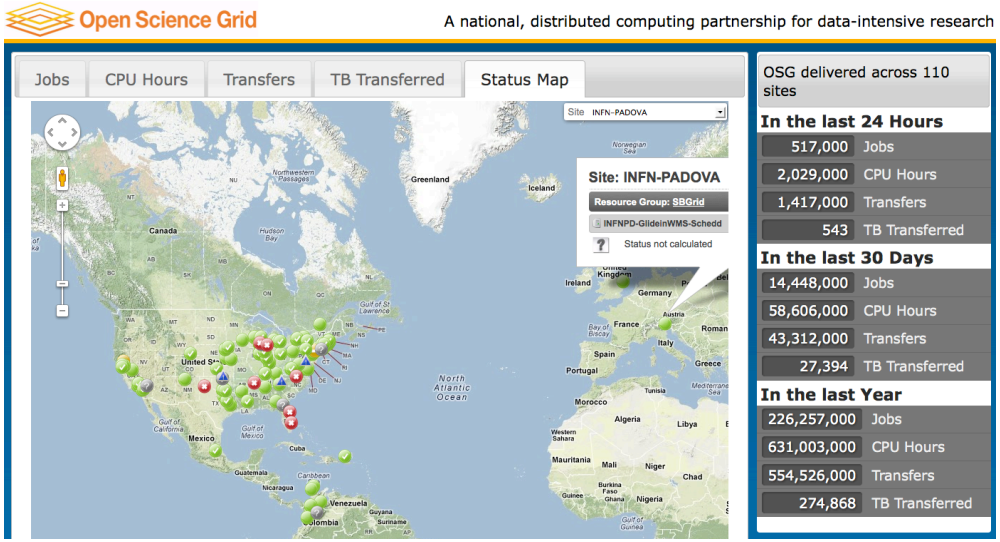
The fact the famous quote is likely incorrectly attributed to him is immaterial. 80 or years later the world may just prove him (or whoever said this) right!

According to Microsoft research chief Rick Rashid, around 20 per cent of all the servers sold around the world each year are now being bought by a small handful of internet companies – he named Microsoft, Google, Yahoo and Amazon.

Computing is becoming device independent: we will be accessing a handful of "supercomputers" through different devices (which includes that device formerly known as your computer)

Characteristics of Computational Resources

- Lots and Lots and Lots of cores
  - Dedicated High Performance Machines (1,000s to 1,000,000's and soon 100,000,000's cores)
  - Distributed Machines/Clusters (100's to 1,000,000's of CPU's each with a 1's to 20's and soon 100's cores)



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 (all computational devices on which simulation applications run will be parallel machines, with a few computational units or millions of units)

- We release 4 applications.

1. OpenSees.exe
2. OpenSeesTk.exe

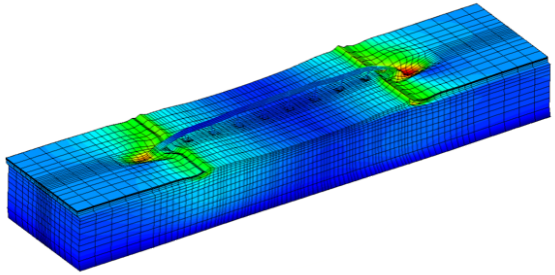
} **sequential processing**

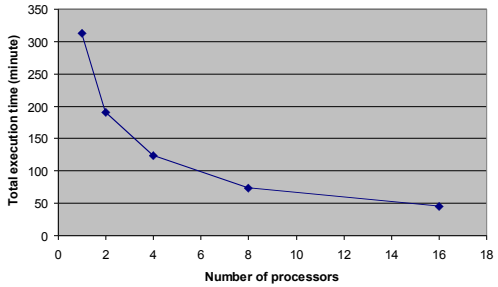
3. OpseseesSP.exe
4. OpenSeesMP.exe

} **parallel processing**

Parallel OpenSees Interpreters

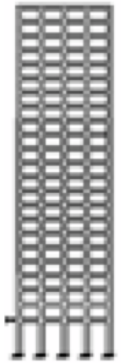
– OpenSeesSP: An application for large models.





– OpenSeesMP: An application for **BOTH** large models and parameter studies.

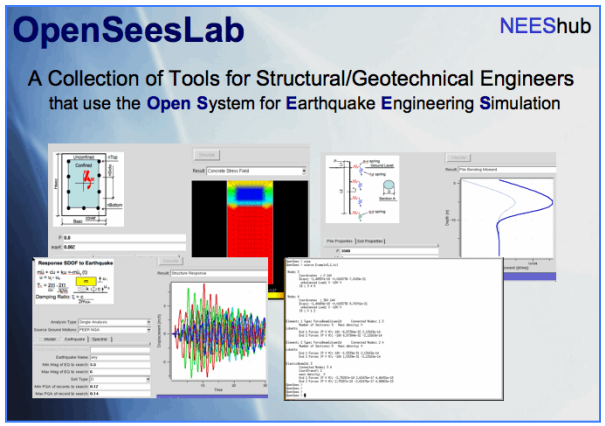
```
set pid [getPID]
set np [getNP]
set count 0;
source parameters.tcl
source ReadSMDFileNewFormat.tcl;
foreach GMfile $iGMFile {
   foreach Factor1248 $iFactor1248 {

      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
      }
   }
}
```



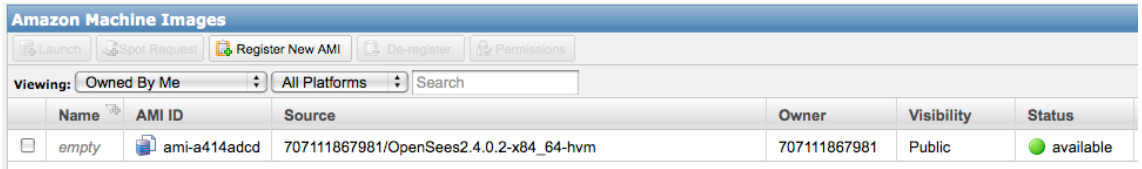
3 buildings, 2 config a building, 44 records, 12 intensities, 5 hour a record, would have, taken 15840 hours or 660 days or 1.8 years. Ran on 44 processors of a XSEDE Ranger in less than 7 days.
(ATC-63/2 project using NEEShub)

So How Do We Use These Applications in the Cloud

Academia/(Industry)



Industry/(Academia)

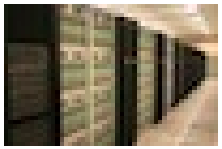


http://nees.org/resources/tools/openseeslab

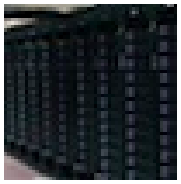
Academia - OpenSeesLab

- Submit Jobs to High Performance XSEDE Machines

Kraken (112,986 cores, #21 Top500.org)

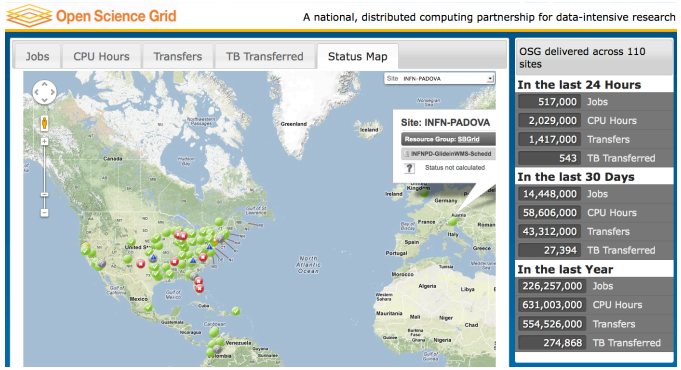


Ranger (62,976 cores, #40 Top500.org)



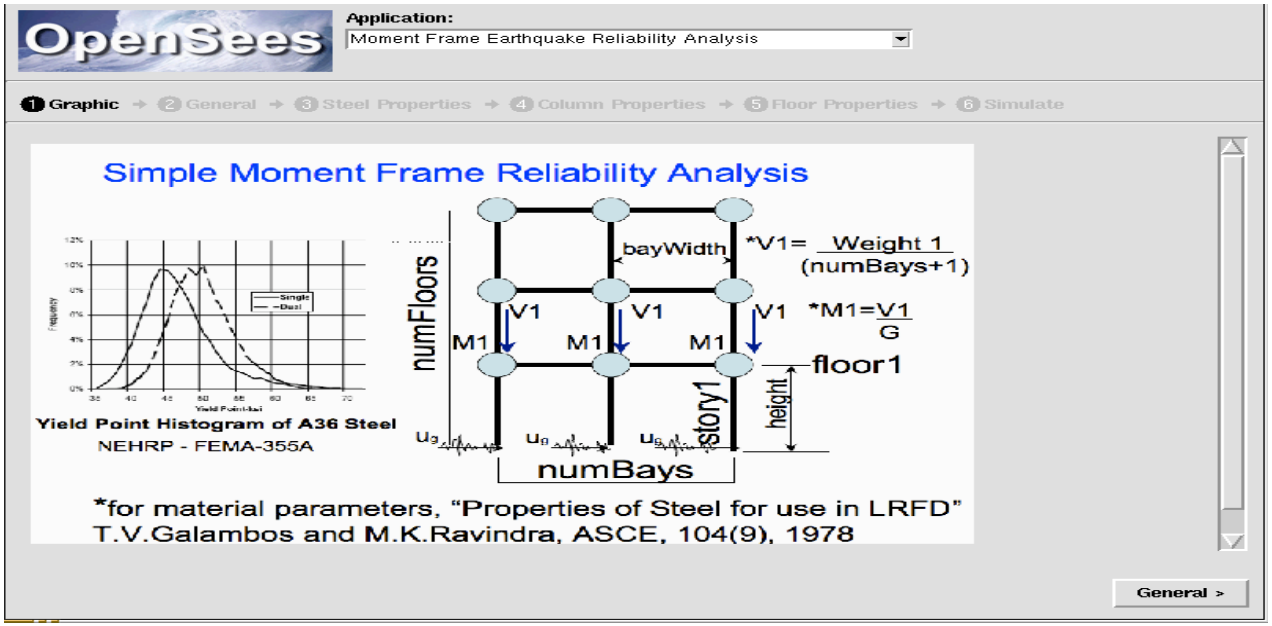
Steele (7,216 cores, not ranked)

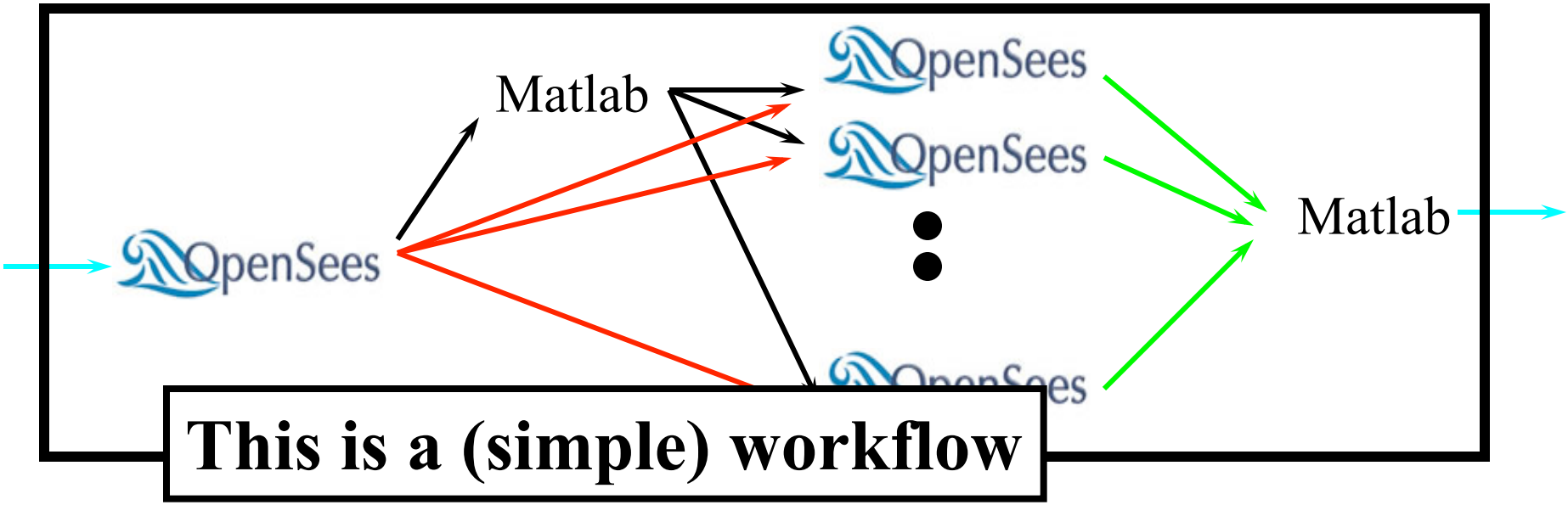
- Submit Jobs to Highly Distributed Machines



OSG (43,000+ cores,
80 institutions US, +abroad)

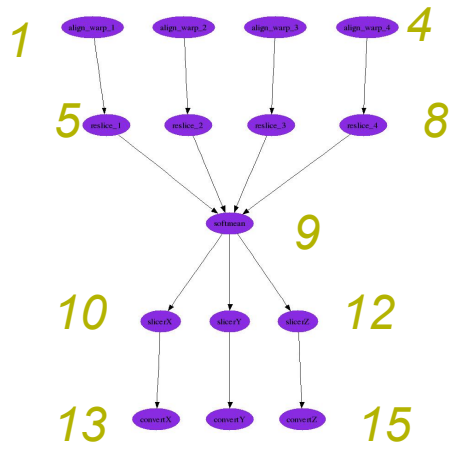
Moment Frame Reliability Analysis



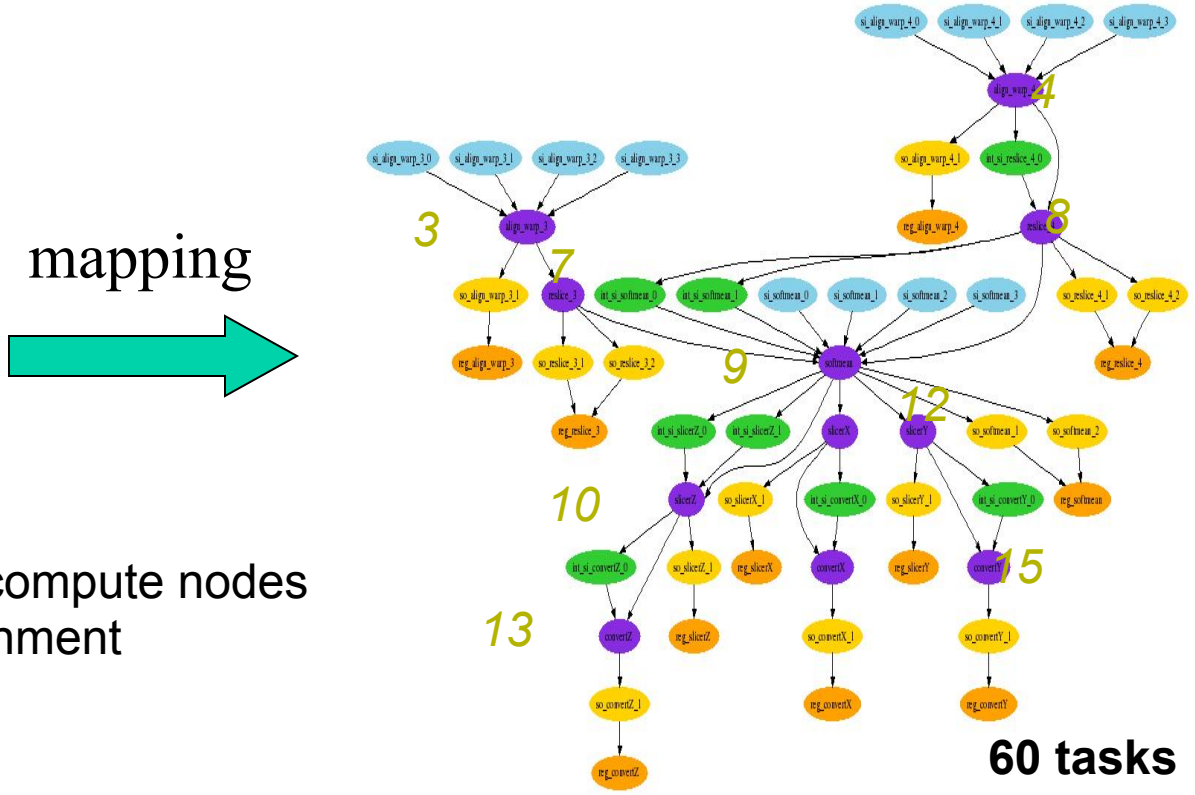


Workflows in the Cloud

Software exists (pegasus, others) for creating scientific workflows that can take advantage of computational resources in the cloud! A scientific workflow allows engineers to compose and execute a series of computational or data manipulation steps in a scientific application.

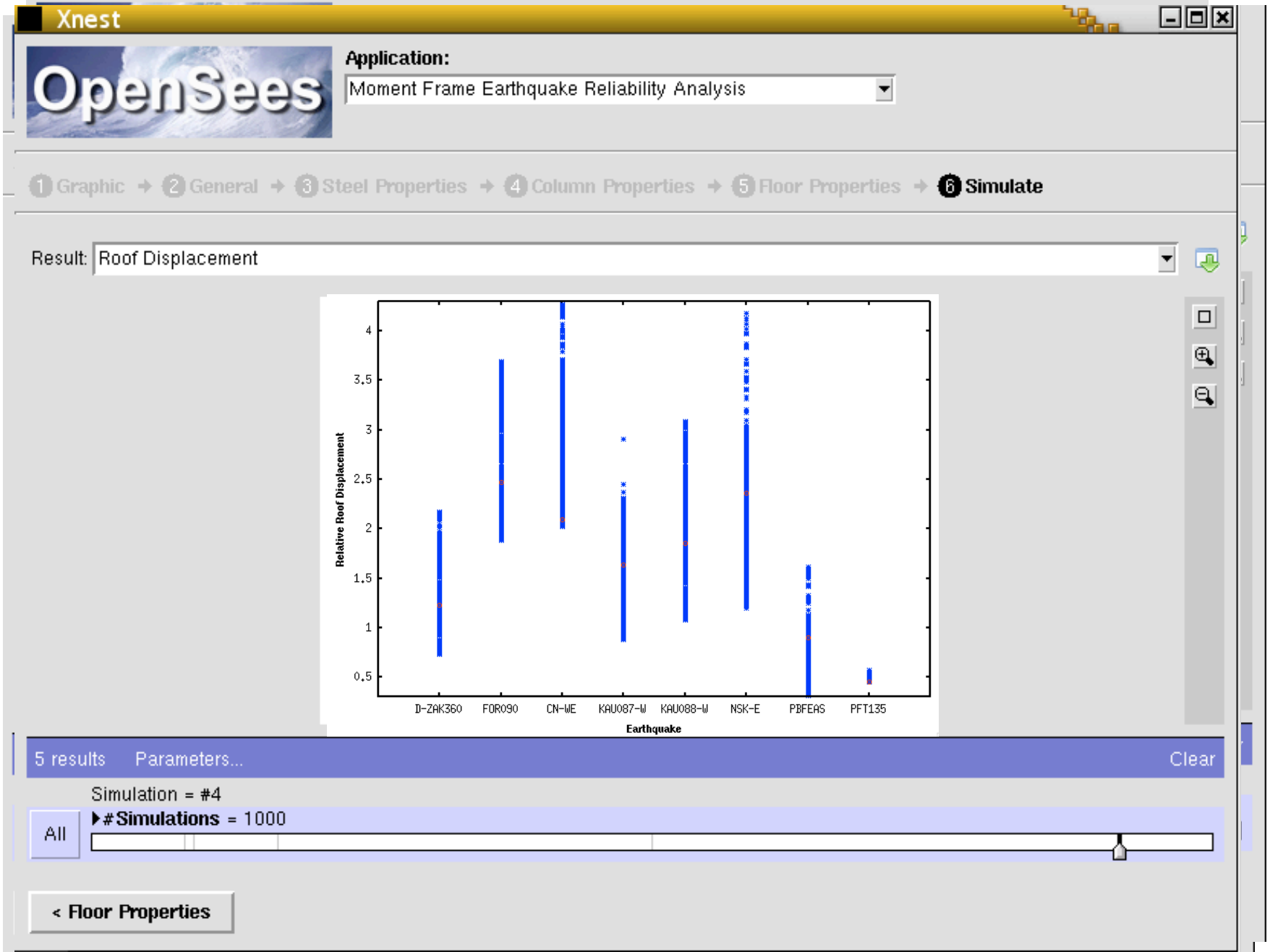


mapping

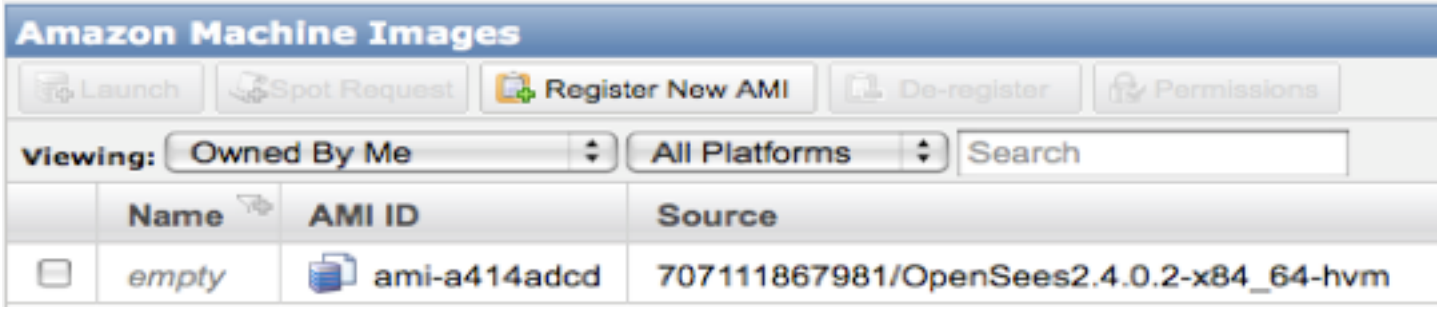


Original workflow: 15 compute nodes devoid of resource assignment

Moment Frame Reliability Analysis

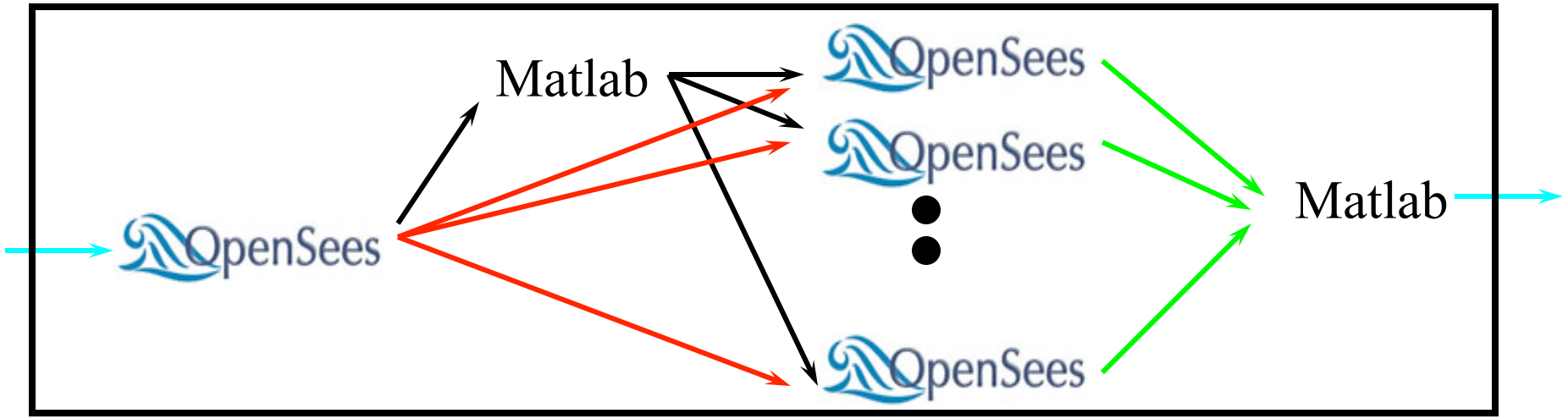


Industry - OpenSees & Amazon EC2



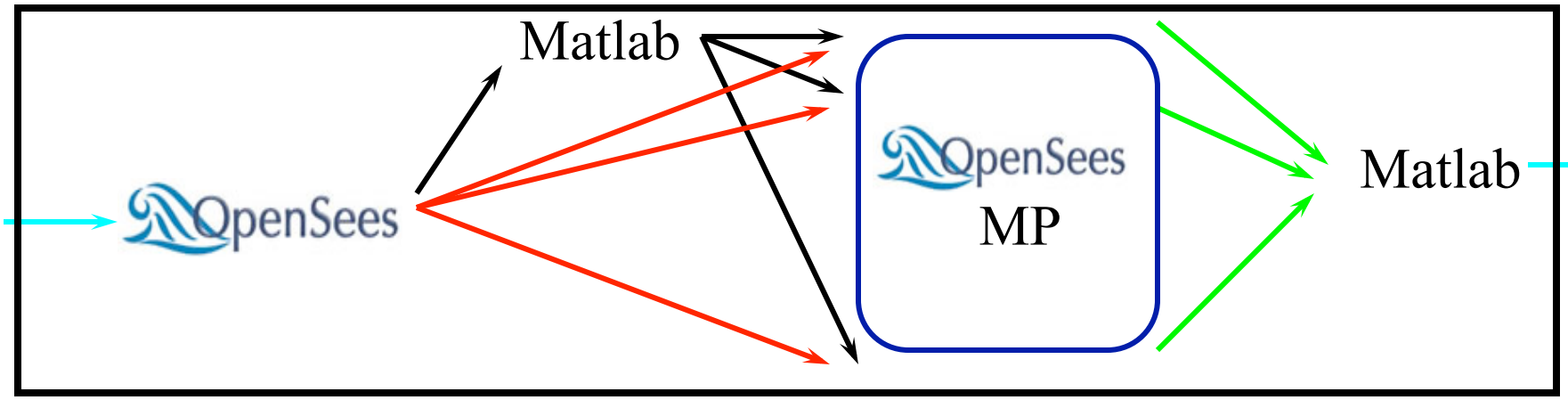
- A 64bit HVM Amazon Machine Image containing OpenSees, OpenSeesSP and OpenSeesMP.
- Run sequential and parallel jobs on single computer and cluster system (specialty built cluster for HPC - a 7,000 core Amazon cluster appeared in last years Top500 at #433)
- Cost $0.02/core-hr to $0.12/core-hr (machine type/standard or **spot (you bid)** pricing)

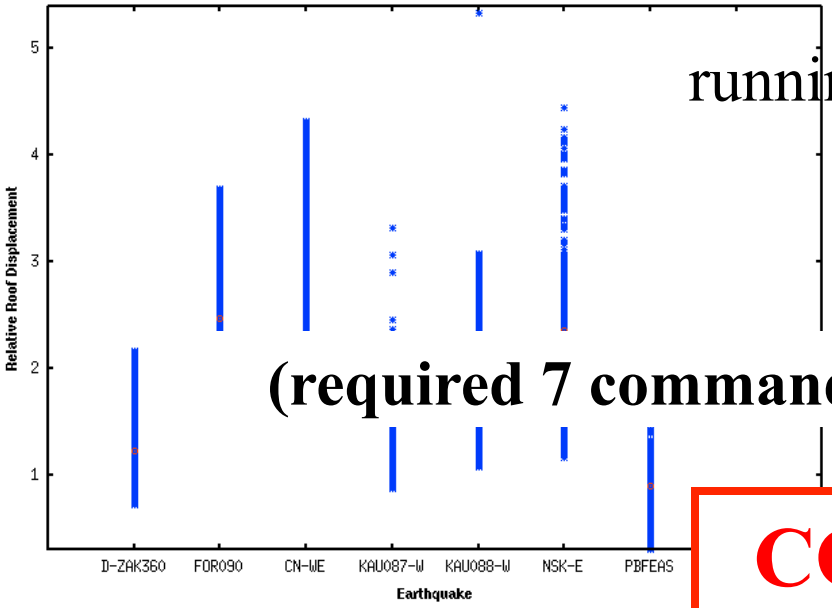
Moment Frame Reliability Analysis



- Doesn't work to well.
- OpenSees can call other programs
  1. Matlab (Octave)
  2. mpirun & OpenSeesMP

Moment Frame Reliability Analysis





running on 16 cc1.4xlarge instance (128 cores)
performed 16,000 simulations
On Amazon-EC2

(required 7 commands from a terminal window)

COST $6.42

Any Questions?

Thank You