BIM A+

European Master in
Building Information Modelling

HTCondor computing environment

Topic 2: Fundamentals of programming

BIM A+3: Parametric Modelling in BIM

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HPC vs HTC

BIM A+

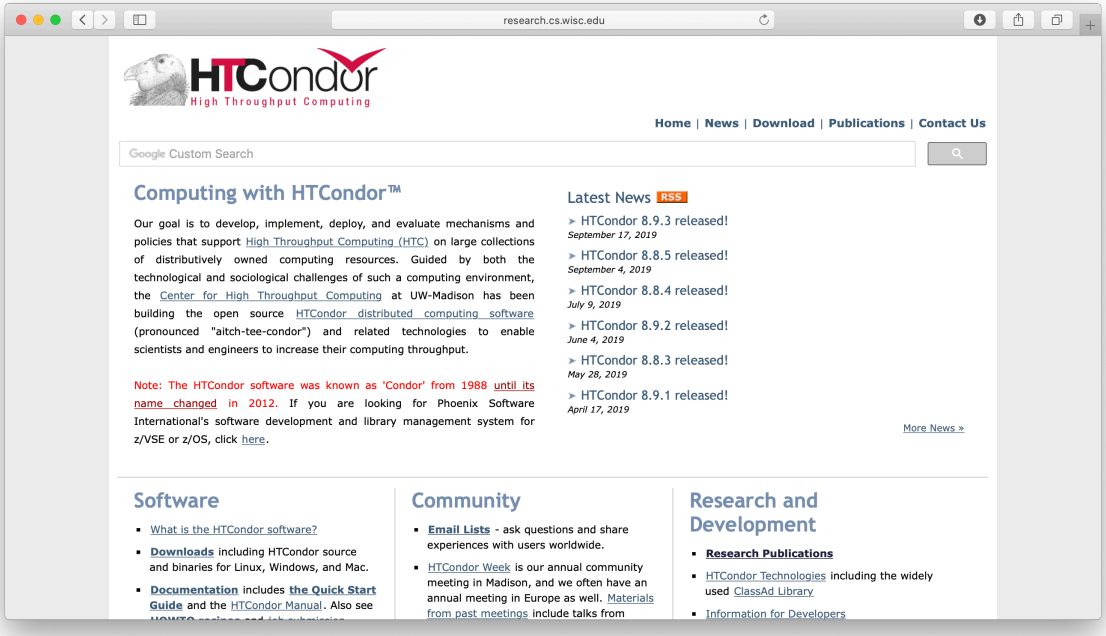
	High-performance Computing HPC	High-throughput Computing HTC
FLOPS	very important, single computing unit	not that important, many computing units
environment	static	dynamic
problem	single large problem	parallel independent jobs
protocols / solutions	MPI, PVM	HTCondor, Torque, SETI@Home

A problem to solve

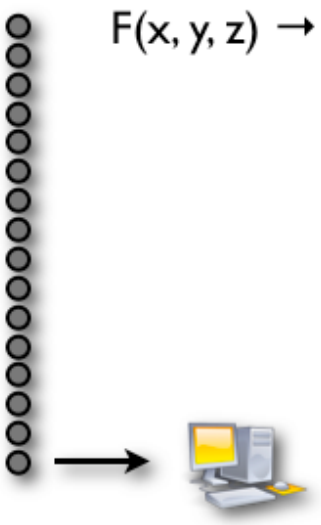
- Frieda has to perform a parametric study.
- The problem:
  - Run a Parameter Sweep of F(x,y,z) for 20 values of x, 10 values of y and 3 values of z (20*10*3 = 600 combinations)
  - F takes on the average 6 hours to compute on a “typical” workstation (total = 3600 hours)
  - F requires a “moderate” (128MB) amount of memory
  - F performs “moderate” I/O - (x,y,z) is 5 MB and F(x,y,z) is 50 MB

HTCondor to the rescue

- Where to get HTCondor
  - http://research.cs.wisc.edu/htcondor/
- Download HTCondor for your OS
  - HTCondor runs on all modern operating systems: Windows, Mac, Linux
- Install HTCondor
  - You can start by installing “Personal HTCondor”



Personal HTCondor



- Where is the benefit?
- Your Personal Condor will:
  - keep an eye on your jobs and will keep you posted on their progress
  - implement your policy on the execution order of the jobs
  - keep a log of your job activities
  - add fault tolerance to your jobs
  - implement your policy on when the jobs can run on your workstation

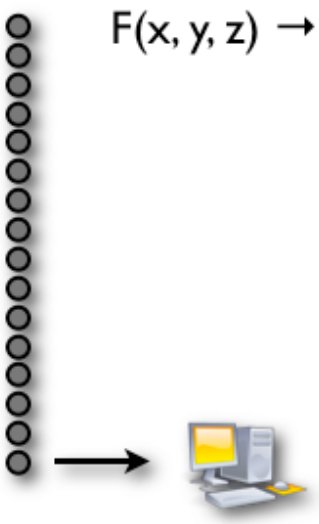
Submitting jobs to HTCondor

- Make your job “batch-ready”
  - Must be able to run in the background: no interactive input, windows, etc.
  - Can still use STDIN, STDOUT, and STDERR, but files are used for these instead of the actual devices
  - Organise data files
- Creating a submit description file
  - A plain ASCII text file
  - Tells Condor about your job
  - Can describe many jobs at once (a “cluster”), each with different input, arguments, output, etc.

Submitting jobs to HTCondor

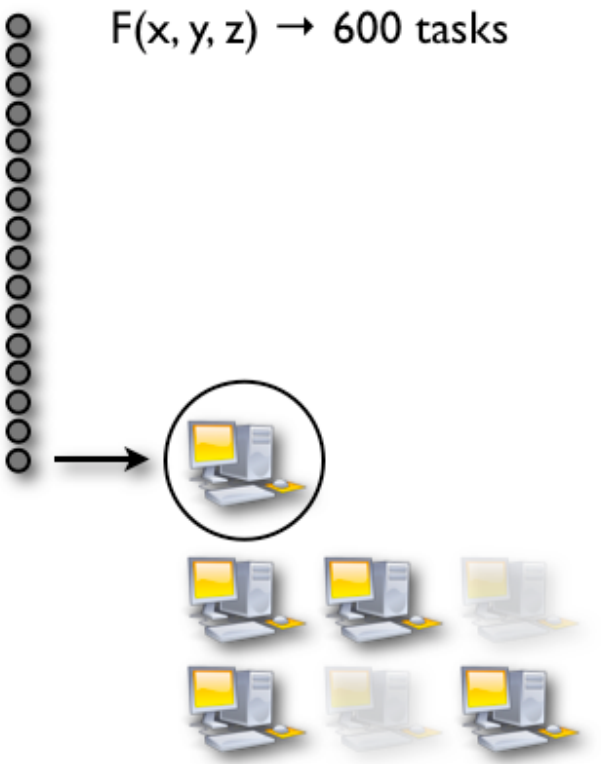
```
# Simple condor_submit input file
# (Lines beginning with # are comments)
# NOTE: the words on the left side are not
#       case sensitive, but filenames are!

Universe   = vanilla
Executable = my_job

Queue
```

Frida's HTCondor pool



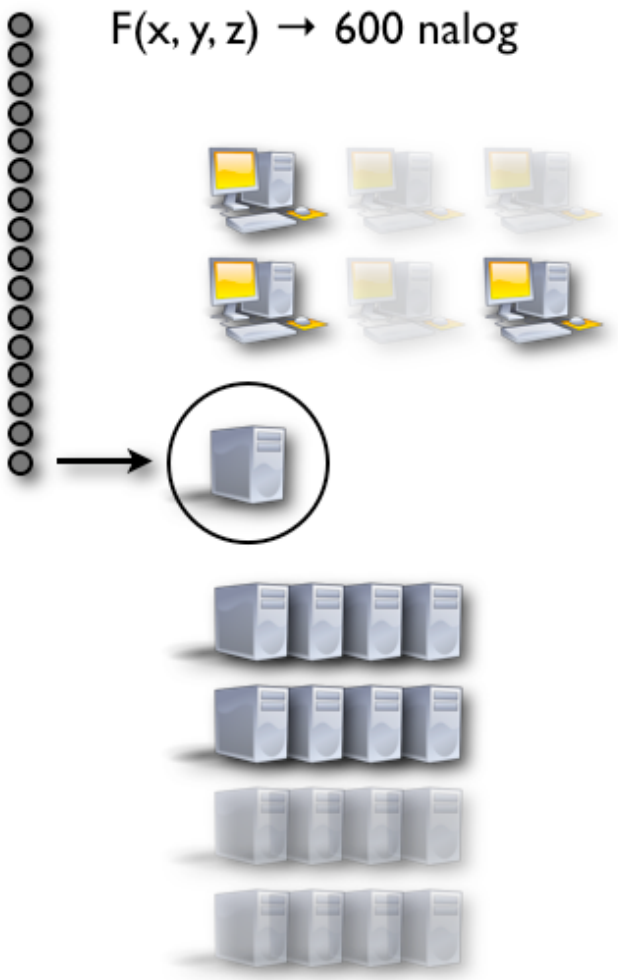
- Frieda can still only run one job at a time, however.
  - There are good news.
  - The Boss says Frieda can add her co-workers' desktop machines into her Condor pool as well…but only if they can also submit jobs.

HTCondor to the rescue



- Frieda installs HTCondor on the desktop machines, and configures them with her machine as the central manager
- These are “non-dedicated” nodes, meaning that they can't always run HTCondor jobs
- Now, Frieda and her co-workers can run multiple jobs at a time so their work completes faster.

HTCondor to the rescue

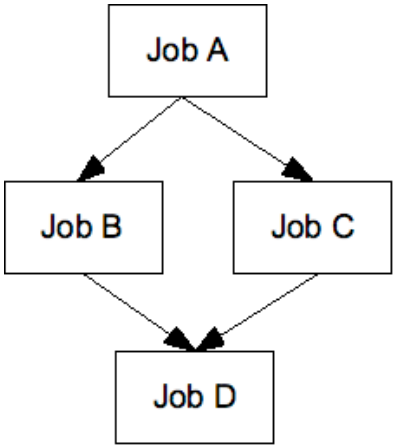


- They need more!
- The organisation buys a dedicated cluster.
  - Frieda Installs HTCondor on all the dedicated Cluster nodes and adds a dedicated central manager
  - She configures her entire pool with this new host as the central manager…
  - With the additional resources, Frieda and her co-workers can get their jobs completed even faster.

Job dependencies

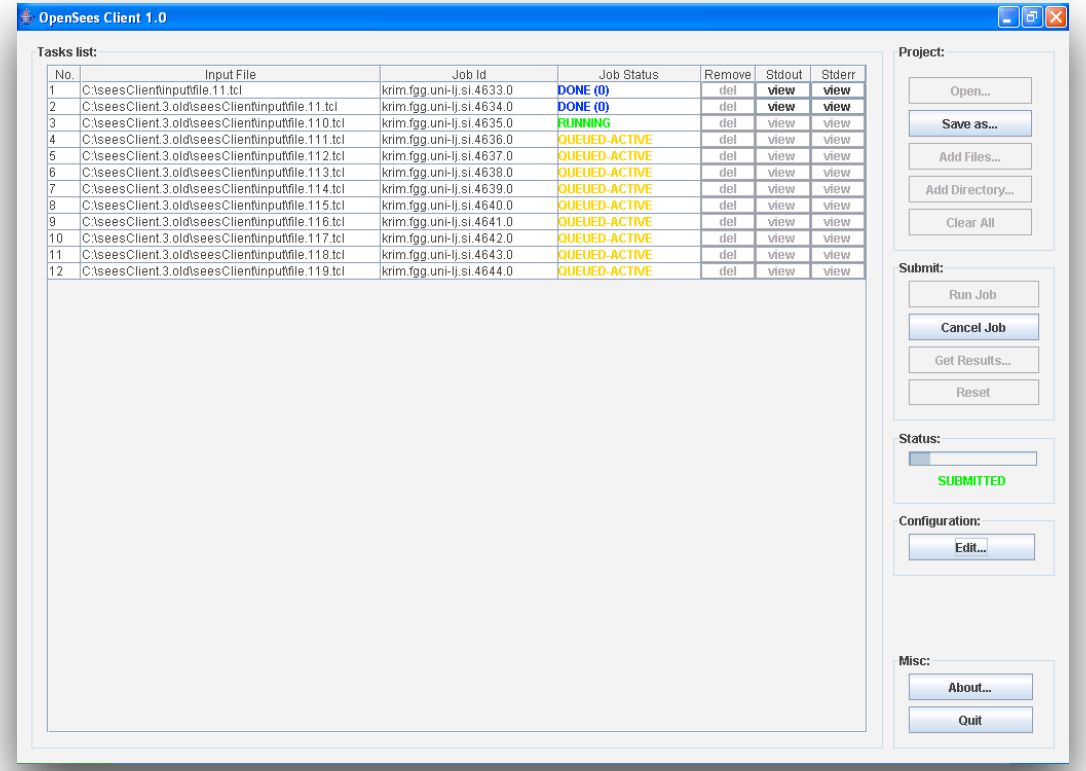
- Directed Acyclic Graph Manager (DAGMan)
  - DAGMan allows you to specify the dependencies between your HTCondor jobs, so it can manage them automatically for you. (e.g., “Don’t run job “B” until job “A” has completed successfully.”)
- What is DAG
  - A DAG is the data structure used by DAGMan to represent these dependencies.
    Each job is a “node” in the DAG.
    Each node can have any number of “parent” or “children” nodes – as long as there are no loops!
- Defining a DAG
  - A DAG is defined by a .dag file, listing each of its nodes and their dependencies
    Each node will run the Condor job specified by its accompanying Condor submit file

```
# diamond.dag
Job A a.sub
Job B b.sub
Job C c.sub
Job D d.sub
Parent A Child B C
Parent B C Child D
```



DRMAA

- DRMAA == Distributed Resource Management Application API
- Programming API (C/C++, Java, Python, Ruby, ...)
- OpenDSP: WS impl. of the DRMAA API



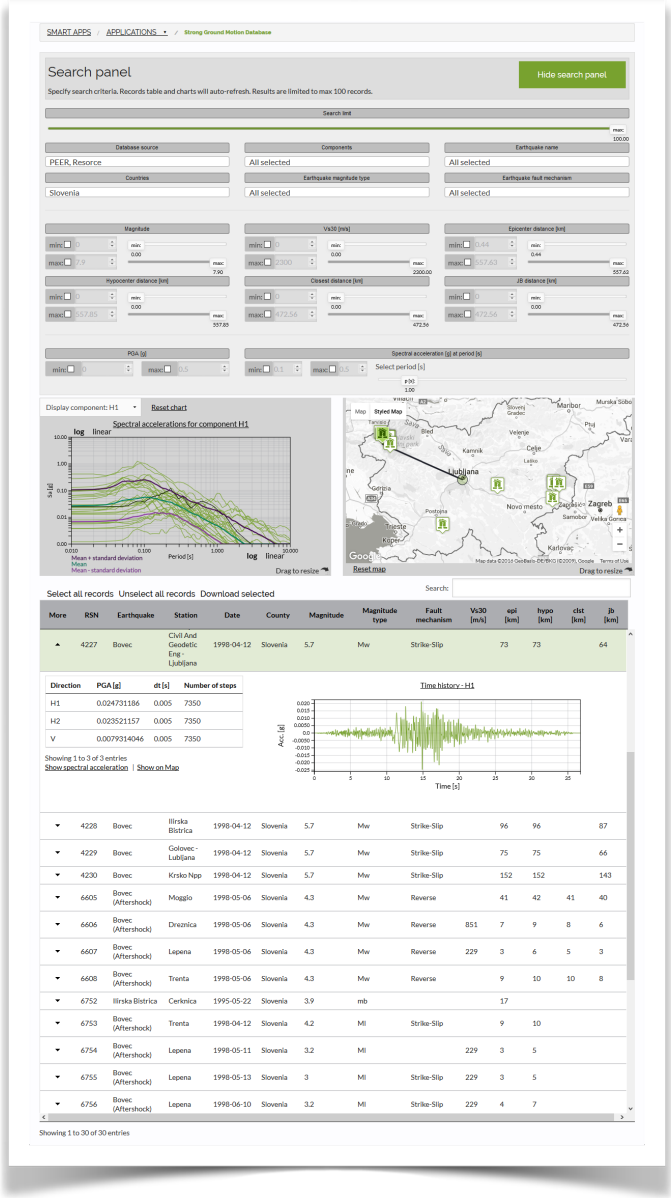
History of HTCondor @ UL FGG

HTCondor @ UL FGG (July 2019)

- Hardware
  - Intel Xeon CPUs
  - 8/16/32 GB RAM (total 316 GB)
  - 316 CPU
- Software
  - Ubuntu Server 18.04 LTS
  - HTCondor, MPI enabled
  - General applications: MATLAB, BLAS, LINPACK, …
  - Specific applications: OpenSees, Abaqus, …

Example: IDA analysis (OpenSees)

- Earthquake analyses (IDA, 3R, Qfactor)
- Parametric studies - OpenSees, MATLAB
- Energy officient buildings
- Parametric studies - Nandrad (TUD-IBK), Therakles (TUD-IBK), Riuska (Gradlund)
- CFD analises
- Parallel programs (MPI) - Sofistik CFD, 96 CPU
- 3D numerical analyses
- Parallel programs (MPI) - Abaqus, 16 CPUs



Examples

- Earthquake analyses (IDA, 3R, Qfactor)
  - Parametric studies - OpenSees, MATLAB
- Energy officient buildings
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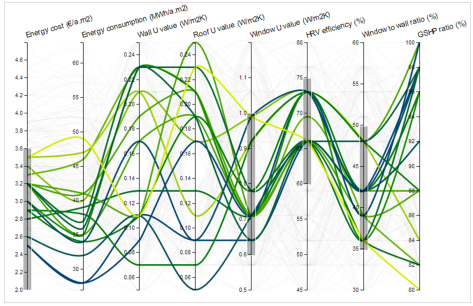
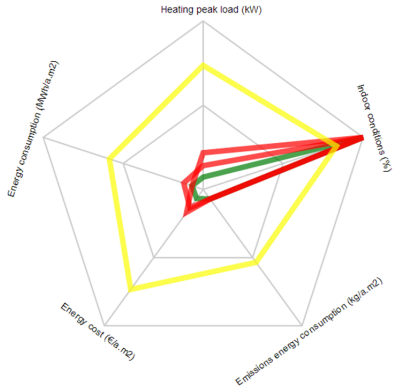
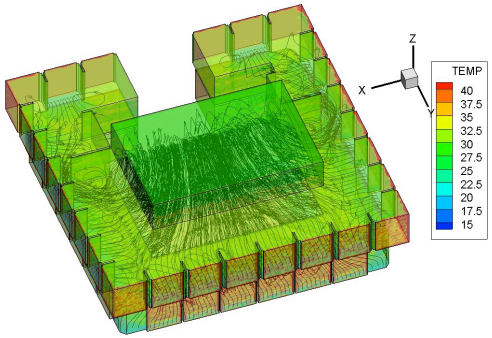
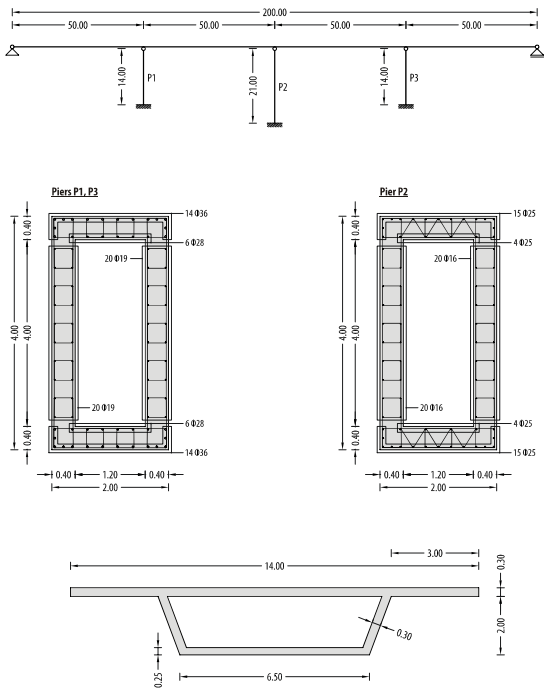
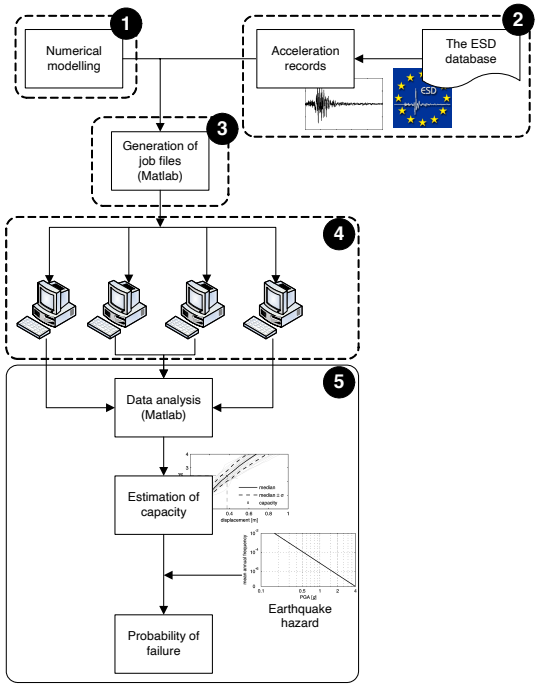






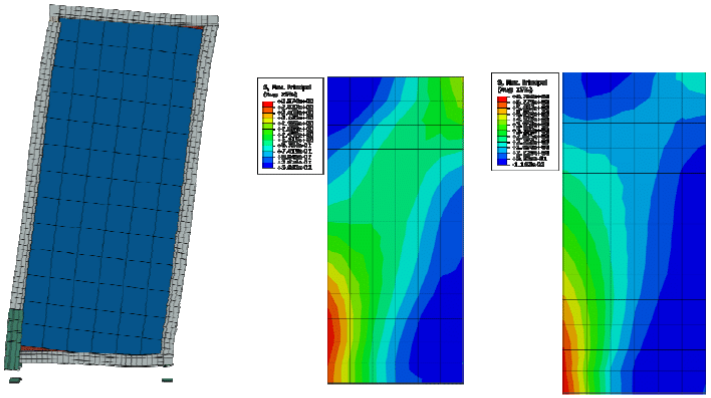
Examples: IDA analysis (OpenSees)

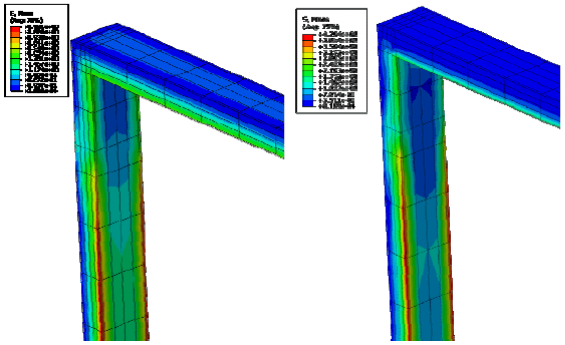


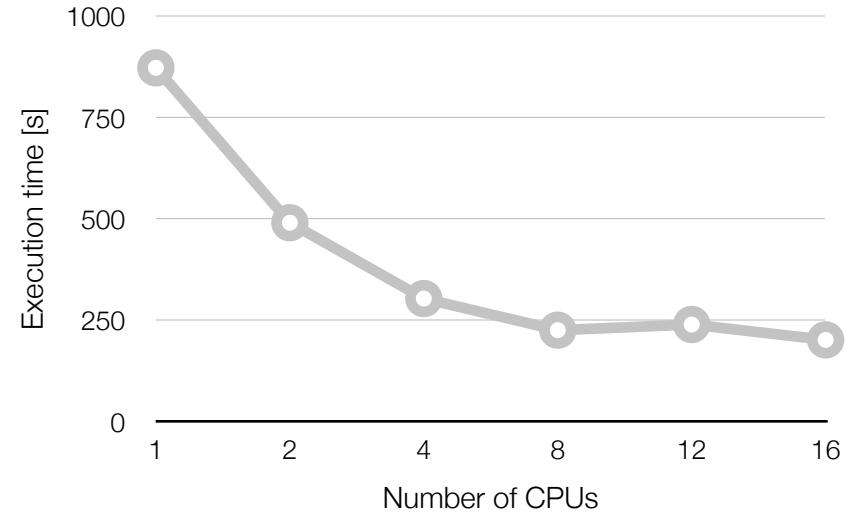


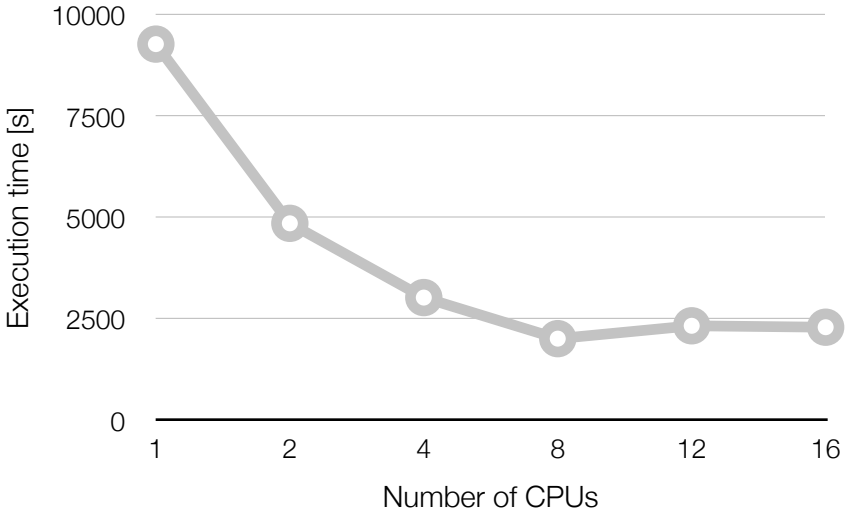
Number of CPUs	Execution time [h]	Speedup factor
1	61,3	1
5	14,7	4,17
10	7,1	8,63
25	2,5	24,52

Examples: MPI based analysis (Abaqus)









Demo