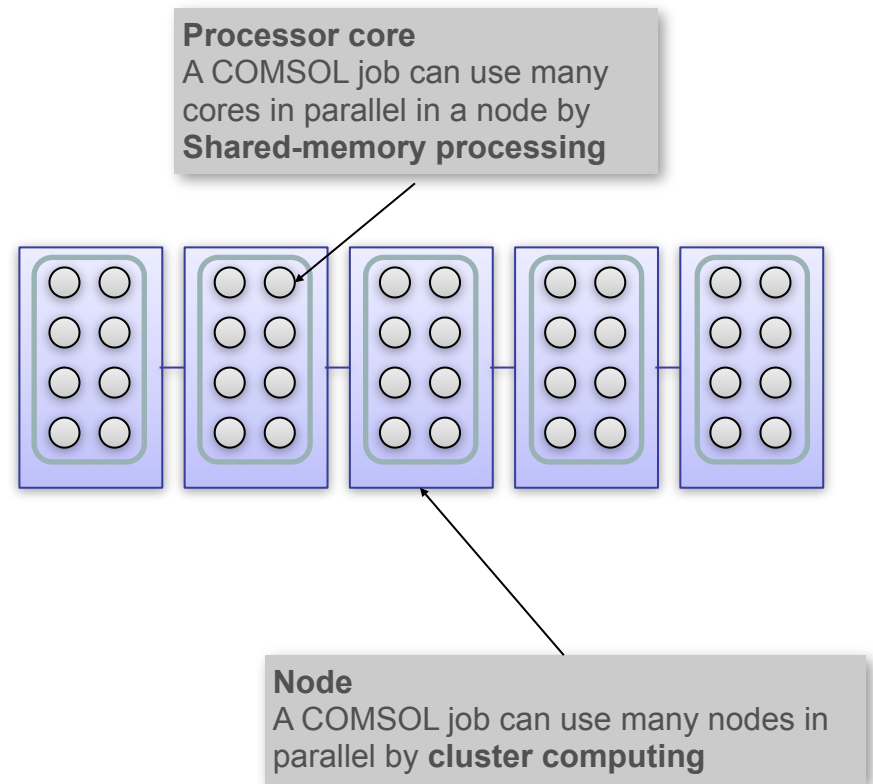# Running COMSOL in parallel

- COMSOL can run a job on many cores
in parallel (Shared-memory processing or multithreading)

- COMSOL can run a job run on many physical nodes (cluster computing)

- Both parallel operations above can be used in combination to maximize parallelization benefits

- Cluster computing requires a floating network license

Processor core
A COMSOL job can use many cores in parallel in a node by **Shared-memory processing**

Node
A COMSOL job can use many nodes in parallel by **cluster computing**

COMSOL

Four ways to run a cluster job, overview

- You can choose from different ways to submit a cluster job, depending on your personal preference:
  1. Submit cluster-enabled batch job from the Linux command prompt or scheduler script
  2. Branch off cluster-enabled batch jobs from a COMSOL Desktop GUI process started on headnode
  3. Start a cluster-enabled COMSOL desktop GUI on the headnode and work interactively with cluster jobs
  4. Start the COMSOL Desktop GUI as a client on a local PC or Macintosh and connect to a cluster-enabled COMSOL server on the Linux headnode and work interactively

COMSOL

Four Ways to Run a Cluster job, details

1. Submit batch job from the command line of the headnode
    – No GUI
    – Direct control through commands,
      can be used in shell scripts
    – Requires completed and saved
      model mph file
   – Recommended for use together with schedulers, like LSF or PBS

> See `comsol -h` for details

```
head:~>comsol -nn 8 mpd boot
head:~>comsol -nn 8 batch -inputfile in.mph
head:~>comsol mpd allexit
```

COMSOL

Four Ways to Run a Cluster job, cont.

2. Branch off cluster-enabled batch jobs from a COMSOL Desktop GUI started on headnode
   - Allows GUI model work, and batch job submission from within the GUI
   - Limited command-line proficiency needed
   - Allows you to submit and queue multiple jobs (different scenarios) from one COMSOL Desktop GUI process and continue working in the GUI while cluster jobs are computing in the background (requires a license with a minimum of 2 concurrent users)
   - Can be used together with custom schedulers like LSF or PBS
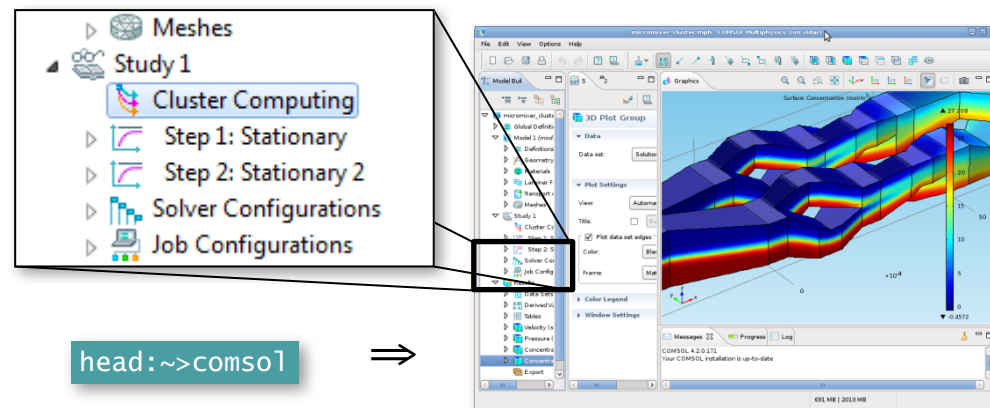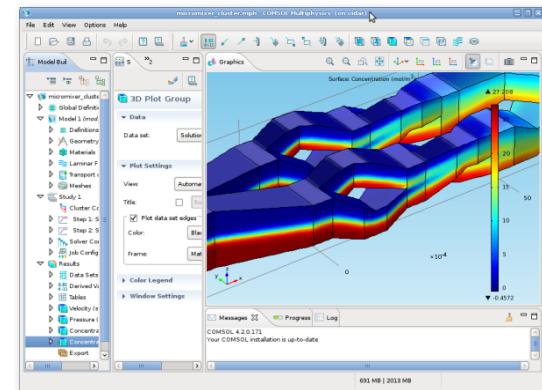

`head:~>comsol`

Four Ways to Run a Cluster job, cont.

3. Start a cluster-enabled COMSOL desktop GUI on headnode
   - Allows interactive modeling and cluster jobs by the click of a button from within the COMSOL Desktop GUI.
   - Desktop GUI will be mostly locked up while computing the solution
   - Limited command line proficiency needed
   - Not for use with custom schedulers

```
head:~>comsol -clustersimple -nn 8
```

$\Rightarrow$

COMSOL

Four Ways to Run a Cluster job, cont.

4. Start the COMSOL Desktop GUI as a client on a local PC or Macintosh and connect to a cluster-enabled COMSOL server on the Linux headnode and work interactively

   – Same as alternative 3 above, except that the COMSOL desktop is on a work computer, separated from the cluster.

   – *You can also use this configuration to submit batch jobs, like in alternative 2.
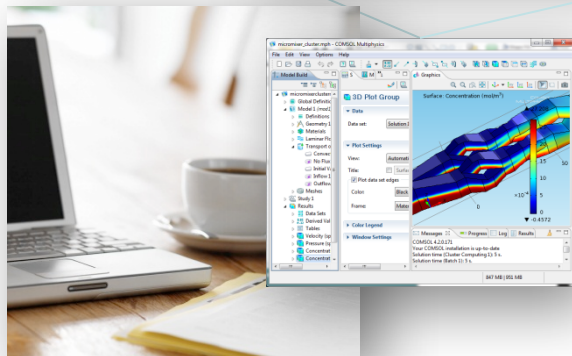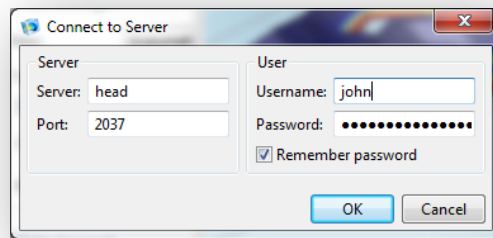
client/server

```
head:~>comsol server -nn 8 –clustersimple
```

Example 1: Command line batch submission

a) Start mpd on the 8 nodes listed in the file "machinefile". Then submit the COMSOL job. Use the ssh protocol to communicate between nodes. Shut down mpd after job completes. Log the job detals in b.log

```
head:~> comsol -nn 8 mpd boot -f machinefile -mpirsh ssh
head:~> comsol -nn 8 batch -inputfile in.mph -outputfile out.mph -batchlog b.log
head:~> comsol mpd allexit
```

b) Shorthand version using the clustersimple option

```
head:~> comsol -clustersimple batch -nn 8 -f hostfile -mpirsh ssh -inputfile in.mph \
-outputfile out.mph -batchlog b.log
```
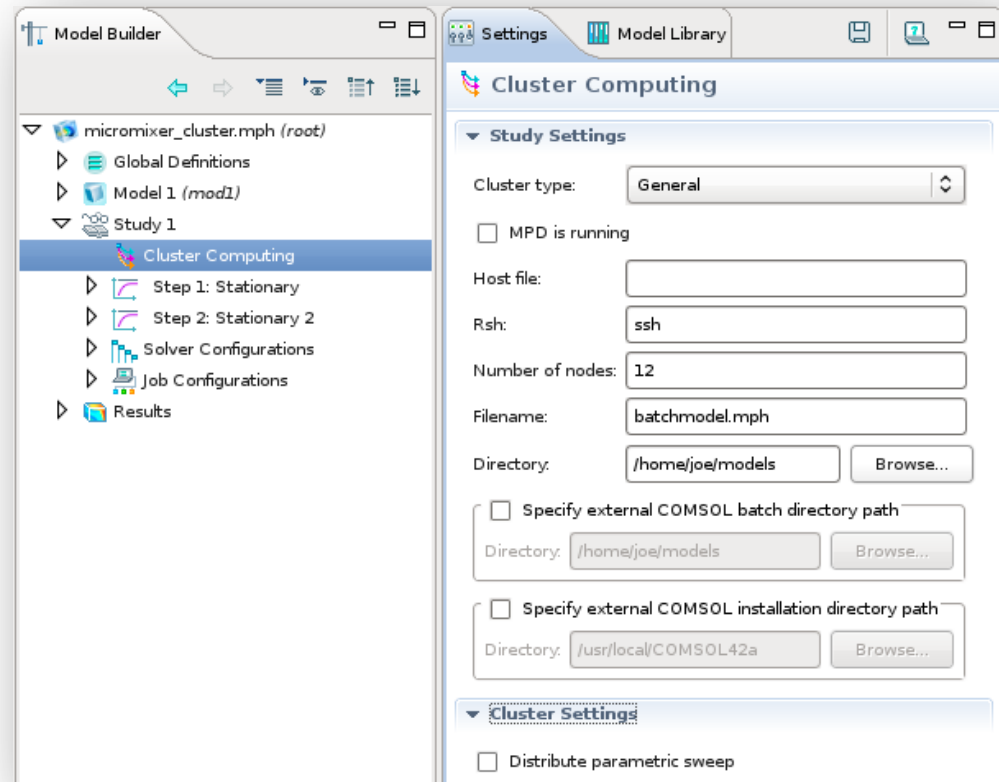
c) If you use a scheduler, it can automatically detect how many nodes are reserved for the job:

```
head:~> comsol -clustersimple batch -inputfile input.mph -outputfile output.mph
```

COMSOL

Example 2, Desktop GUI, branch off batch job for cluster computation

- See details in COMSOL Multiphysics User's Guide, section *Running COMSOL in Parallel*

Find more information

- For a fully documented Desktop GUI cluster example, see the model library examples COMSOL_Multiphysics/Tutorial_Models micromixer_cluster and thermal_actuator_jh_distributed
- For troubleshooting, see
  - knowledge base solution 1001 http://www.comsol.com/support/knowledgebase/1001/
- For command line options, see "comsol –h" and COMSOL installation and Operations Guide:
  - *Running COMSOL on clusters*
  - *COMSOL Cluster Commands, troubleshooting MPI*
- COMSOL Multiphysics User's Guide, sections:
  - *Parallel COMSOL*
  - *Running COMSOL in Parallel*

COMSOL