UPPMAX Introduction

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Martin Dahlö
martin.dahlo@scilifelab.uu.se

Valentin Georgiev
valentin.georgiev@icm.uu.se

Enabler for Life Sciences

SciLifeLab

Uppsala Multidisciplinary Center
Advanced UPPMAX Computational Science

UPPNEX

UPPSALA UNIVERSITET

What is UPPMAX what it provides

Projects at UPPMAX

How to access UPPMAX

Jobs and queuing systems

How to use the resources of UPPMAX

How to use the resources of UPPMAX in a good way!
Efficiency!!!

Uppsala Multidisciplinary Center for Advanced Computational Science

http://www.uppmax.uu.se

3 clusters

Milou: 16 cores (128GB RAM) decommissioned
Rackham: ~ 600 computers à 20 cores (128GB RAM)
Bianca: 200 nodes à 16 cores (128GB RAM) - virtual cluster

\>12 PB fast parallel storage
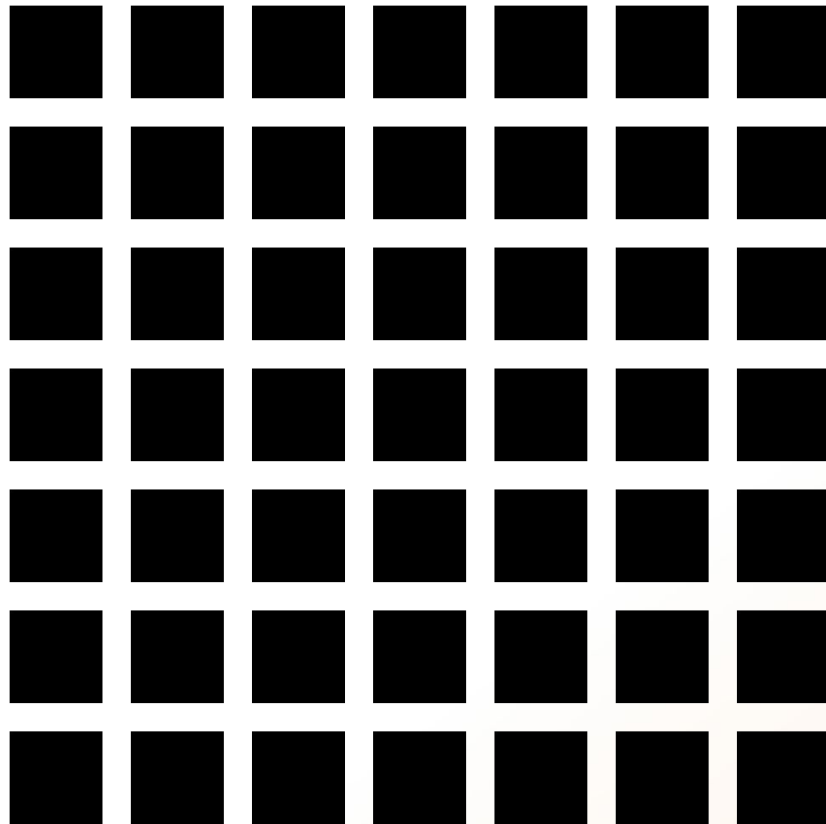
Bioinformatics software

The basic structure of supercomputer

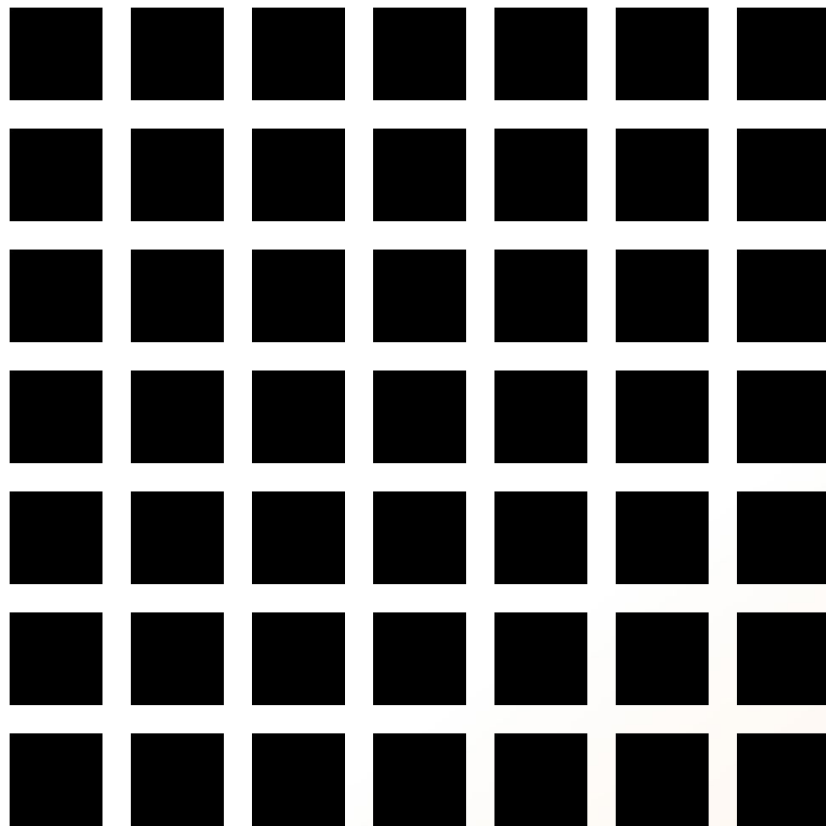node = computer

Login nodes

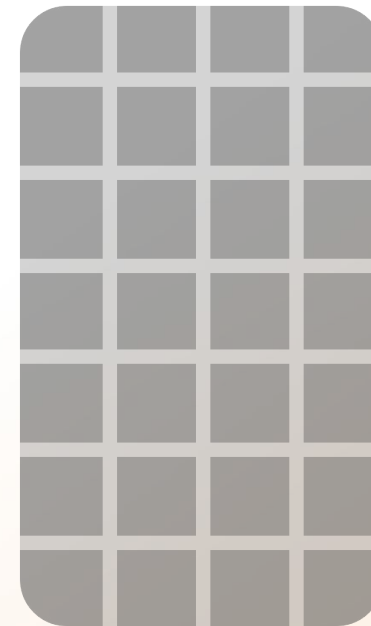# The basic structure of supercomputer

Calculation nodes

Login nodes

The basic structure of supercomputer

Calculation nodes

Storage

Login nodes
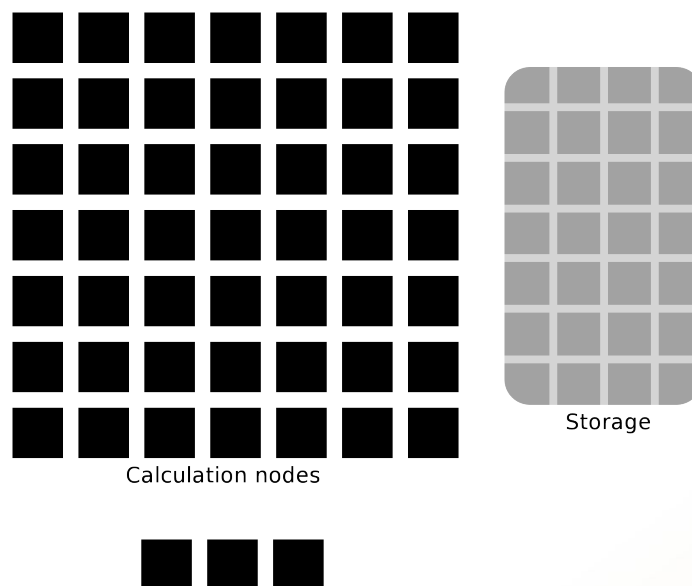
SciLifeLab UPPSALA

Calculation nodes

Storage

UPPMAX provides

Compute and **Storage**

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Efficiency!!!

UPPMAX provides its resources via

projects

your project

Storage

Calculation nodes

Resources:

compute
(core-hours/month)

storage
(GB)

before - UPPNEX projects:

cluster **Milou**
  2000 core-hours/month
  1 TB

This course's project ID: g2018009

now - two separate projects:

<u>SNIC project</u>:
cluster **Rackham**
2000 core-hours/month
128 GB

<u>Uppstore Storage project</u>:
storage system **CREX**
1 - 100 TB

What is UPPMAX what it provides

Projects at UPPMAX
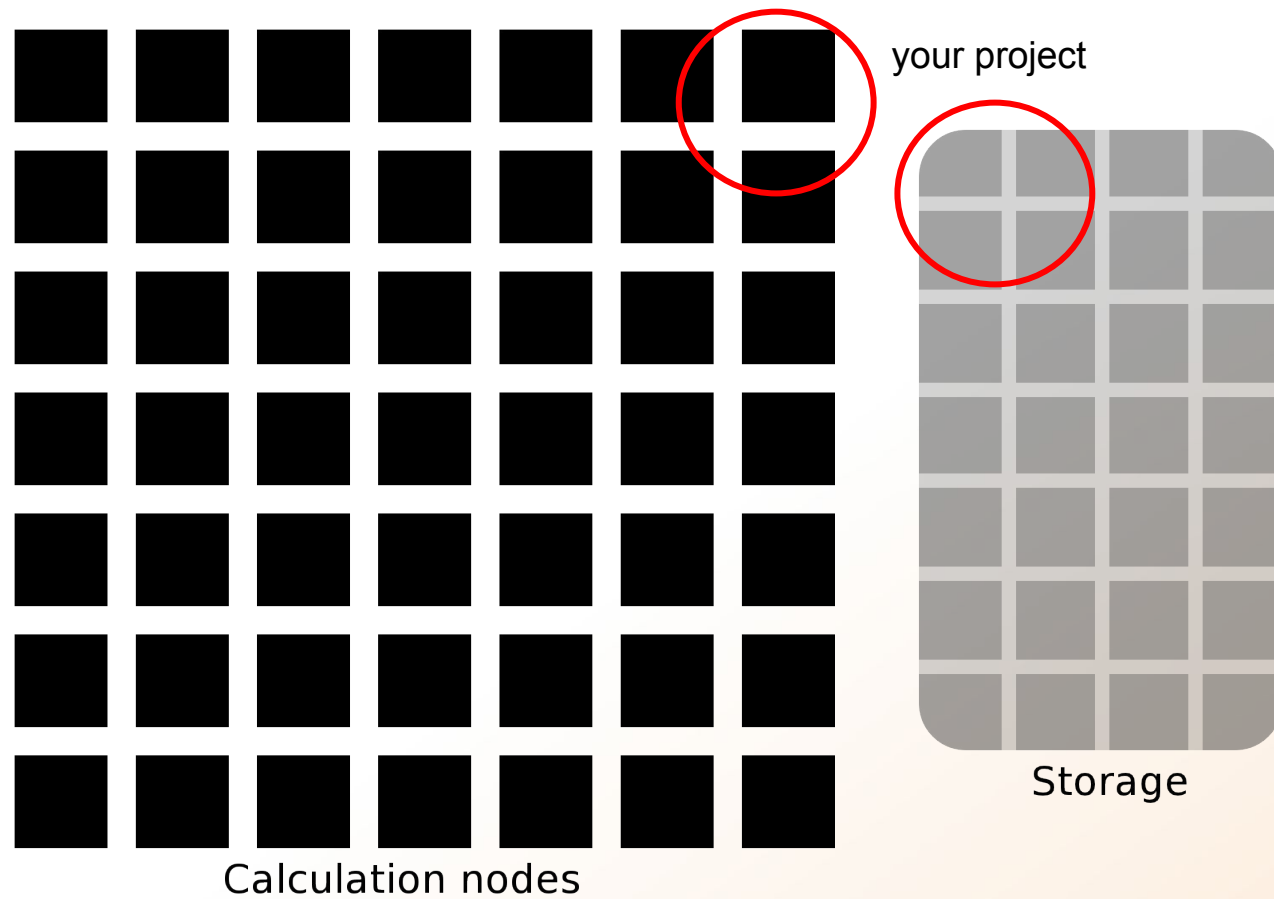
How to access UPPMAX

Jobs and queuing systems

How to use the resources of UPPMAX

How to use the resources of UPPMAX in a good way!
                                        Efficiency!!!

SSH to a cluster

ssh -Y *your_username@cluster_name*.uppmax.uu.se

How to access UPPMAX

SSH to Milou

```
[VG-MBP:~ valentingeorgiev$ ssh -Y valent@milou.uppmax.uu.se
Last login: Sun Oct 22 10:02:44 2017 from host-95-195-196-83.mobileonline.telia.com
  _    _ ____ ____ __  __ _   __  __
 | |  | |  _ \|  _ \|  \/  | /\ \ \/ /      | System:    milou2
 | |  | | |_) | |_) | |\/| |/ _ \ \  /       | User:      valent
 | |__| |  __/|  __/| |  | / ___ \ /  \      | Jobs:      0 running
  \___/|_|   |_|   |_| |_/_/   \_\/_/\_\     | Queue:     0 pending


####################################################################################

        User Guides: http://www.uppmax.uu.se/support/user-guides
        FAQ: http://www.uppmax.uu.se/support/faq

        Write to support@uppmax.uu.se, if you have questions or comments.


[valent@milou2 ~]$ ▌
```

How to access UPPMAX

SSH to Rackham

```
[VG-MBP:~ valentingeorgiev$ ssh -Y valent@rackham.uppmax.uu.se
Last login: Sun Oct 22 10:14:21 2017 from host-95-195-196-83.mobileonline.telia.com
  _   _ ____  ____  __  __    _    __  __
 | | | |  _ \|  _ \|  \/  |  / \   \ \/ /    | System:    rackham1
 | | | | |_) | |_) | |\/| | / _ \   \  /     | User:      valent
 | |_| |  __/|  __/| |  | |/ ___ \  /  \     | Jobs:      0 running
  \___/|_|   |_|   |_|  |_/_/   \_\/_/\_\    | Queue:     0 pending

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        FAQ: http://www.uppmax.uu.se/support/faq

        Write to support@uppmax.uu.se, if you have questions or comments.


[valent@rackham1 ~]$
```
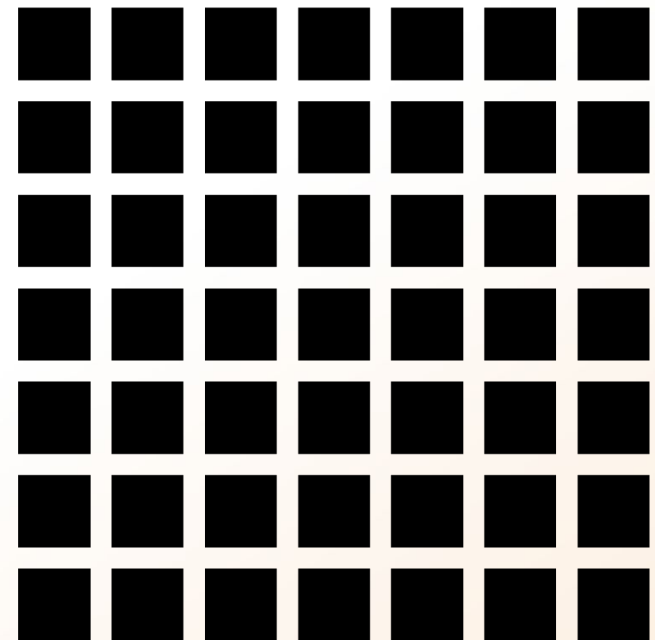
SSH

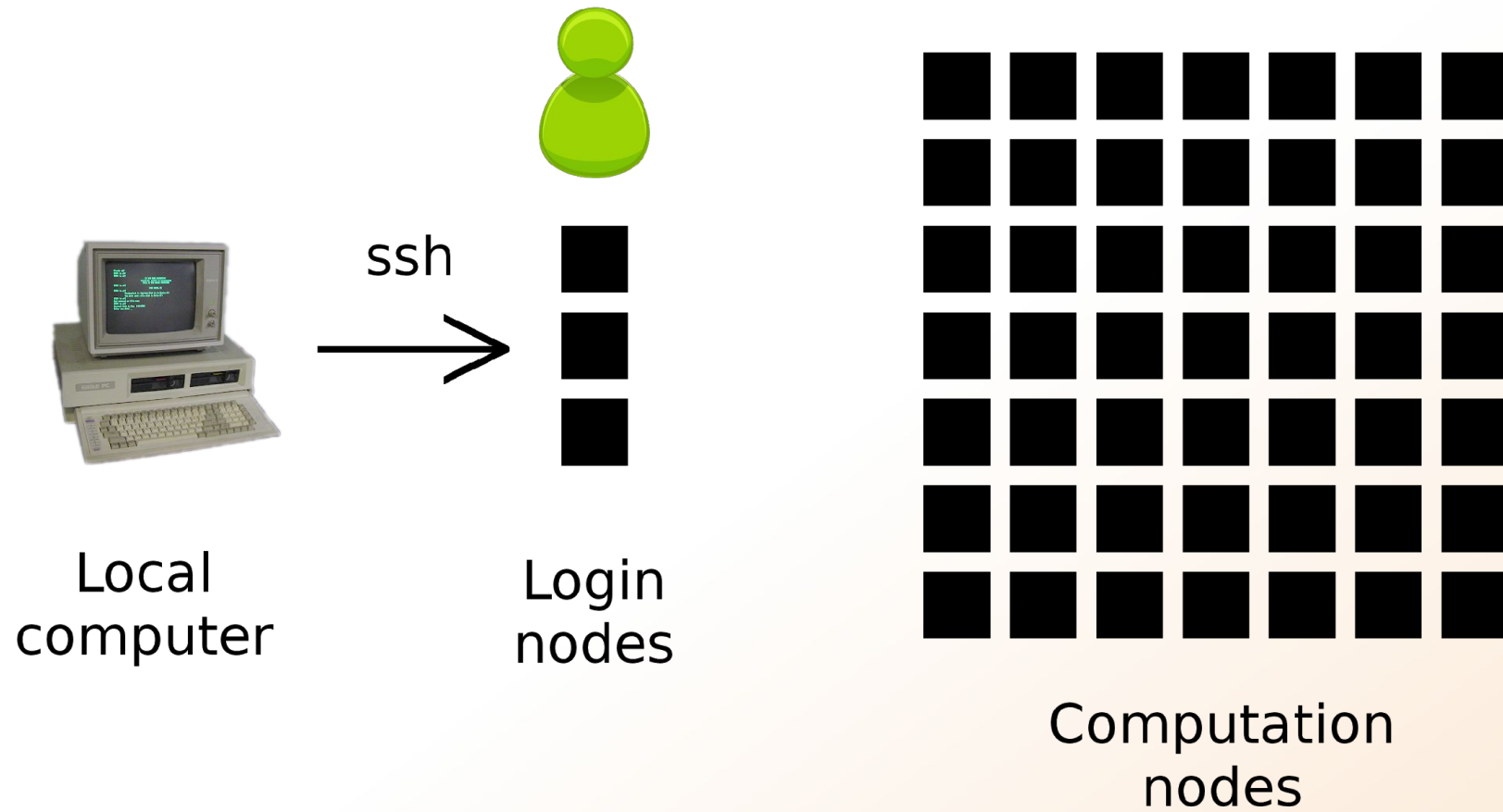Local computer

Login nodes

Computation nodes

SSH

Local computer

ssh

Login nodes

Computation nodes

Login nodes

use them to access UPPMAX
never use them to run **jobs**
don't even use them to do "quick stuff"

Calculation nodes

do your work here - testing and running

Calculation nodes

not accessible directly
SLURM (queueing system) gives you access

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How to use the resources of UPPMAX

How to use the resources of UPPMAX in a good way!
Efficiency!!!

Job (computing)

From Wikipedia, the free encyclopedia

For other uses, see Job (Unix) and Job stream.

In computing, a **job** is a unit of work or unit of execution (that performs said work). A component of a job (as a unit of work) is called a *task* or a *step* (if sequential, as in a job stream). As a unit of execution, a job may be concretely identified with a single process, which may in turn have subprocesses (child processes; the process corresponding to the job being the parent process) which perform the tasks or steps that comprise the work of the job; or with a process group; or with an abstract reference to a process or process group, as in Unix job control.

Read/open files

Do something with the data

Print/save output

Read/open files

Do something with the data

Print/save output

The basic structure of a supercomputer
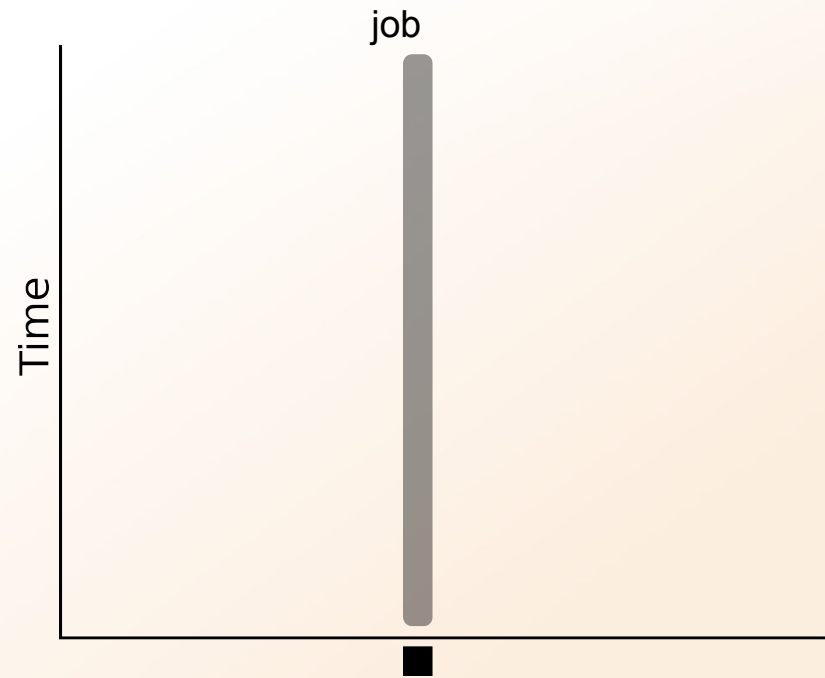
Parallel computing!!!
Not one super fast

job

Time

The basic structure of a supercomputer

Parallel computing!!!
Not one super fast

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More users than nodes
Need for a queue

nodes - hundreds
users - thousands
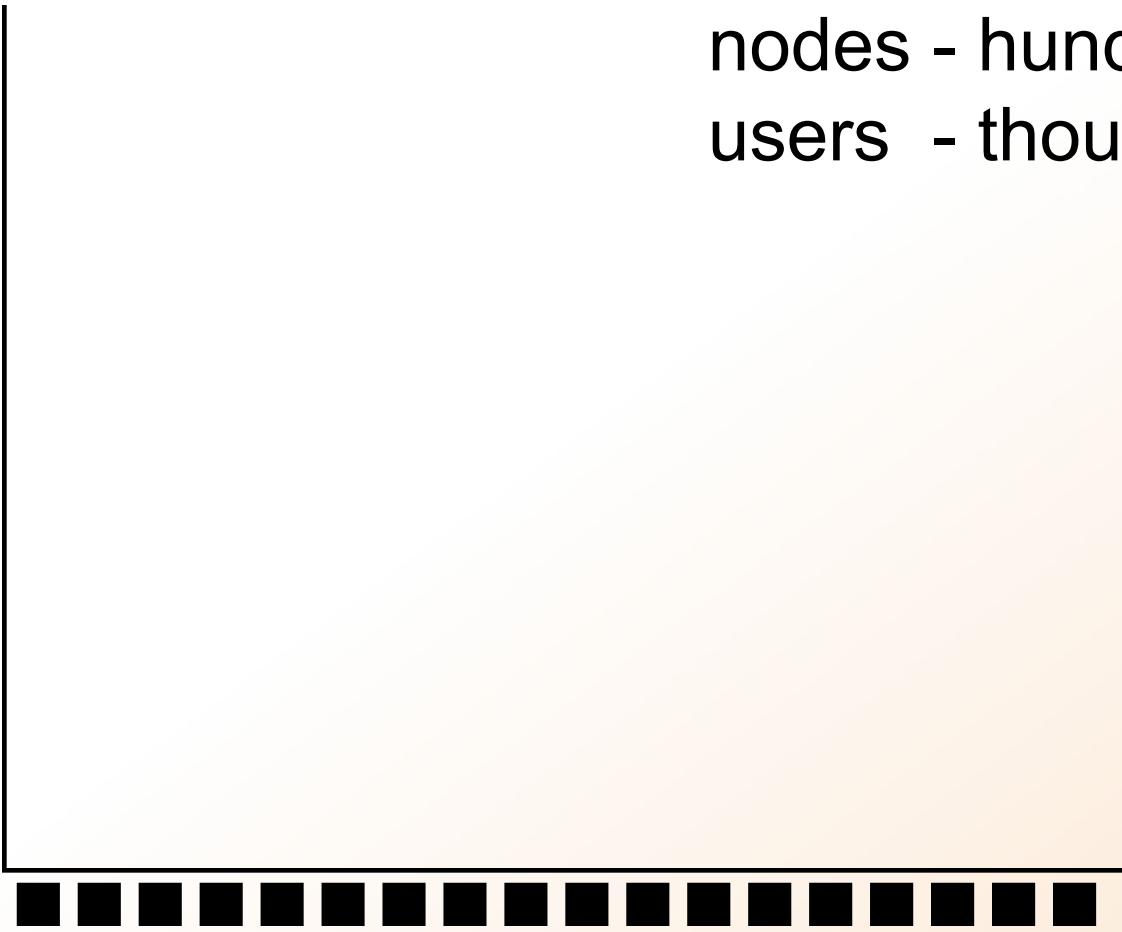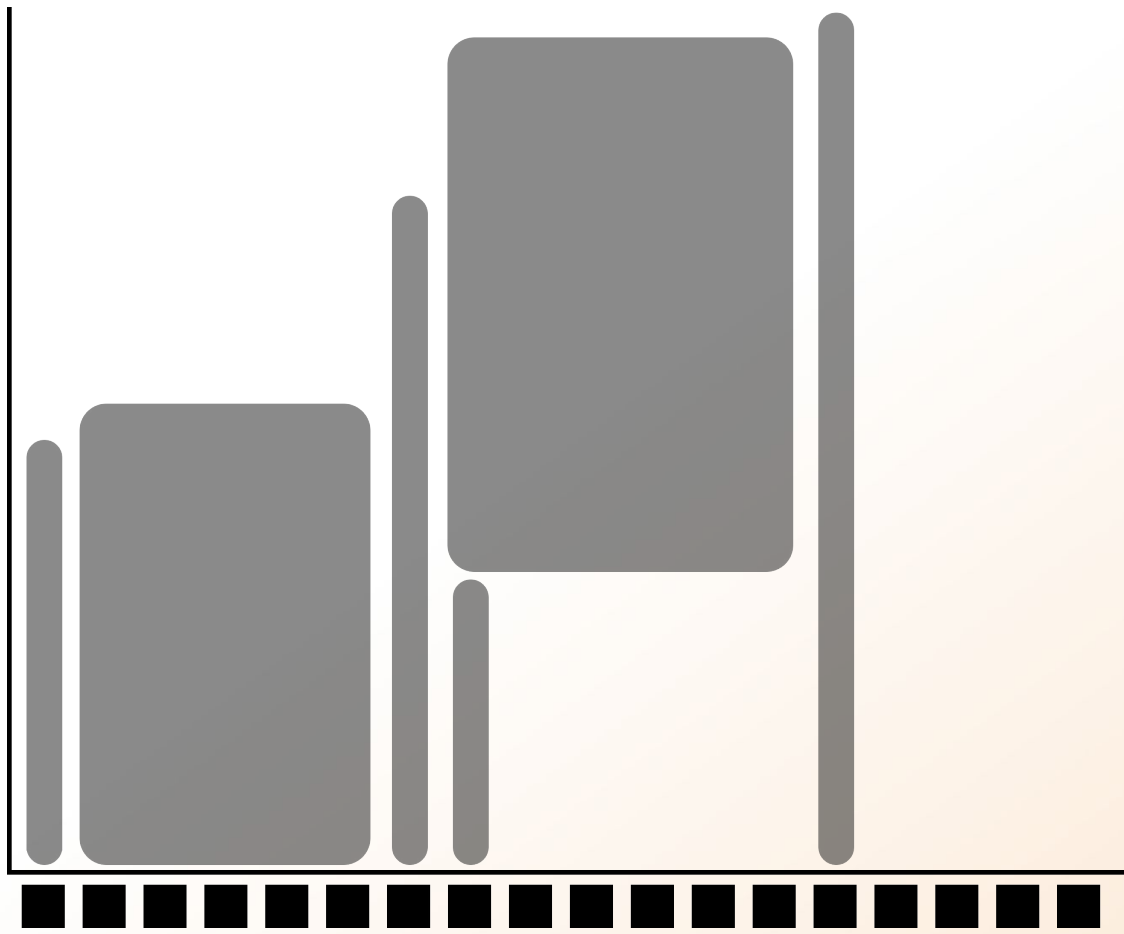
More users than nodes

Need for a queue

More users than nodes
Need for a queue

Added job
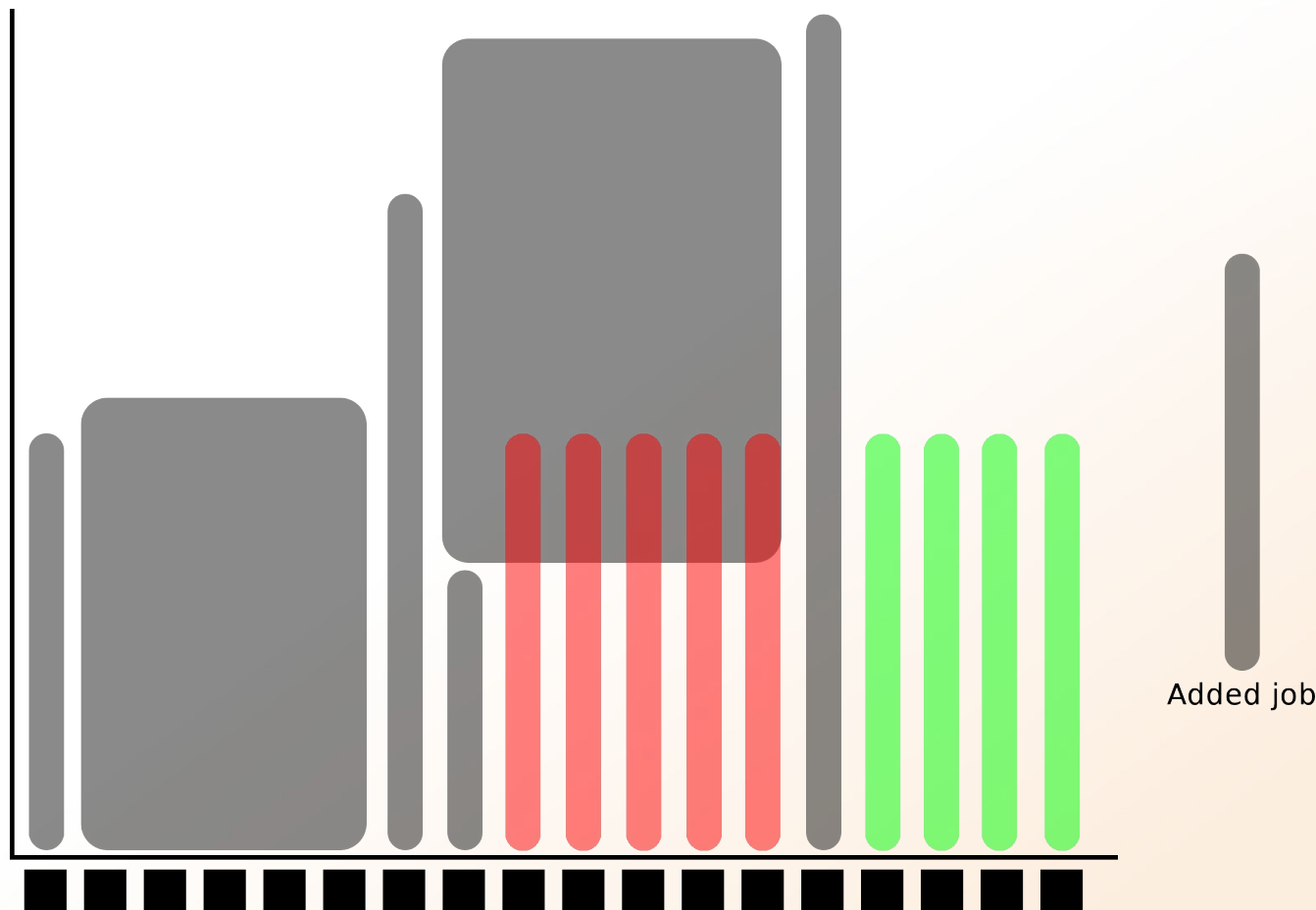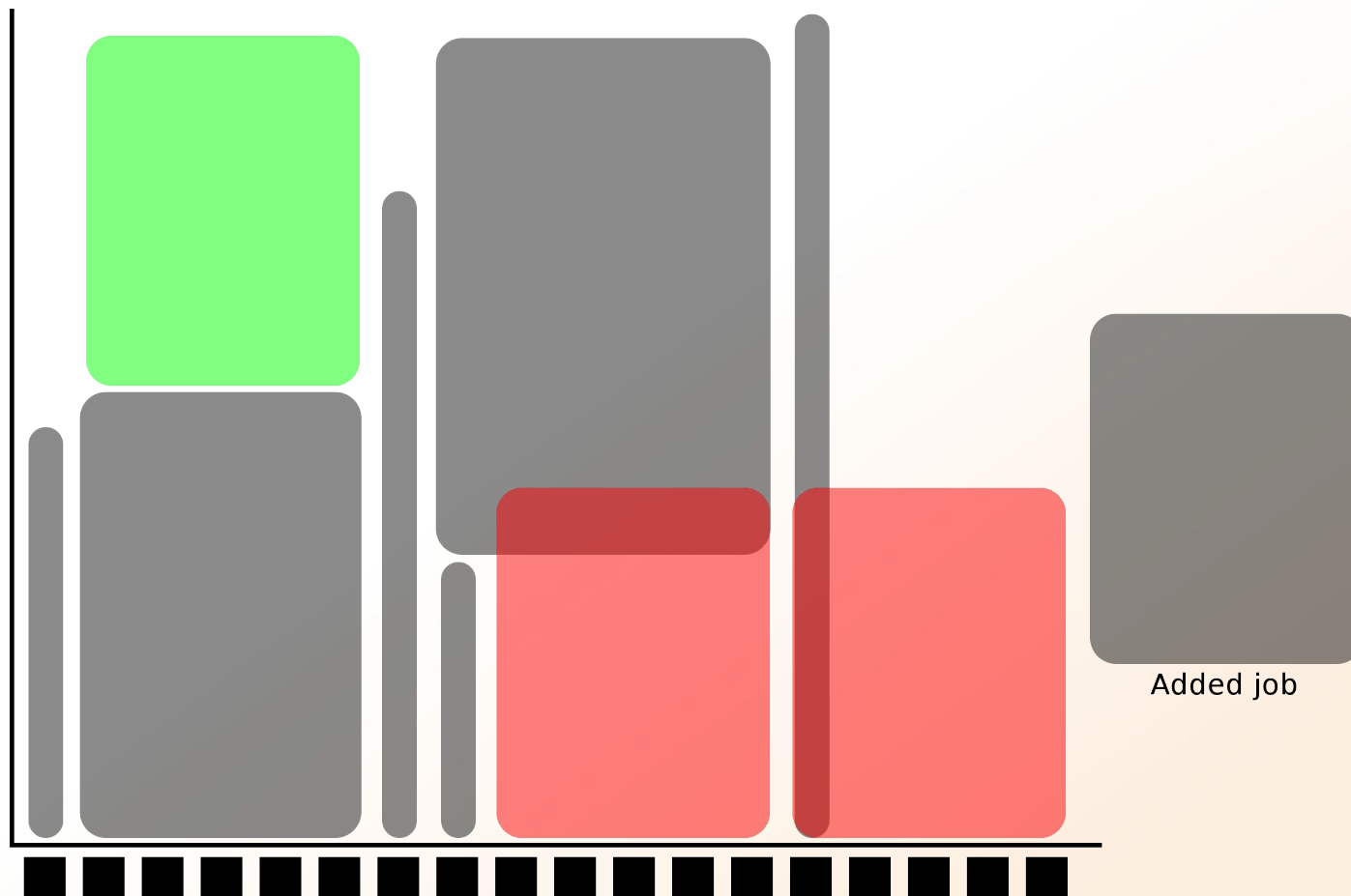
**workload manager
job queue
batch queue
job scheduler**

SLURM (Simple Linux Utility for Resource Management)
free and open source

What is UPPMAX what it provides

Projects at UPPMAX

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How to use the resources of UPPMAX

How to use the resources of UPPMAX in a good way!
Efficiency!!!

1) Ask for resource and run jobs manually
   mainly for testing and small jobs

2)Write a script and submit it to SLURM
   do the real job

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UPPSALA

1) Ask for resource and run jobs manually

salloc -A b2015245 -p core -n 1 -t 00:05:00

salloc - command
mandatory job parameters:
-A   - project ID (who "pays")
-p   - node or core (the type of resource)
-n   - number of nodes/cores
-t   - time

-A   this course project g2018009
        you have to be a member

-p   1 node = 16 cores
        1 hour walltime = 16 core-hours

-n   number of cores (default value = 1)
-N   number of nodes

-t   format - hh:mm:ss
        default value= 7-00:00:00
jobs killed when time limit reaches - always overestimate ~ 50%

Information about your jobs

squeue -u <user>

```
[valent@milou2 valent]$ squeue -u valent
          JOBID PARTITION     NAME      USER ST       TIME  NODES NODELIST(REASON)
       11334919      core       sh    valent  R       0:11      1 m164
```

```
[valent@milou2 valent]$ salloc -A b2015245 -p core -n 1 -t 00:05:00 &
[2] 10994
[valent@milou2 valent]$ salloc: Granted job allocation 11334919

[valent@milou2 valent]$ squeue -u valent
          JOBID PARTITION     NAME     USER ST       TIME  NODES NODELIST(REASON)
       11334919      core       sh   valent  R       0:11      1 m164
[valent@milou2 valent]$ ssh -Y m164

  _   _ ____ ____ __  __  _    __ __
 | | | |  _ \|  _ \|  \/  | / \   \ \/ /      | System:   m164
 | | | | |_) | |_) | |\/| |/ _ \   \  /       | User:     valent
 | |_| |  __/|  __/| |  | / ___ \  /  \       | Jobs:     1 running
  \___/|_|   |_|   |_| |_/_/   \_\/_/\_\      | Queue:    0 pending

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        FAQ: http://www.uppmax.uu.se/support/faq

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[valent@m164 ~]$ ▮
```
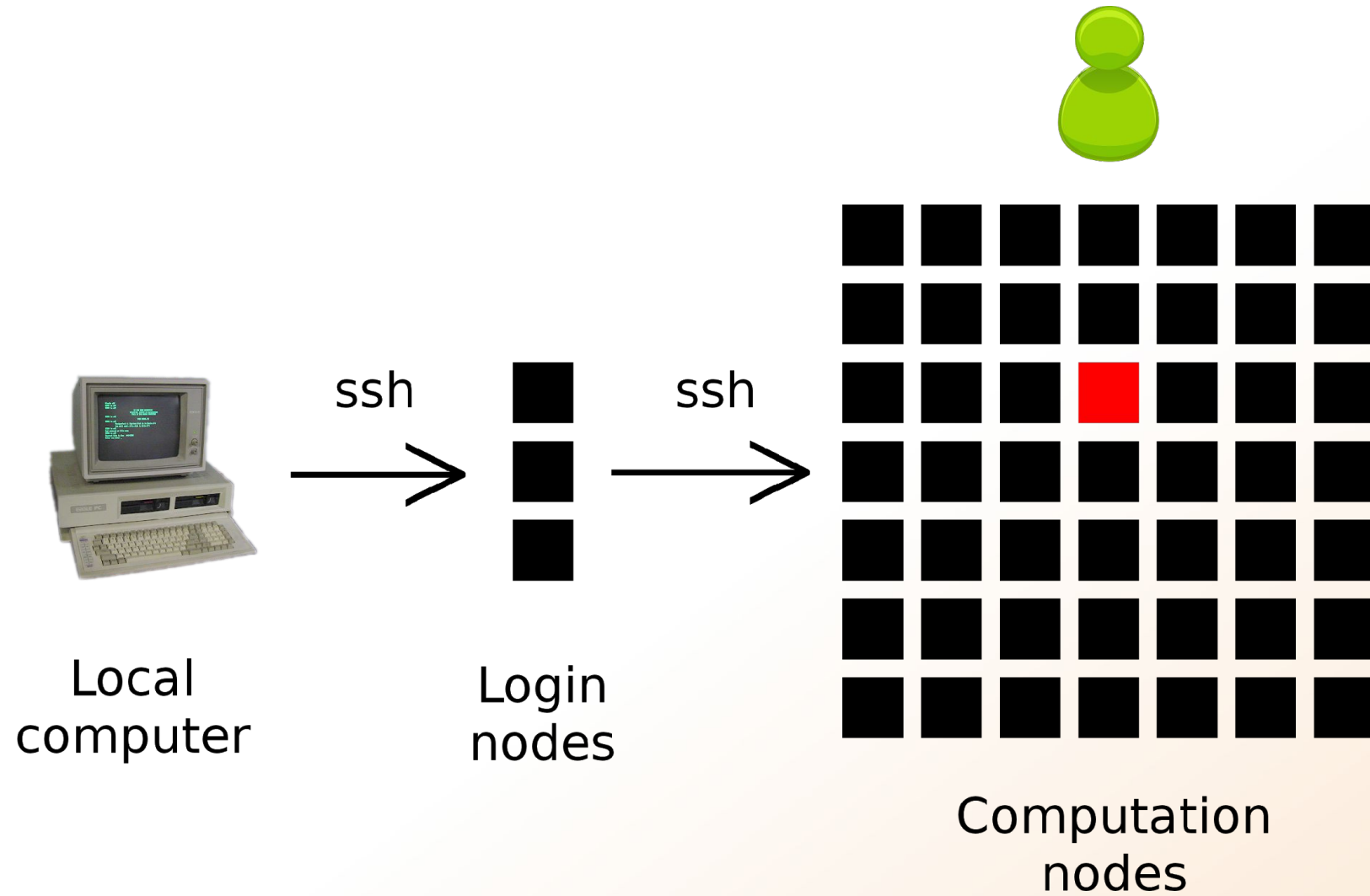
SSH to a calculation node (from a login node)

ssh -Y *<node_name>*

SLURM

ssh

ssh

Local
computer

Login
nodes

Computation
nodes

1a) Ask for node/core and run jobs manually

Interactive - books a node and connects you to it

interactive -A b2015245 -p core -n 1 -t 00:05:00

```
 _____ _____ _____ __ __ _____ __ __
|   |   |   _   |   _   |   |   |   _   |   _   |   |   |   _   \   _   |   |   \ \ / /   |  System:    m1
|   |   |   |_) |   |_) |   |   |   | | / _ \ \ /          |  User:      valent
|   |_| |  __/|  __/|   |   |   |/ ___ \ /   \        |  Jobs:      1 running
 \___/|_|   |_|    |_|   |_/_/    \_\/_/\_\       |  Queue:     0 pending

################################################################################

        User Guides: http://www.uppmax.uu.se/support/user-guides
        FAQ: http://www.uppmax.uu.se/support/faq

        Write to support@uppmax.uu.se, if you have questions or comments.


[valent@m1 valent]$ ▮
```

2)Write a script and submit it to SLURM

put all commands in a text file - script

↓

tell SLURM to run the script
(use the same job parameters)

2)Write a script and submit it to SLURM

put all commands in a text file - script

```
#! /bin/bash -l
#SBATCH -A g2012157
#SBATCH -p core
#SBATCH -J Template_script
#SBATCH -t 08:00:00
```
job parameters

```
# go to some directory
cd ~/glob

# do something
echo Hello world!
```
tasks to be done

2)Write a script and submit it to SLURM

put all commands in a text file - script

```
#! /bin/bash -l
#SBATCH -A g2012157
#SBATCH -p node
#SBATCH -J Template_script
#SBATCH -t 08:00:00
```

```
# go to the correct directory
cd /home/dahlo/glob/work/uppmaxScripts/misc

# run tophat on the data, using 8 cores
tophat -p 8 /bubo/proj/g2012157/indexes/bowtie/hg19 tophat/input/ad12.fq
```

2)Write a script and submit it to SLURM

tell SLURM to run the script
(use the same job parameters)

sbatch test.sbatch

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2)Write a script and submit it to SLURM

tell SLURM to run the script
(use the same job parameters)

sbatch test.sbatch

sbatch - command
test.sbatch - name of the script file

SLURM Output

Prints to a file instead of terminal
slurm-<job id>.out

```
[[valent@milou2 temp]$ ll
total 32
-rw-rw-r-- 1 valent valent 209 Oct 22 13:34 test.sbatch
[[valent@milou2 temp]$ sbatch test.sbatch
Submitted batch job 11334939
[[valent@milou2 temp]$ ll
total 64
-rw-rw-r-- 1 valent valent  31 Oct 22 13:35 slurm-11334939.out
-rw-rw-r-- 1 valent valent 209 Oct 22 13:34 test.sbatch
[[valent@milou2 temp]$ cat slurm-11334939.out
this goes to slurm-<jobID>.out
[[valent@milou2 temp]$ cat test.sbatch
#!/bin/bash -l

#SBATCH -A b2015245
#SBATCH -p core
#SBATCH -n 1
#SBATCH -t 00:05:00


# go to dir work
cd ~/work
# do something useless
echo "this goes to slurm-<jobID>.out"
echo "Hello, world!" > hello.txt
[valent@milou2 temp]$ ▉
```

Squeue

Shows information about your jobs

squeue -u <user>

```
[[valent@milou2 temp]$ sbatch test.sbatch
Submitted batch job 11334948
[[valent@milou2 temp]$ squeue -u valent
         JOBID PARTITION     NAME     USER ST       TIME  NODES NODELIST(REASON)
      11334948      core test.sba   valent CG       0:01      1 m200
```

jobinfo -u <user>

SLURM user guide
go to http://www.uppmax.uu.se/
click User Guides (left-hand side menu)
click Slurm user guide

or just google "uppmax slurm user guide"

link:
http://www.uppmax.uu.se/support/user-guides/slurm-user-guide/

100+ programs installed

Managed by a 'module system'

Installed, but hidden

Manually loaded before use

module avail - Lists all available modules

module load <module name> - Loads the module

module unload <module name> - Unloads the module

module list - Lists loaded modules

module spider <word> - Searches all modules after 'word'

UPPMAX Software

Most bioinfo programs hidden under bioinfo-tools
Load bioinfo-tools first, then program module

```
[dahlo@kalkyl3 work]$ module load cufflinks/1.2.1
ModuleCmd_Load.c(200):ERROR:105: Unable to locate a modulefile for 'cufflinks/1.2.1'
[dahlo@kalkyl3 work]$ module load bioinfo-tools
[dahlo@kalkyl3 work]$ module load cufflinks/1.2.1
[dahlo@kalkyl3 work]$
```

or

```
[dahlo@kalkyl3 work]$ module load samtools
ModuleCmd_Load.c(200):ERROR:105: Unable to locate a modulefile for 'samtools'
[dahlo@kalkyl3 work]$ module load bioinfo-tools samtools
[dahlo@kalkyl3 work]$
```

```
[dahlo@kalkyl4 work]$ module load bioinfo-tools
[dahlo@kalkyl4 work]$ module avail

------------------------------- /bubo/sw/mf/kalkyl/bioinfo-tools/alignment -------------------------------
MUMmer/3.22(default)            blast/2.2.24(default)          maq/0.7.1(default)
anfo/0.97                       blast/2.2.24+                  mosaik-aligner/1.0.1388(default)
anfo/0.98(default)              blast/2.2.25                   mosaik-aligner/1.1.0021
blast/2.2.15                    blat/34                        mpiblast/1.6.0(default)
blast/2.2.18                    bwa/0.5.8a                     splitseek/1.3.2
blast/2.2.23                    bwa/0.5.9                      splitseek/1.3.4(default)
blast/2.2.23+                   hmmer/3.0

------------------------------- /bubo/sw/mf/kalkyl/bioinfo-tools/assembly -------------------------------
Ray/0.0.4             abyss/1.2.4            abyss/1.3.0            velvet/1.0.03(default)
Ray/0.0.7(default)    abyss/1.2.5(default)  abyss/1.3.2            velvet/1.1.04
Ray/1.6.1             abyss/1.2.7           mira/3.0.0            velvet/1.1.04_K101
abyss/1.2.3           abyss/1.2.7-maxk96    mira/3.2.0(default)   velvet/1.1.07

------------------------------- /bubo/sw/mf/kalkyl/bioinfo-tools/misc -------------------------------
BclConverter/1.7.1             freebayes/0.8.9               samtools/0.1.12-10(default)
BioPerl/1.6.1                  freebayes/0.9.4               samtools/0.1.16
BioPerl/1.6.1_PERL5.10.1(default) gcta/0.92.0                samtools/0.1.18
BioPerl/1.6.1_PERL5.12.3       gcta/0.92.6                   samtools/0.1.7a
FastQC/0.6.1                   genometools/1.3.5(default)    samtools/0.1.8
FastQC/0.7.2(default)          htseq/0.4.6                   samtools/0.1.9
Fastx/0.0.13(default)          htseq/0.5.1                   snpEff/2.0.3
IGV/1.5.51                     matrix2png/1.2.1              trinity/2011-05-13
biopython/1.56                 picard/1.40                   trinity/2011-10-29
cellprofiler/20111024          picard/1.41
emmax/beta-07Mar2010           plink/1.07

------------------------------- /bubo/sw/mf/kalkyl/bioinfo-tools/phylogeny -------------------------------
concaterpillar/1.4    garli/2.0            raxml/7.0.4(default)  raxml/7.2.8
garli/0.96b8(default) mrbayes/3.1.2-mpi    raxml/7.2.7

------------------------------- /bubo/sw/mf/kalkyl/bioinfo-tools/pipelines -------------------------------
ab_wtp/1.1(default)    cufflinks/0.9.2       cufflinks/1.1.0        tophat/1.2.0
bowtie/0.12.6(default) cufflinks/0.9.3       cufflinks/1.2.1        tophat/1.3.3
```

UPPMAX Commands

uquota

```
[dahlo@biologin work]$ uquota
Your File Area              Usage (GB)   Quota Limit (GB)   Over Quota   Grace Time
--------------              ----------   ----------------   ----------   ----------
dahlo glob                        196               2048                          -
dahlo home                          4                 32                          -
/proj/b2010015                    229                256                          -
/proj/b2010015/nobackup             0                512                          -
/proj/b2010033                    132               6348                          -
/proj/b2010033/nobackup            27                512                          -
```

UPPMAX Commands

projinfo

```
[dahlo@kalkyl4 work]$ projinfo
(Counting the number of core hours used since 2012-08-19/00:00:00 until now.)

Project          Used[h]   Current allocation [h/month]
   User
--------------------------------------------------------
b2010015         1257.20                   2000
   ameur         1257.20


--------------------------------------------------------
b2010069            0.00                   2000


--------------------------------------------------------
b2010074          110.98                   2000
   dahlo            1.01
   seba           109.97


--------------------------------------------------------
b2012044            0.00                   2000


--------------------------------------------------------
g2012005            0.00                   2000


--------------------------------------------------------
g2012083            0.00                   2000


--------------------------------------------------------
g2012157            0.12                   2000
   dahlo            0.12

[dahlo@kalkyl4 work]$
```
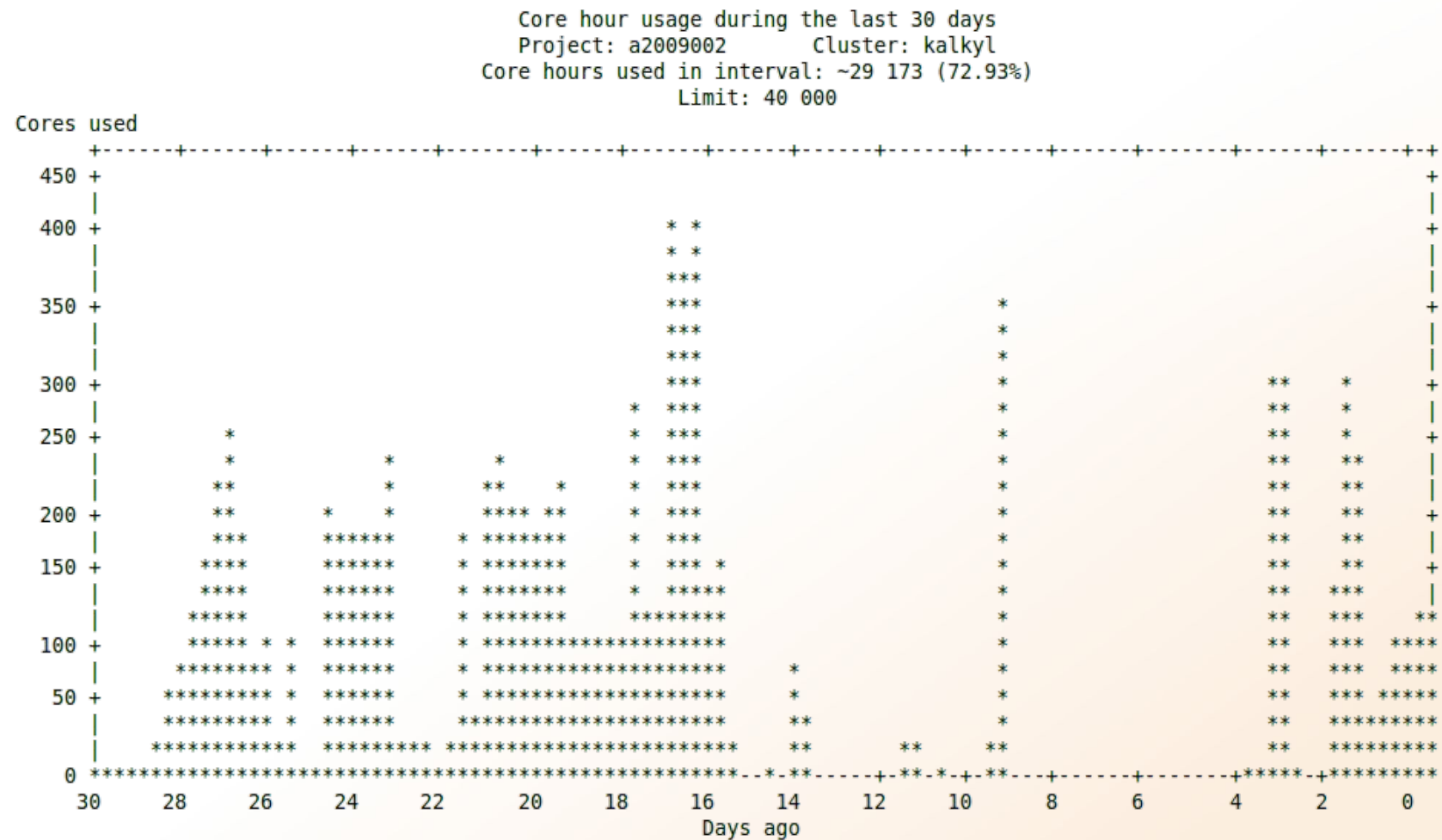
UPPMAX Commands

projplot -A <proj-id>   (-h for more options)

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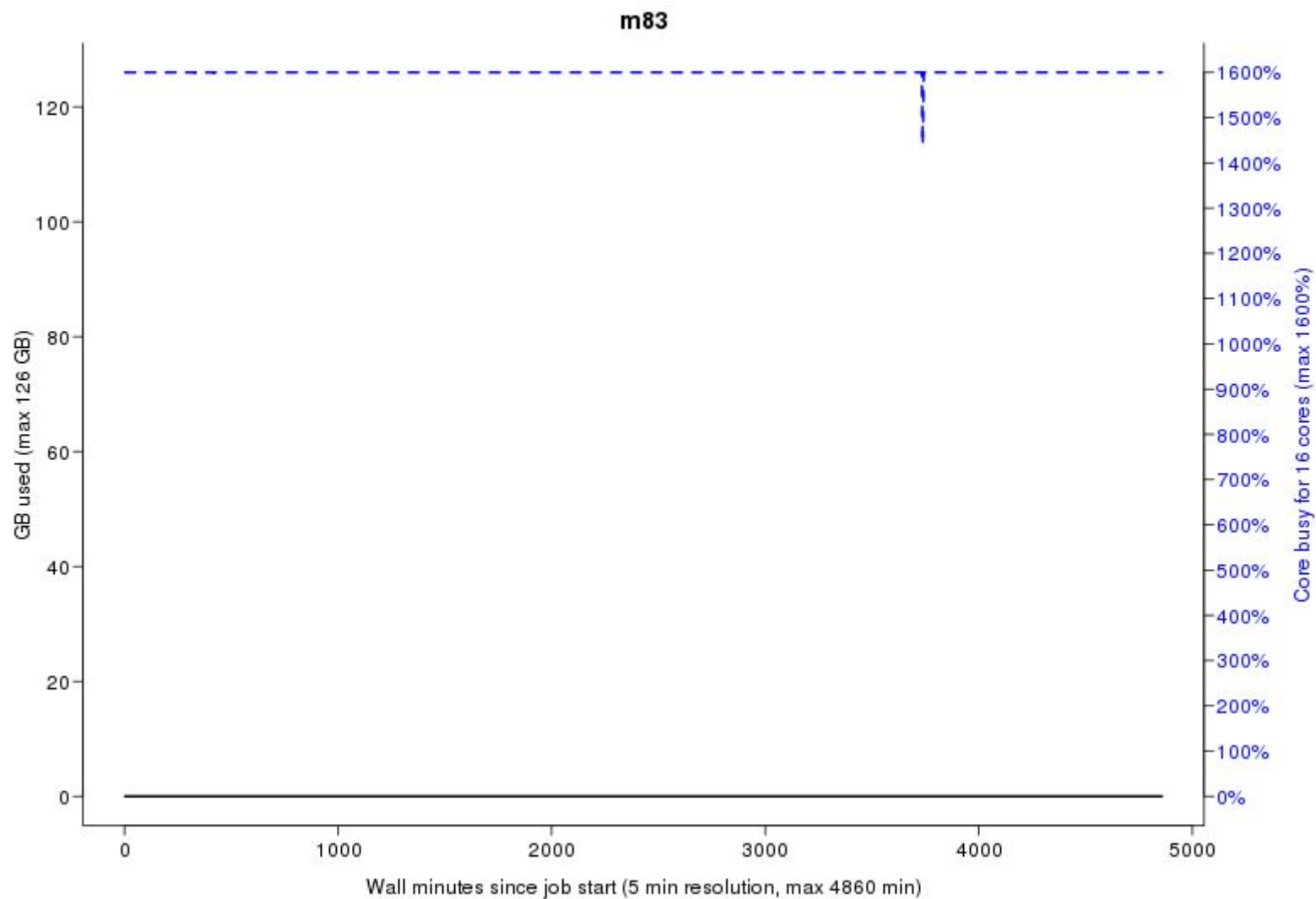How to use the resources of UPPMAX in a good way!
Efficiency!!!
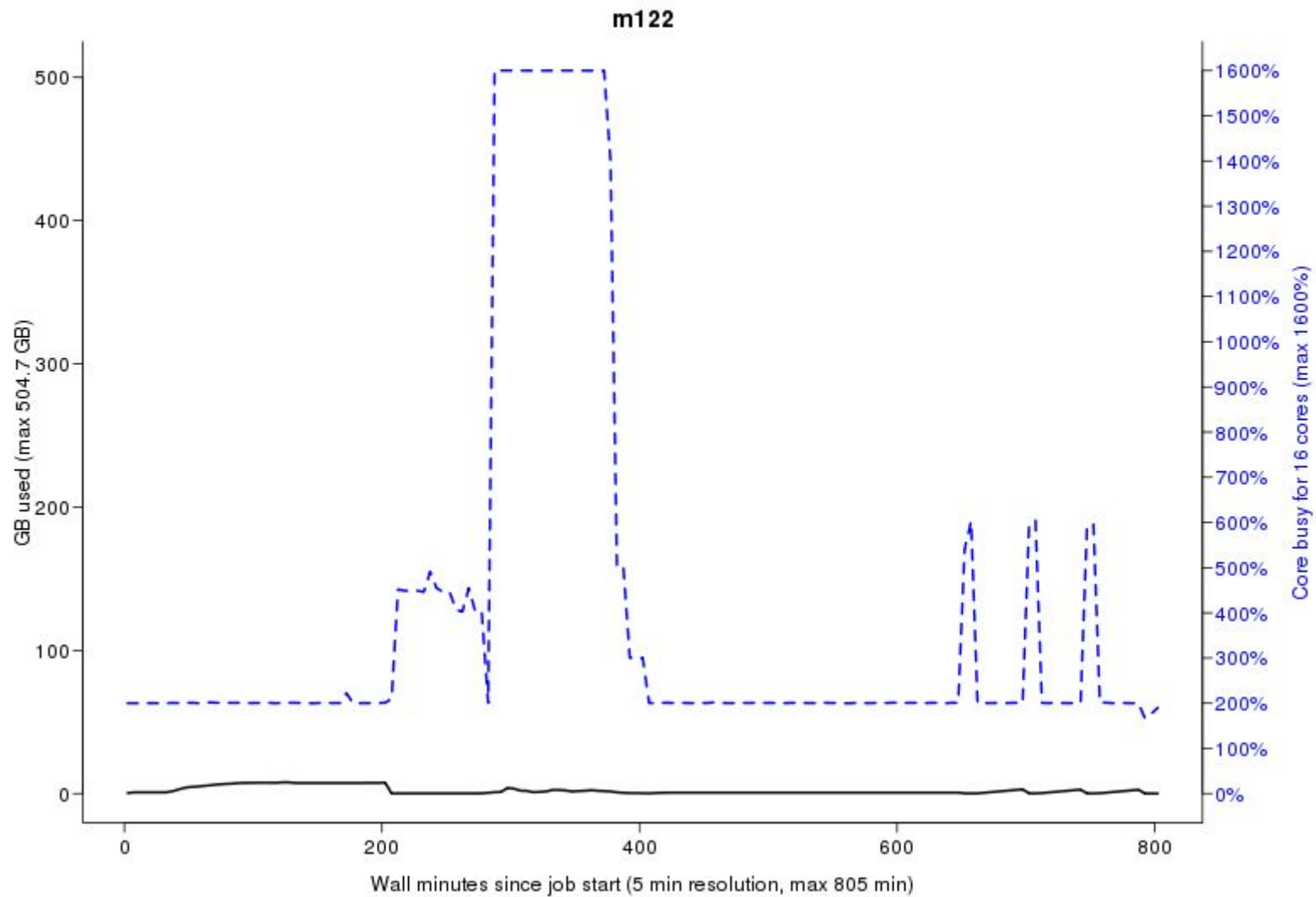
UPPMAX Commands

Plot efficiency
  jobstats -p -A <projid>

2719328 on 'milou' end: 2014-09-09T08:26:34 runtime: 03-08:59:53

m83

Wall minutes since job start (5 min resolution, max 4860 min)

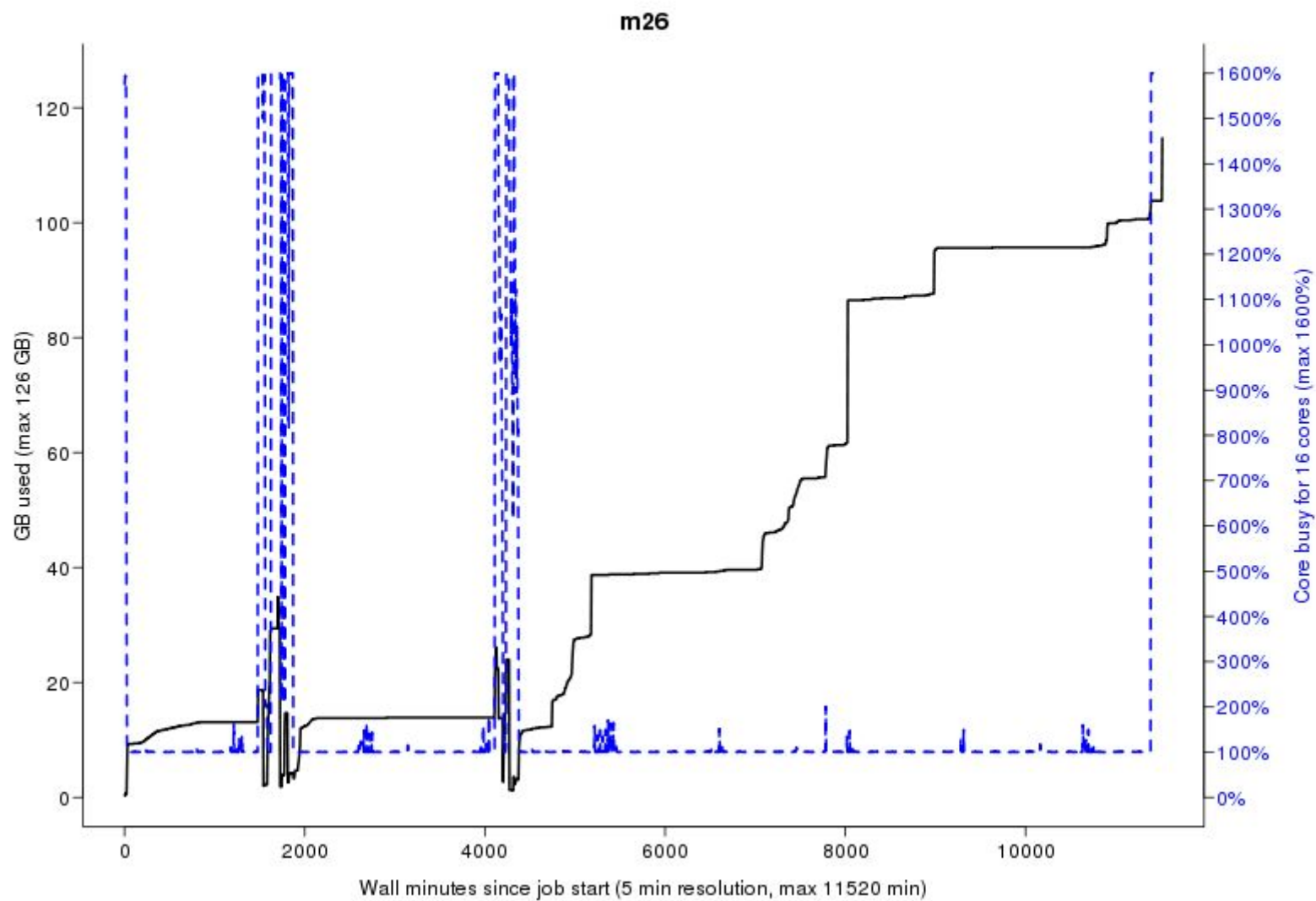## 2934193 on 'milou' end: 2014-09-26T01:40:23 runtime: 13:30:23

Flags: mem_underused:504.7:7.9   node_type_misbooked:mem512GB:mem128GB

m122

Wall minutes since job start (5 min resolution, max 805 min)

Take-home messages

- The difference between **user account** and **project**
- **Login nodes** are not for running jobs
- SLURM gives you access to the **compute nodes** when you specify a project that you are member of
- Use **interactive** for quick jobs and for testing
- Don not ask for more cores/nodes than your job can actually use
- A job script usually consists of:
  - Job settings (-A, -p, -n, -t)
  - Modules to be loaded
  - Bash code to perform actions
  - Run a program, or multiple programs

Summary

All jobs are run on nodes through queue system

A job script usually consists of

Job settings (-A, -p, -n, -t)

Modules to be loaded

Bash code to perform actions

Run a program, or multiple programs

More info on UPPMAX homepage

http://www.uppmax.uu.se/milou-user-guide

Laboratory time! (again)