

NorduGrid ARC Tutorial

Arto Teräs <arto.teras@csc.fi> and Olli Tourunen <olli.tourunen@csc.fi>

Innopoli, Espoo, Finland

May 31st 2006

Contents

- **Part 1: Introduction to Grids and NorduGrid**
 - Grid basics
 - NorduGrid collaboration and ARC middleware
 - Authentication and authorization in Grids
 - Grid environment compared to local computing resources
 - Job workflow and ARC user interface
- **Part 2: Hands-on exercises**
 - Submitting jobs in NorduGrid, writing job description files
 - Simple file transfers
 - Monitoring jobs using the Grid Monitor graphical interface

What is Grid?

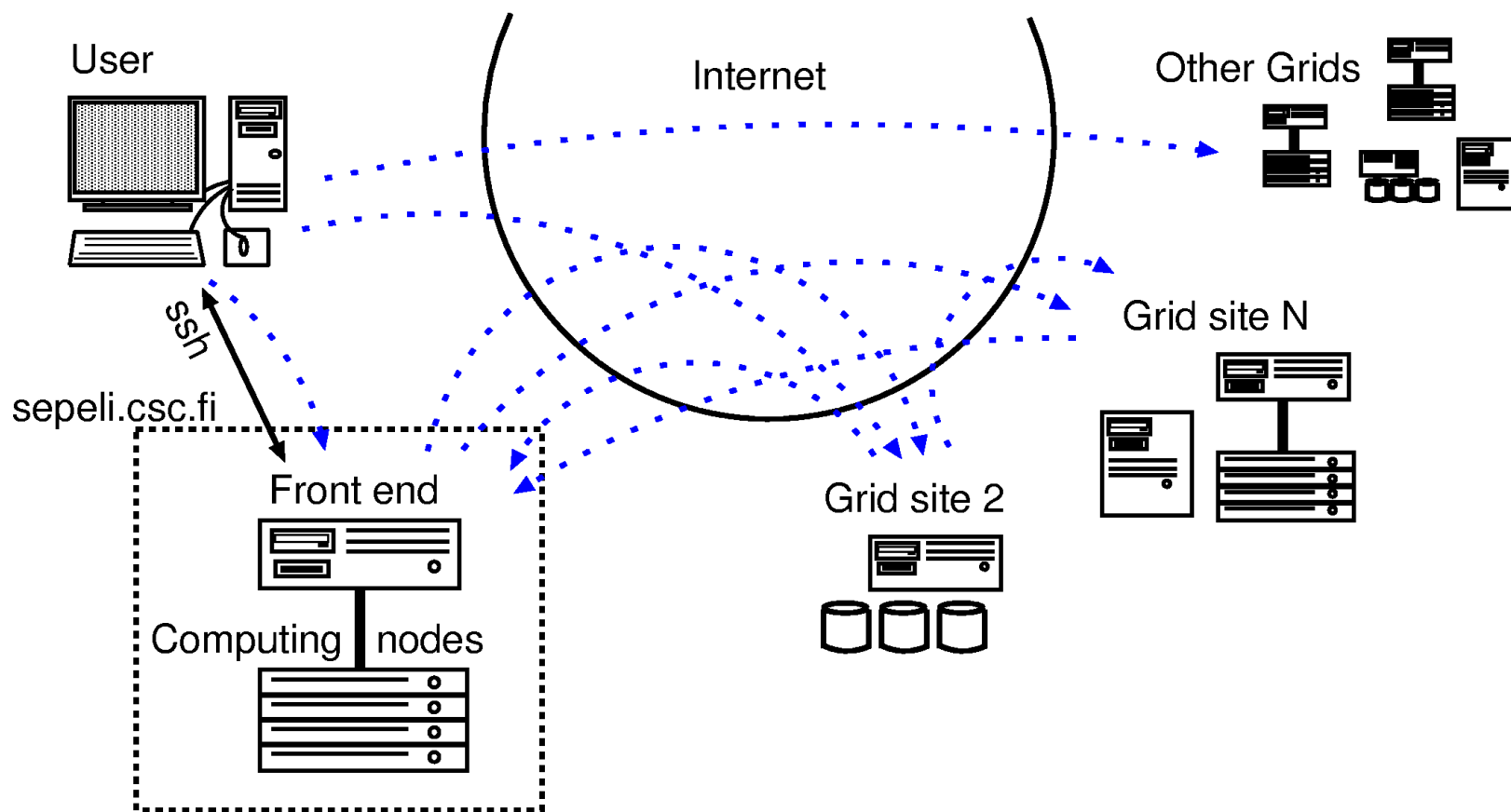
- Uniform and secure access to geographically distributed heterogeneous systems
- Both the set of users and connected resources vary dynamically
- Grids go across **multiple administrative domains!**

Common Misconceptions

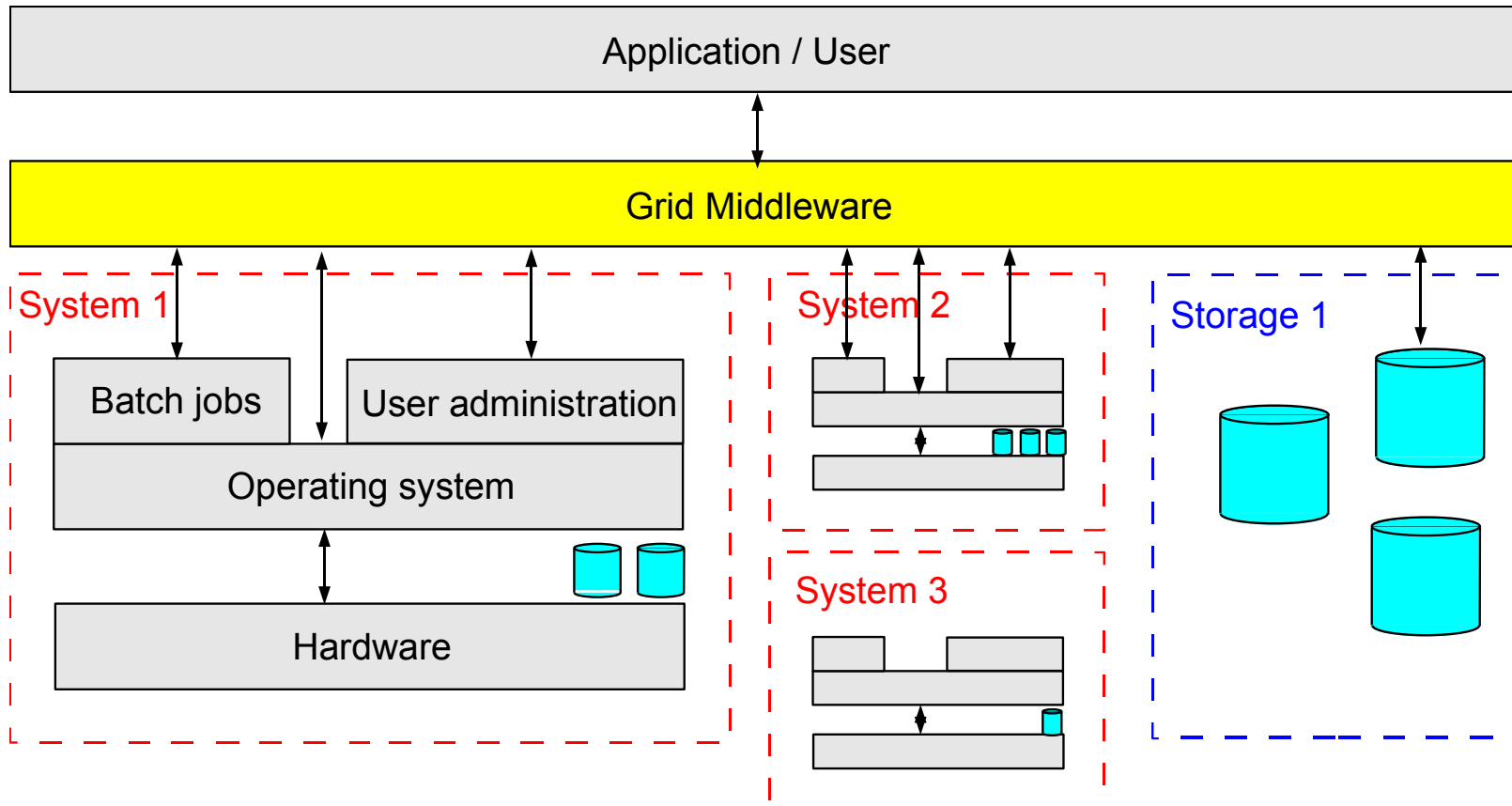
- **Grid increases resources**
 - Popular comparison with the World Wide Web is misleading:
 - One web server may serve a thousand users, but one grid user wants to use a thousand servers...
 - Effective use of resources can bring some savings, but new services and easy access much more important
- **Grid magically binds software together**
 - Vision: Computing power as electricity from the plug
Reality: still quite far from it
 - If data formats or APIs are incompatible Grid doesn't help
 - Possibility to monitor job execution is important — trying to make a black box easily results in a black hole



Grid Overview



Role of Grid Middleware



Does One Need to Change Existing Applications?

- **Three different approaches:**

- 1) Using the application as is: grid middleware will move the executable and the data to the target system
 - Library dependencies often need to be resolved by linking statically or packing them to go with the application
- 2) Installing the application on the target system and using it via the Grid interface
 - Batch processing type applications normally work without changes, interactive applications are more difficult
- 3) Modifying the application to fully exploit a distributed environment
 - Distributing over a large geographical area is not practical unless the computation can be split to independent subtasks

NorduGrid Collaboration

- **Past:** Grid pilot project by Nordunet in 2001
 - Implemented a production Grid system working non stop since May 2002
- **Present:** A community around open source Grid middleware: NorduGrid ARC
 - National Grids (e.g. M-grid, SweGrid), users also outside the Nordic countries
 - Real users, real applications
- **Open for anyone to participate**



The Material Sciences Grid (M-grid)

- **Goal: Throughput computing capacity mainly for the needs of physics and chemistry researchers**
 - Opened to all CSC customers in Nov 2005, not limited by the field of research
- **Joint project between seven Finnish universities, Helsinki Institute of Physics and CSC**
 - Partners mainly laboratories and departments, not university IT centers
- **First large initiative to put Grid middleware into production use in Finland**
 - Uses NorduGrid ARC middleware
- **Platform: Linux based PC clusters**



NorduGrid ARC

- **ARC (Advanced Resource Connector) is the middleware used and developed by the NorduGrid collaboration**
- **Based on Globus Toolkit™ 2 libraries, can also use Globus 4.0**
 - Adds services not provided by Globus such as scheduling
 - Extends or completely replaces some Globus components
- **Initial development principles: simple, stable, non-invasive**
 - Resources don't need to be dedicated to the Grid
- **GPL licence**
- **<http://www.nordugrid.org>**

Grid Security

- **Objective: Convenient but secure access to different kinds of resources**
 - Grid account is a pass to computers beyond organizational domains!
 - Great power => great damage
- **Security aspects have been considered in the technology**
 - Strong authentication and encryption: no plain-text passwords
 - Identity tied to a certificate: revocation blocks access in the whole Grid
- **Implementation details may vary from site to site**
 - Be careful if your data is sensitive!



Authentication: local vs Grid

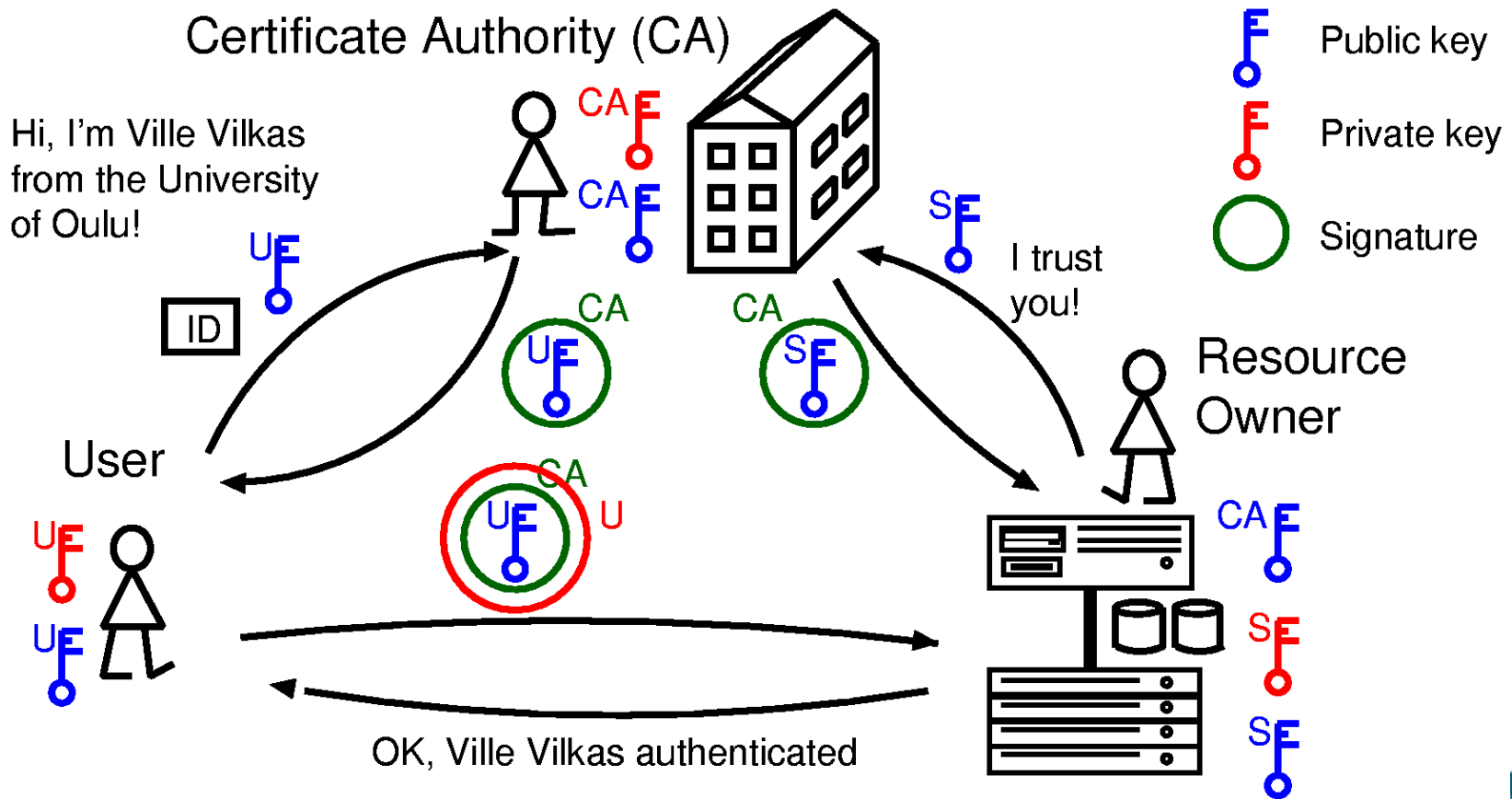
- **Local resources**

- User name and password
- “Login” authenticates and usually also authorises to use local resources

- **Grid environment**

- Authentication based on X.509 certificates granted by a third trusted party, Certificate Authority (CA)
- Each user has his/her own personal certificate
- Authentication is separate from authorization => having a valid certificate does not automatically give access to resources

Certificate Based Authentication



Authorization in Grid

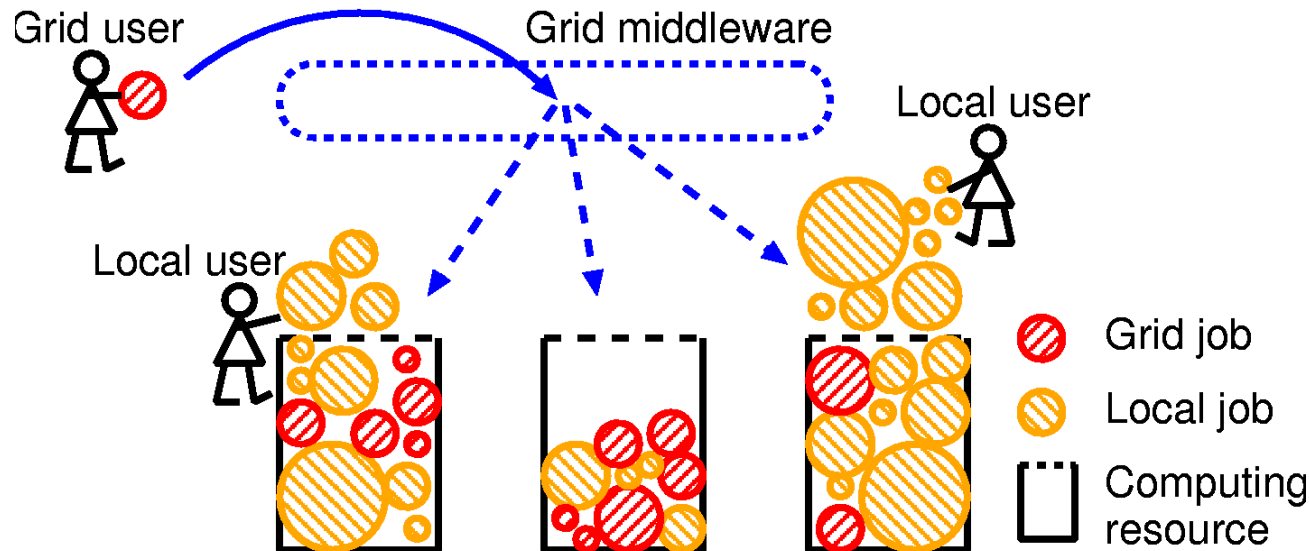
- **Users are grouped into Virtual Organizations (VO)**
 - Based on common research area, nationality, funding agency or project
 - The same user can belong to several VOs
- **Resource providers grant access to VOs**
 - Scales better than managing individual users at every resource
 - Implies trust towards the organization managing the VO
 - E.g. in the M-grid the users of each site form one VO, and we could combine all to a larger "M-grid VO" when negotiating with external parties

Resource Sharing

- **Many different models are in use**
 - Anarchy: for example local resources in laboratories — relies on solidarity and personal relations
 - Centralized allocation within an organization, organization level agreements
 - Giving away free cycles while local jobs have higher priority: a model used in several NorduGrid clusters
- **Challenges in resource allocation and sharing**
 - User friendliness
 - Maximal resource utilization rate
 - Technical implementation, lack of standards

Resource Sharing in M-grid

- **Policy:** Jobs can be submitted both to the local queue and through the grid interface
- **Goal is to minimize waste of resources:** empty nodes are always available for use (dynamical sharing)



Grid Environment Compared to Local Resources

- **NorduGrid can in some respects be viewed as an extended batch queue system**
 - Of course it's much more, but we have to start from somewhere...

Local Jobs and Grid Jobs

- **Local batch jobs**

- Batch queue system options specifying job requirements are usually written to small scripts, defining also directory paths etc.
- qsub, llsbmit, ...

- **Grid jobs**

- Described using (extended) Resource Specification Language (xRSL)
- ngsb
- Runtime Environments
- File transfers from the submitting machine or separate file servers on the Grid, Storage Elements (SE)
- Grid middleware transforms the Grid job to a local batch job

Steps to Start Using NorduGrid

- 1) Get an account for a system with the NorduGrid client installed (or install it on your own PC)**
- 2) Request a certificate from a Certificate Authority (CA)**
- 3) Install the certificate**
- 4) Log in to the Grid**
- 5) Write a job description using xRSL language**
- 6) Submit the job**
- 7) Monitor the progress of the job**
- 8) Fetch the results**

Installing the NorduGrid Client

- **Required to submit jobs to NorduGrid**
- **Download from <http://ftp.nordugrid.org/download/>**
 - Binaries for various Linux distributions, source code also available
- **Easiest way to install the client is to use the standalone version**
 - Uncompress in a directory (no root privileges required):
\$ **tar zxvf nordugrid-standalone-<latest>.i386.tgz**
 - Run the environment setup script:
\$ **cd nordugrid-standalone-<latest>**
\$ **. ./setup.sh**
- **RPM packages are recommended for multi-user installations**



Requesting and Installing the Certificate

- **Create a certificate request**

\$ **grid-cert-request -int**

- Generates the **.globus** subdirectory with a key (**userkey.pem**) and the request (**usercert_request.pem**)
- Identity string: e.g. **/O=Grid/O=NorduGrid/OU=csc.fi/CN=Arto Teras**
- Remember to select a good passphrase and keep the key secret!

- **Send the file `~/.globus/usercert_request.pem` to a Certification Authority (CA)**

- See the instructions at your local site / country which CA to contact

- **Wait for an answer from the CA**

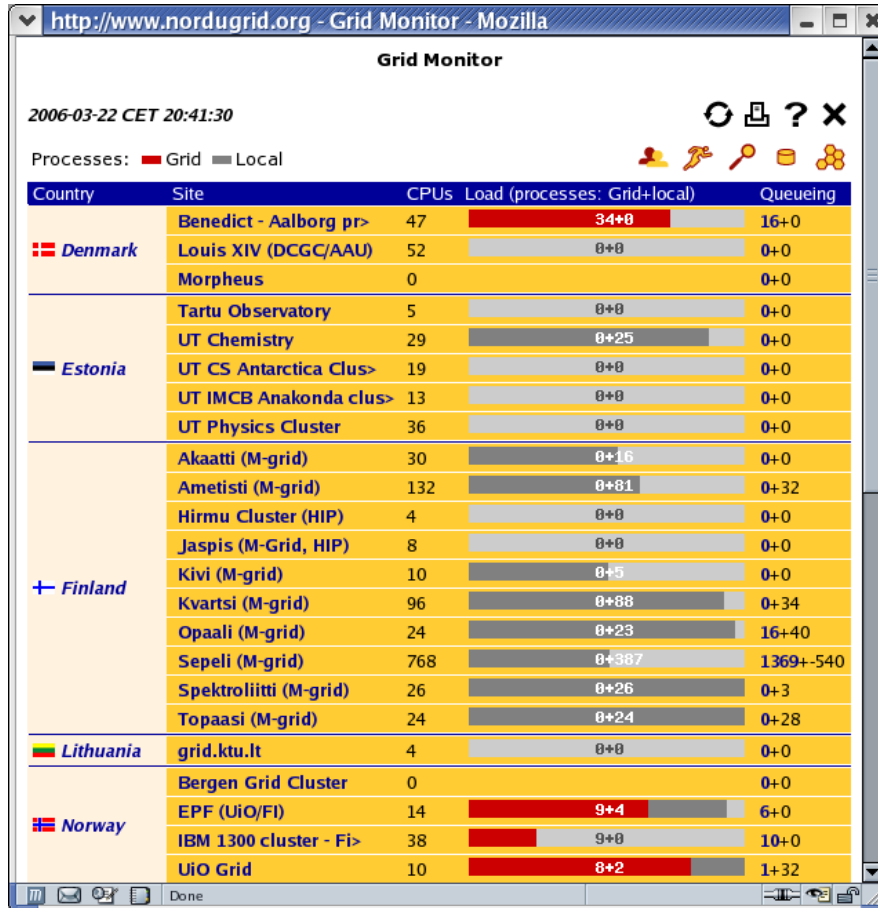
- Signed certificate returned by the Certificate Authority should be saved as file **.globus/usercert.pem**



User Interface

- **grid-proxy-init / grid-proxy-destroy** - log in / out
- **ngsub** - find suitable resource and start a job
- **ngstat** - check the status of jobs
- **ngcat** - display the stdout or stderr of a running job
- **ngget** - retrieve the results of a finished job
- **ngkill** - stop a job
- **ngclean** - delete a job from a computing resource
- **ngsync** - find users's jobs
- **ngrenew** - update remote credentials (authorization)
- **ngls** - list files on a storage element or in job's directory
- **ngcopy / ngcp** - transfer files to and from clusters and storage elements
- **ngrequest** - third party transfers or data tasks
- **ngremove / ngrm** - delete remote files

Grid Monitor on the NorduGrid Website



- Shows currently connected resources
- Almost all elements "clickable"
 - Browse queues and job states by cluster
 - List jobs belonging to a certain user
- No authentication, anyone can browse the info
 - privacy issues

Logging in to the Grid

- "Log in": **grid-proxy-init**
 - The command does not actually log in anywhere, but decrypts the private key and uses it to create a time-limited proxy
 - The proxy is used for authenticating to the resources
- "Log out": **grid-proxy-destroy**
 - Destroys the proxy

Writing a Job Description File

- **Resource Specification Language (RSL) files are used to specify job requirements and parameters for submission**
 - NorduGrid uses an extended language (xRSL) based on the Globus RSL
- **Similar to scripts for local queueing systems, but include some additional attributes**
 - Job name
 - Executable location and parameters
 - Location of input and output files of the job
 - Architecture, memory, disk and CPU time requirements
 - Runtime environment requirements

xRSL Example

- **hellogrid.sh**

```
#!/bin/sh  
echo "Hello Grid!"
```

- **hellogrid.xrsl**

```
& (executable=hellogrid.sh)  
  (jobname=hellogrid)  
  (stdout=hello.out)  
  (stderr=hello.err)  
  (gmlog=gridlog)  
  (cputime=10)  
  (memory=32)  
  (disk=1)
```

Submitting the Job

- **Submit the job**

```
$ ngsb -d 1 -f hellogrid.xrsl
```

- **A job id is returned**

```
=> Job submitted with jobid gsiftp://ametisti.grid.  
helsinki.fi:2811/jobs/455611239779372141331307
```

Monitoring the Job

- Query the status using the command line

```
$ ngstat hellogrid
```

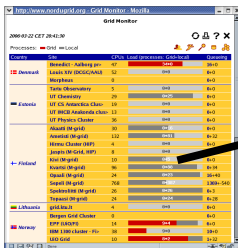
```
=> Job gsiftp://ametisti.grid.helsinki.fi:2811/  
jobs/455611239779372141331307
```

```
Jobname: hellogrid
```

```
Status: INLRMS:Q
```

- Most common status values are ACCEPTED, PREPARING, INLRMS:Q, INLRMS:R, FINISHING, FINISHED

- Or use the Grid Monitor



Jobs at kivi.csc.fi



Job name	Owner	Status	CPU (min)	Queue	CPUs
1 hellogrid	Arto Teras	INLRMS: R		mgrid	1
2 hellogrid	Arto Teras	INLRMS: R		mgrid	1

Fetching the Results

- **Print the job output**

```
$ ngcat hellogrid
```

- shows the standard output of the job
- this can be done also during the job is running

- **Download the result files**

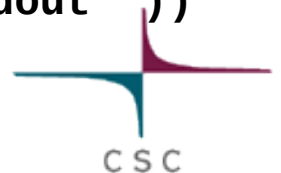
```
$ ngget hellogrid
```

```
=> ngget: downloading files to  
    /home/ajt/455611239779372141331307  
    ngget: download successful - deleting job  
    from gatekeeper.
```

Using a Storage Element

- **Storage Elements are disk servers accessible via the Grid**
 - Can be used to store job output while user is logged out and client machine disconnected from the Grid
- **Allows to store input files close to the cluster where the program is executed, on a high bandwidth network**
- **Some files can be local and some remote:**

```
(inputFiles=  
    ('input1', '/home/user/myexperiment'  
    ('input2', 'gsiftp://se.example.com/files/data'))  
  
(outputFiles=  
    ('output', 'gsiftp://se.example.com/mydir/result1')  
    ('prog.out', 'gsiftp://se.example.com/mydir/stdout'))  
  
(stdout='prog.out')
```



Gsincftp

- **Can be used to transfer files to and from storage elements**
 - Based on the popular **ncftp** ftp client, but uses certificate based authentication instead of standard ftp authentication
- **Example session:**

```
$ gsincftp se1.ndgf.csc.fi  
...Logged in to se1.ndgf.csc.fi.  
  
$ cd ndgf/tutorial  
  
$ get hello.out
```
- **Already deprecated by the Globus project, does not work with the latest Globus GridFTP server**
 - replacement: UberFTP (<http://dims.ncsa.uiuc.edu/set/uberftp/>)



Runtime Environments

- **Software packages which are preinstalled on a computing resource and made available through Grid**
 - Avoid the need of sending the binary at the start of executing a job
 - Useful if there are many users of the same software or if the same program is used frequently
 - Allow local platform specific optimizations
- **Implemented simply by shell scripts which initialize the environment and are placed in a specific directory**
- **Required runtime environments can be specified in the job description file, for example:**
(runtimeenvironment=APPS/GRAPH/POVRAY-3.6)
- **Runtime Environment Registry: <http://www.csc.fi/grid/rer/>**

Real Life Applications

- **It's common to send several subjobs to the Grid to solve a larger problem**
- **Parallel MPI jobs to a single cluster are supported (if correct runtime environment installed), but no MPI between clusters**
- **Splitting the job to suitable parts and gathering the parts together is left to the user**
 - More error prone environment than traditional local systems => error checking and recovery important
 - Fault reporting and debugging has room for improvements
 - New ARClib API available in the development version

Information Resources

- **Lots of documentation, presentations and tutorials on the NorduGrid web site <http://www.nordugrid.org>**
 - User guide: <http://www.nordugrid.org/documents/userguide.pdf>
- **NorduGrid user support mailing list nordugrid-support@nordugrid.org**
- **NorduGrid technical discussion mailing list nordugrid-discuss@nordugrid.org**
 - Main communication channel between developers
- **M-grid resources:**
 - M-grid documents: <http://www.csc.fi/proj/mgrid/docs/>
 - User support and discussion list mgrid-discuss@postit.csc.fi
- **Thank you! Questions?**