

The GridFactory web services

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1 The GridFactory computing system

GridFactory [GRIDFACTORY] is a system for aggregating computing resources on local and wide area networks in order to carry out heavy-duty batch calculations. The system has a hierarchical pull-architecture, with servers pulling compute jobs from other servers and at the end of the chain, so-called worker nodes pulling jobs from one or several servers. The services running on the servers are implemented through Apache modules. The standard modules `mod_dav` and `mod_ssl` plus a new module, `mod_gacl` are used to implement a file server with access control based on X.509 identities and virtual organisations¹. Compute jobs are described by records in a database. The worker nodes interact with this database through a RESTful [REST] web service, also implemented as a new Apache module – `mod_gridfactory`. The web services making up a GridFactory server are the subject of the present paper.

1.1 Job description

A compute job is described by a record in a database table. This record contains information for the worker nodes on where to download input files and upload output files, the current status of the job, the requirements of the jobs etc. All fields of a job description record are readable through the `mod_gridfactory` web service.

1.2 Job submission

Submitting a job consists in creating a directory in the job spool directory on the server served via HTTPS, and subsequently creating a file called “job” in this directory. The file called “job” is a shell script that contains directives in-lined as comments. A spool daemon on the server scans the spool directory with regular intervals and when a new job is found, parses these directives in the “job” file and creates a corresponding record in the database.

1.3 Job execution

Jobs are picked up by worker nodes that each run a daemon that regularly scans the job database table on the GridFactory server. When a worker node daemon finds a new job, it downloads input files from the server via HTTPS, boots up a virtual machine if needed or requested (by the job or by its own configuration), executes the job and uploads the output files via HTTPS. During such a cause of events, the worker node daemon regularly updates the database with information on the job status. This, it does via the `mod_gridfactory` web service.

1.4 Job query and manipulation

Once a job has been submitted, the only field of a job record that is modifiable by the submitter or the worker node is the status field. By modifying this field, the submitter can prompt the worker node daemon to kill, pause or resume the job or upload the current stdout and stderr of the job to the server – from where it can then be downloaded. Modifying this field also allows a worker node to request the job and report on its status.

1.5 Job history

A separate database table is used to keep information about each job that has been accepted. All fields of a job history record are readable through the `mod_gridfactory` web service.

¹`mod_gacl` is described in a separate publication [MOD_GACL].

1.6 Node information

Another database table is used to keep information about the worker nodes that are currently pulling jobs from the server. All fields of a job history record are readable through the mod_gridfactory web service.

2 Interface specification

2.1 Job directives

The file “job” in the job directory can either be:

- a single directive pointing to the executable job script (containing the in-lined job directives)

```
#GRIDFACTORY -x [executable script]
```

- the executable job script itself – containing the in-lined directives

```
#GRIDFACTORY -n [job name]
#GRIDFACTORY -i [input file 1] [input file 2] ...
#GRIDFACTORY -e [executable 1] [executable 2] ...
#GRIDFACTORY -t [running time on a 2.8 GHz Intel Pentium
processor]
#GRIDFACTORY -m [required memory in megabytes]
#GRIDFACTORY -z (request virtualisation)
#GRIDFACTORY -o [output files]
#GRIDFACTORY -r [runtime environment 1] [runtime environment 2] ..
#GRIDFACTORY -y [operating system]
#GRIDFACTORY -s [distinguished name identifying the submitter]
#GRIDFACTORY -v [allowed virtual organization 1]
[allowed virtual organization 2]
#GRIDFACTORY -u [unique identifier of the form
https://my.server/gridfactory/jobs/[identifier]]
```

List-arguments, like the list of input files, can be given either like a space-separated list of strings (not containing spaces) or by repeated use of the directive.

2.2 Database schemas

Field	Type
identifier	varchar(255)
name	varchar(255)
csStatus	varchar(255)
userInfo	varchar(255)
inputFileURLs	text
outFileMapping	text
providerInfo	varchar(255)
created	datetime
lastModified	datetime
outTmp	varchar(255)
errTmp	varchar(255)
jobID	varchar(255)
metaData	text
host	varchar(255)
gridTime	int(16)
memory	int(16)
executable	varchar(255)
executables	text
opSys	varchar(255)
runtimeEnvironments	text
allowedVOs	text
virtualize	tinyint(4)
stdoutDest	varchar(255)
stderrDest	varchar(255)

Table 1: Schema of the job definition table.

Field	Type
identifier	varchar(255)
name	varchar(255)
csStatus	varchar(255)
userInfo	varchar(255)
inputFileURLs	text
outFileMapping	text
providerInfo	varchar(255)
stdoutDest	varchar(255)
stderrDest	varchar(255)
created	datetime
lastModified	datetime
jobID	varchar(255)
metaData	text
host	varchar(255)
gridTime	int(16)
memory	int(16)
executable	varchar(255)
executables	text
opSys	varchar(255)
runtimeEnvironments	text
allowedVOs	text
virtualize	tinyint(4)
csStatusHistory	text

Table 2: Schema of the job history table.

Field	Type
identifier	varchar(255)
host	varchar(255)
maxJobs	int(16)
allowedVOs	text
virtualize	tinyint(4)
hypervisors	text
maxMBPerJob	int(16)
privileges	varchar(255)
inPorts	varchar(255)
outPorts	varchar(255)
providerInfo	varchar(255)
created	datetime
lastModified	datetime

Table 3: Schema of the node information table.

2.3 Mime types

Mimetype	Description
gridfactory/jobrecords+text	A list of job records in the form of an SQL response (with newline as record separator and tab as field separator)
gridfactory/jobrecord+text	A job newline-separated job record with lines of the form [key]:[value]
gridfactory/noderecords+text	A list of job records in the form of an SQL response (with newline as record separator and tab as field separator)
gridfactory/noderecord+text	A job newline-separated job record with lines of the form [key]:[value]

Table 4: Mime types for request bodies and response documents.

A job record is represented by a tab-separated line of values corresponding to the fields of table 1 plus a value corresponding to an extra field, 'dbUrl', added by mod_gridfactory. This last field, 'dbUrl', is the URL representing a single job as seen from the worker node, i.e. the URL on the server where information on a specific job can be obtained. Such a job may have been submitted directly to the server or the server may have pulled it from another server. Thus 'dbUrl' is not to be confused with 'identifier', which is the URL to which the job was originally submitted; even in the first case, depending on the set-up, they may or may not agree.

2.4 Communication and security

In the GridFactory system, the only network communication protocol used is HTTPS. Worker nodes and submitters communicate only with the server and communication is always initiated by the worker node or the submitter – never by the server (pull paradigm).

The HTTPS communication is two-way authenticated, so all peers must possess a public X.509 certificate and a secret RSA key.

The GridFactory security set-up is described in more detail in [GRIDFACTORY].

2.5 Submitting a job and uploading input files

The string [identifier] is chosen by the submitter. The submission utility that comes with GridFactory generates a time-based UUID [UUID], but in principle, any string can be used².

URL	https://my.server/db/jobs/[identifier]
Method	MKCOL
Returns	201 Created
	401 Access Denied
	403 Forbidden
	405 Method Not Allowed

Table 5: Creating a job directory.

Example:

```
MKCOL http://lx08/db/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945
-----
201 Created
```

URL	https://my.server/db/jobs/[identifier]/job
Method	PUT

²Uniqueness of the full URL is guaranteed by the fact that two different directories cannot have the same path.

Returns	201 Created
	200 OK
	401 Access Denied
	403 Forbidden
	405 Method Not Allowed

Table 6: Uploading a job file.

Example:

PUT http://lx08/db/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/job

201 Created

2.6 Getting job definition records

URL	https://my.server/db/jobs/	
Method	GET	
Query string	csStatus=	Filter by status
	userInfo=	Filter by DN of submitter
	providerInfo=	Filter by DN of provider
	start=	The number of the first job to return - 0 is the number of the first record
	end=	The number of the last record to return
Returns	200 OK & TEXT (gridfactory/jobrecords+text)	
	401 Unauthorized	
	404 Not Found	

Table 7: Getting multiple job definition records.

Example:

GET https://gridfactory.nbi.dk/gridfactory/db/jobs/?status=ready&start=0&end=1

200 OK

identifier	name	csStatus	userInfo	inputFileURLs	outFileMapping	
providerInfo	stdoutDest	stderrDest	created	lastModified	outTmp	errTmp
jobID	metaData	host	gridTime	memory	executable	executables
opSys	runtimeEnvironments	allowedVOs	virtualize	dbUrl		
https://orellana.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-11dd-80f2-c3b981785945	job	ready	https://gridfactory.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-11dd-80f2-c3b981785945/job	https://gridfactory.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-11dd-80f2-c3b981785945/stdout	https://gridfactory.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-11dd-80f2-c3b981785945/stderr	2008-05-29 11:11:32 2008-05-29 11:17:23
	-1	-1	job			0
https://lx08/db/jobs/3a86aacc-2d5f-11dd-80f2-c3b981785945						
https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945	job	ready	https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/job	https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/stdout	https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/stderr	2008-05-29 11:18:10 2008-05-29 11:24:56
	-1	-1	job			0
https://lx08/db/jobs/3a86aacc-2d5f-11dd-80f2-c3b981785945						

2.7 Getting a specific job definition record

URL	https://my.server/db/jobs/[identifier]
Method	GET
Returns	200 OK & TEXT (gridfactory/jobrecord+text)
	401 Unauthorized
	404 Not Found

Table 8: Getting a single job definition record.

Example:

GET http://lx08/db/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945

200 OK

identifier: https://orellana.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945

name: job

csStatus: ready

userInfo:

inputFileURLs: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/job

outFileMapping:

```
providerInfo:
stdoutDest: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-
c3b981785945/stdout
stderrDest: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-
c3b981785945/stderr
created: 2008-05-29 11:11:32
lastModified: 2008-05-29 11:11:32
outTmp:
errTmp:
jobID:
metaData:
host:
gridTime:-1
memory:-1
executable:job
executables:
opSys:
runtimeEnvironments:
allowedVOs:
virtualize:0
```

Notice that the identifier contains a host name different from the one of the host running the service. This indicates that the host running the service has pulled the job from somewhere else. The host name in the identifier is the name of the host to which job was originally submitted.

2.8 *Modifying the status of a job*

To modify an existing job, we'll PUT a text representation of a job to the URL of our job.

URL	https://my.server/db/jobs/[identifier]
Method	PUT
Request body	TEXT (gridfactory/jobrecord+text)
Returns	201 Created & Location
	401 Unauthorized
	404 Not Found
	415 Unsupported Media Type

Table 9: Modifying a single job definition record.

Since we don't want people to create new job records using PUT, only update existing job records, we'll return a '404 Not' Found error if the resource doesn't already exist.

Example:

PUT http://lx08/db/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945

csStatus: ready

201 Created

Notice all values of a job record can be changed, except for those corresponding to the keys 'created' and 'lastModified'. These are set by the server. The value of 'lastModified' is changed on each PUT, regardless of whether the job record is actually changed.

2.9 Downloading output files

URL	https://my.server/db/jobs/[identifier]/[file]
Method	GET
Returns	200 OK & BODY
	401 Unauthorized
	404 Not Found

Table 10: Getting a single job output file.

Example:

GET http://lx08/db/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/output_file_1.data

200 OK

File body

2.10 Getting job history records

URL	https://my.server/db/history/	
Method	GET	
Query string	created=	Filter by created. Format: "YYYYMMDDHHMMSS".

		This string may be prepended by "<" or ">"
	lastModified=	Filter by lastModified
	csStatus=	Filter by status
	userInfo=	Filter by DN of submitter
	providerInfo=	Filter by DN of provider
	start=	The number of the first job to return - 0 is the number of the first record
	end=	The number of the last record to return
Returns	200 OK & TEXT (gridfactory/jobrecords+text)	
	401 Unauthorized	
	404 Not Found	

Table 11: Getting multiple job history records.

Example:

```
GET https://gridfactory.nbi.dk/gridfactory/db/history/?
status=done&start=0&end=1&created=>29052008100000&created=<29052008160000

-----
200 OK

identifier    name  csStatus    userInfo    inputFileURLs    outFileMapping
providerInfo  stdoutDest  stderrDest    createdlastModified  outTmp    errTmp
jobID  metaData    host  gridTime    memory    executable    executables
opSys  runtimeEnvironments  allowedVOs  virtualize    dbUrl

https://orellana.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-11dd-80f2-c3b981785945    job
ready    https://gridfactory.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-11dd-80f2-
c3b981785945/job    https://gridfactory.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-
11dd-80f2-c3b981785945/stdout    https://gridfactory.nbi.dk/gridfactory/jobs/3a86aacc-2d5f-
11dd-80f2-c3b981785945/stderr    2008-05-29 11:11:32 2008-05-29 11:17:23
-1    -1    job    0
https://lx08/db/history/3a86aacc-2d5f-11dd-80f2-c3b981785945

https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945    job
ready    https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-
c3b981785945/job    https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-
11dd-80f2-c3b981785945/stdout    https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-
11dd-80f2-c3b981785945/stderr    2008-05-29 11:18:10 2008-05-29 11:24:56
-1    -1    job    0
https://lx08/db/history/3a86aacc-2d5f-11dd-80f2-c3b981785945
```

2.11 Getting a specific job history record

URL	https://my.server/db/history/[identifier]
Method	GET
Returns	200 OK & TEXT (gridfactory/jobrecord+text)
	401 Unauthorized
	404 Not Found

Table 12: Getting a single job history record.

Example:

GET http://lx08/db/history/3b16dcdd-2d5f-11dd-80f2-c3b981785945

200 OK

identifier: https://orellana.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945

name: job

csStatus: done

userInfo:

inputFileURLs: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/job

outFileMapping:

providerInfo:

stdoutDest: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/stdout

stderrDest: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-c3b981785945/stderr

created: 2008-05-29 11:11:32

lastModified: 2008-05-29 11:17:23

jobID:

metaData:

host:

gridTime:-1

memory:-1

executable:job

executables:

opSys:
runtimeEnvironments:
allowedVOs:
virtualize:0
csStatusHistory: requested 2008-05-29 11:12:12, prepared 2008-05-29 11:13:24, uploaded 2008-05-29 11:16:56

2.12 Getting node information records

URL	https://my.server/db/nodes/	
Method	GET	
Query string	created=	Filter by created - may be prepended by "<" or ">"
	lastModified=	Filter by lastModified - may be prepended by "<" or ">"
	maxJobs	Filter by max jobs - may be prepended by "<" or ">"
	maxMBPerJob=	Filter by memory - may be prepended by "<" or ">"
	providerInfo=	Filter by DN of provider
	start=	The number of the first record to return - 0 is the number of the first record
	end=	The number of the last record to return
Returns	200 OK & TEXT (gridfactory/noderecords+text)	
	401 Unauthorized	
	404 Not Found	

Table 13: Getting multiple node information records.

Example:

GET https://gridfactory.nbi.dk/gridfactory/db/nodes/?start=0&end=1

200 OK

identifier	host	maxJobs	allowedVOs	virtualize	hypervisors	maxMBPerJob
privileges		inPorts	outPorts	providerInfo	created	lastModified
						dbUrl

```

https://orellana.nbi.dk/gridfactory/nodes/3a86aacc-2d5f-11dd-80f2-c3b981785946
  gridworker01 2      https://gridfactory.nbi.dk/vos/atlas.txt      0      VM/KQEMU,
VMVirtualBox    1024 Administrator 22, 5901      all      2008-05-29 10:07:28 2008-05-
29 11:19:12 https://orellana.nbi.dk/db/nodes/3a86aacc-2d5f-11dd-80f2-c3b981785946
https://orellana.nbi.dk/gridfactory/nodes/3a86aacc-2d5f-11dd-80f2-c3b981785947
  gridworker02 2      https://gridfactory.nbi.dk/vos/atlas.txt      0      VM/KQEMU,
VMVirtualBox    1024 Administrator 22, 5901      all      2008-05-29 10:07:33 2008-05-
29 11:19:27 https://orellana.nbi.dk/db/nodes/3a86aacc-2d5f-11dd-80f2-c3b981785947

```

2.13 Getting a specific node information record

URL	https://my.server/db/nodes/[identifier]
Method	GET
Returns	200 OK & TEXT (gridfactory/noderecord+text)
	401 Unauthorized
	404 Not Found

Table 14: Getting a single node information record.

Example:

```

GET http://lx08/db/nodes/3b16dcdd-2d5f-11dd-80f2-c3b981785946
-----
200 OK

identifier: https://orellana.nbi.dk/gridfactory/nodes/3b16dcdd-2d5f-11dd-80f2-c3b981785946
name: job
csStatus: done
userInfo:
inputFileURLs: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-
c3b981785945/job
outFileMapping:
providerInfo:
stdoutDest: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-
c3b981785945/stdout
stderrDest: https://gridfactory.nbi.dk/gridfactory/jobs/3b16dcdd-2d5f-11dd-80f2-
c3b981785945/stderr
created: 2008-05-29 11:11:32

```


lastModified: 2008-05-29 11:17:23

jobID:

metaData:

host:

gridTime:-1

memory:-1

executable:job

executables:

opSys:

runtimeEnvironments:

allowedVOs:

virtualize:0

csStatusHistory: requested 2008-05-29 11:12:12, prepared 2008-05-29 11:13:24, uploaded 2008-05-29 11:16:56

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