Chapter 0

Introduction to KMI-R1

1. Overview

K*Grid project is an initiative in Grid researches supported by MIC (Ministry of Information and Communication), Republic of Korea and started in 2002. KISTI (Korea Institute of Science and Technology Information) plays a leading role in building and operating a production quality Grid infrastructure needed for large-scale collaborative Grid researches including scientific and business applications.

KMI (K*Grid Middleware Initiative) is an integrated Grid middleware package which makes scientists able to set easily the computational Grid and data Grid environment for their researches and harness all the advantages of Grid in their fingertips. KMI is developed for building K*Grid infrastructure, but not limited for it.

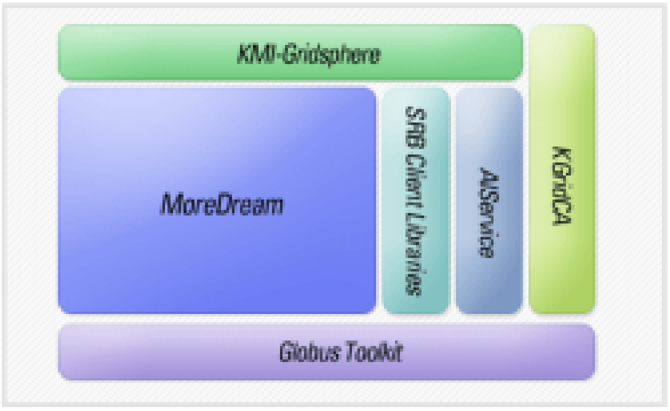


Figure 0-1 Architecture of KMI-R1

KMI is an integration of the **MoreDream** Toolkit (KISTI), which contains **GRASP** (Grid Resource Allocation Services Package) for Grid resource allocation service, **GAIS** (Grid Advanced Information System) for Grid information service and **MPICH-GX** for parallel computing service, with some key software packages such as Globus Toolkit® (ANL), **KGridCA** System

(KISTI) for Grid CA Service, **AIService** (CNU) for Grid accounting service, SRB (Storage Resource Broker, SDSC) and **KMI-GridSphere** (GridLab)
The detailed descriptions of each system in KMI are in the following chapters.

Chapter 1

MoreDream

1. GRASP

1.1 Introduction

The problem of Grid resource allocation is concerning about delivering the users distributed resources with computing powers, data storage capacity, network connectivity, etc. The Managed job service in Globus toolkit 3.x (GT3) is the service to be used to run the job on a remote resource. However, in order to build more useful Grid, there should be added some user-friendly features and advanced resource allocation techniques including resource brokering, scheduling, job monitoring, and so forth. To meet this requirement in Grid resource management area, we designed and implemented a resource allocation system named GRASP(Grid Resource Allocation Services Package), which is to let users to submit their jobs in more efficient and intelligent manner to the Grid resources. The services of GRASP were implemented based on the OGSI specification implementation of GT3 as well as other services in MoreDream. Followings are brief introduction of GRASP functionalities.

1.1.1 Architecture and Components of GRASP

1.1.1.1 Overview

GRASP supports scientific applications with the high performance computing features such as MPI, high throughput computing features such as parametric studies, and data intensive features. GRASP can handle three kinds of job type: SINGLE, XMPI, and HTC. SINGLE is a simple job to use only one computing node. XMPI is an MPI job which can be run over multiple resources. Lastly, HTC is a job for HTC applications such as parametric study. In Both XMPI and HTC job case, GRASP co-allocates multiple resources to the job even though the resources are remotely distributed. To support data intensive features, we added the feature to automatically stage in files from SRB server and stage out the files to SRB server

Furthermore, we have designed the job description language, named JRDL (Job and Resource Description Language) to overcome the limitation of the GT3. RSL2, the GT3 job description language, just describes job specifications rather than resource specifications such as resource preference. RSL2 is also not considering about co-allocation. Therefore, we have proposed JRDL to meet both requirements for the job and resource's preference. The resource preference part is used in matchmaking step in Grid scheduling service (GSS). JRDL is designed based on XML schema.

GRASP is composed of four useful services needed to allocate the resources in Grid as illustrated in Figure 1-1. Firstly, the resource brokering is done by Grid scheduling service (GSS). This service finds out resources from the index service which are fit to a user's job and then reserve the resources in advance through Resource reservation service (RSS). To select proper resources it performs matchmaking between the resource specification from the user and the job/user specification preferred by the resource administrator. And then the resources are allocated to the job. Secondly, Job submission service (JSS) does co-allocation of resources and co-monitoring of the job. Co-allocation in GRASP makes it possible the job submission to the multiple distributed resources simultaneously. And co-monitoring allows the user to monitor her job flow. Lastly, Resource manager service (RMS) authenticates the user for the job execution on a local resource and submits the job to the local batch queuing system such as PBS. RMS should get the permission to allocate resource from RRS before submitting the job.

Followings are the main features of GRASP, job types that is handled by GRASP and job statuses defined in GRASP. The explanation of each service, JSS (Job Submission Service), GSS (Grid Scheduling Service), RMS (Resource Manager Service), and RRS (Resource Reservation Service), will be followed after this overview section.

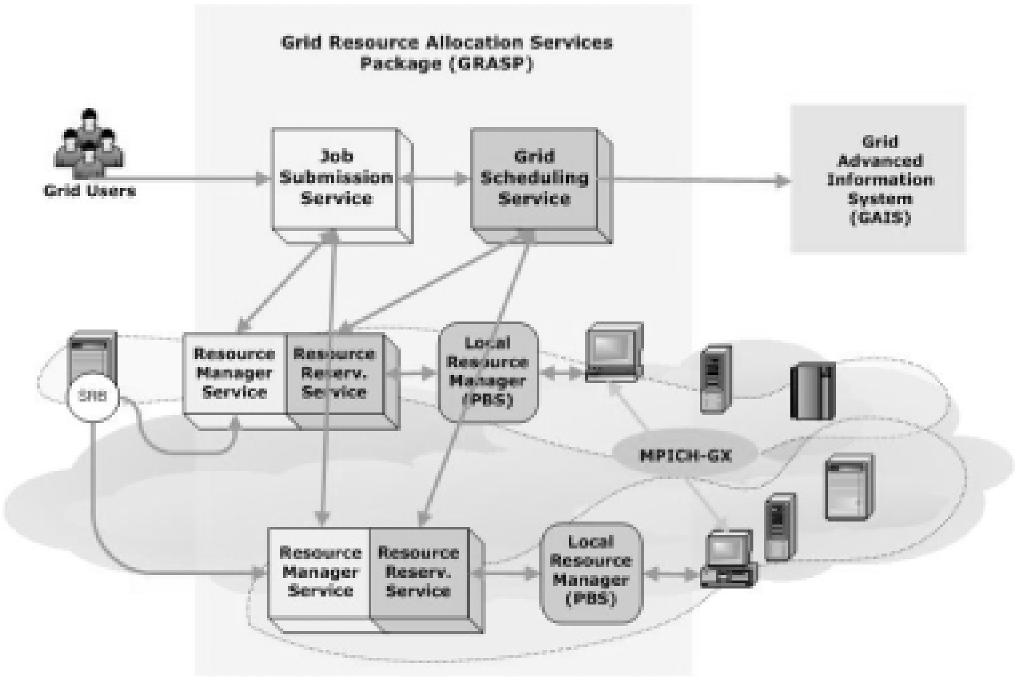


Figure 1-1 Architecture of GRASP

A. Main Features

- All services are OGSI-compliant Grid services.
- GRASP supports three kinds of job type: SINGLE, XMPI, and HTC. SINGLE is a simple job which uses only one computing node. XMPI is an MPI job which can be run over multiple resources. Lastly, HTC is a job for high throughput computing such as parametric study.
- Multiple resources can be co-allocated to a job even though the resources are remotely distributed.

- Scheduler can automatically select resources by matchmaking process.
- Job can reserve resources in advance.
- The input files can be staged in from SRB server and the output files can be staged out to SRB server automatically.
- We provide JRDL (Job and Resource Description Language) as a general language to describe a job and user preferences required allocating resources for a job in Grid environment.
- We bring client tools for job creating, submission, controlling, and monitoring. They provide three user interfaces having same functionality: a command line interface, a graphic user interface, and web interface.

B. Job Type

We are supporting three kinds of job type: SINGLE, XMPI, and HTC.

- SINGLE: It is a simple job which uses only one computational node (e.g. simple script for pre/post processing).
- XMPI: It is an MPI job which uses multiple resources to run even though resources are remotely distributed. Each resource could have several nodes.
- HTC: It is a job which uses multiple resources to run and have no communication between each of all subjobs (e.g. parametric study). Each subjob must be a SINGLE job.

C. Job Status

(a) Job Submission Status

Job submission service manages the status of job submission. The Status has following information:

- State of job

- All subjobs’ statuses
- Fault message.

(b) Job State

- "Unsubmitted": JRDL is unsubmitted to Job submission service.
- "Scheduling": Job is scheduling to find proper resources at Grid scheduling service.
- "Pending": Job is pending even though the subjob is submitted to Resource manager service.
- "Active": Job is active.
- "Suspended": Job is suspended.
- "Done": Job is done.
- "Failed": Job is failed.

(c) Subjob Status

Resource manager service manages the statuses of subjobs. Each status has following information:

- Subjob id
- State of subjob state
- Execution time of subjob: start time and end time of job
- Allocation information of subjob: allocated resources’ address
- Fault message.

(d) Subjob State

- "Unsubmitted": Subjob is unsubmitted to ResourceManagerService.
- "StageIn": Subjob is staging in the files to need to execute.
- "Waiting": Subjob is waiting for its requested execution time to be reached
- "Pending": Subjob is pending even though the subjob is submitted to the local job manager

- “XMPI_init”: XMPI subjob is initializing
- "Active": Subjob is active.
- "StageOut": Subjob is staging out the files to result from executing
- "Suspended": Subjob is suspended.
- "Done": Subjob is done.
- "Failed": Subjob is failed.

1.1.1.2 JSS (Job Submission Service)

A. Key concepts

JSS is a Grid service to enable a job to submit to the resources in Grid testbed and enable a user to monitor the status of submitted job. We provide JRDL language to describe the job, which is "an atomic task" of a workflow specification or other kinds of a complex, multi-step application. The service has the status of job submission and the requested JRDL which are provided as service data.

B. Architecture

The job submission process is illustrated in Figure 1-2. When JSS receives the JRDL, the service can determine resources by GSS which is a Grid service to find out resources which are fit to the user's job from information provider and make a reservation to RRS on each resource. User could the resources manually by specifying the address and local job manager type of resources to JRDL. If the resources are decided, the job is divided into subjobs, then that are co-allocated to RMS on each resource.

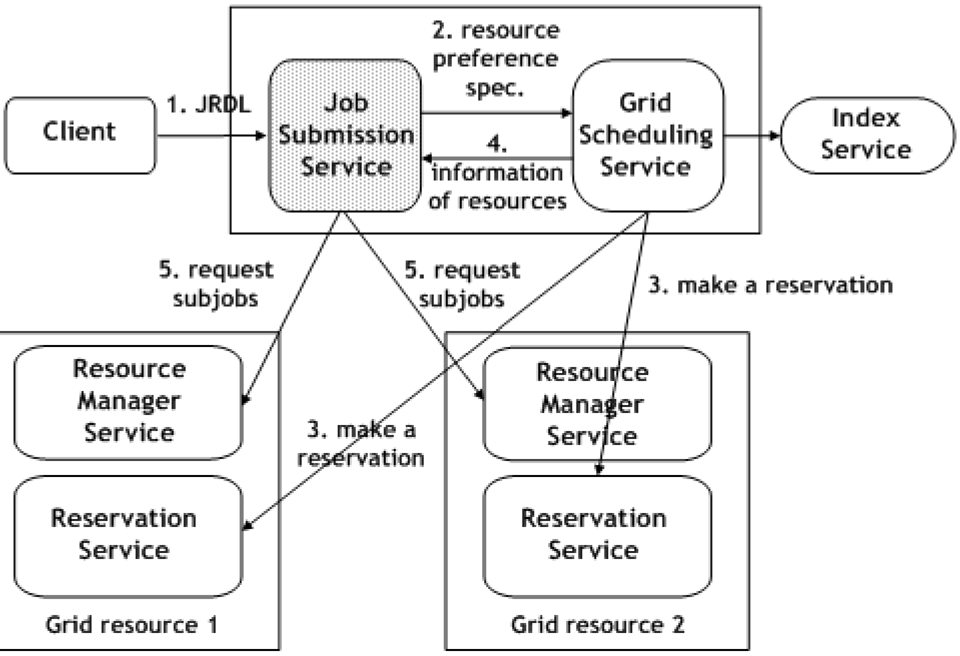


Figure 1-2 Job Submission Process

1.1.1.3 GSS (Grid Scheduling Service)

A. Key concepts

Grids consist of a large variety of services which reveal accessibilities to resources and the access to a resource is under control of the policies of the resource owners. Besides, complicate bottom layer Grid fabric should be hidden from Grid users. Therefore, the scheduling service which coordinates between various resources and higher level consumers satisfying policies on both sides is acutely needed in the Grid computing environment. The GSS in GRASP was designed and implemented to do scheduling in such a complex Grid infrastructure for the jobs from various applications.

Major purpose of the GSS is to find resources which meet user's requirements and select resources according to a scheduling algorithm. In order to discover proper resources the GSS queries an information service, GAIS in MoreDream, with resource specification for the job. The GSS does screening process to choose the resources which meet minimal requirements to execute the job.

And then, with the filtered resources, selection is done by the specific scheduling policy. The Grid scheduling service can have several scheduling plugins which implement application-specific policies or scheduling algorithms. The plugin selected by the user will be applied to select most appropriate resources.

Once the selection process is done by a scheduling plugin, the service tries reservations to the selected resources for the time that user have specified in JRDL file. If the reservation fails, the service gains recent information about available resources from the reservation services, does scheduling again, and then retries reservation to the resources. These processes are repeated until the selected resources are confirmed with reservation IDs.

B. Architecture

The architecture of GSS is described in Figure 1-3. Following paragraphs explains each parts of GSS.

The GSS has the factory mechanism i.e. the GSS factory service creates a GSS instance and the created instance deals with the requested job until it gains resources. GSS acquires candidate resources thru Resource Broker. In this step, Resource Broker queries information of available resources to GAIS filtering out the unfit resources.

The scheduling plugin which was specified in the job request takes the job and resource candidates. And then it makes a map between the job and resources according to the scheduling policy. Scheduling plugin can have policies or selection algorithm. GSS has the default plugin, in which a opportunistic load balancing (OLB) algorithm is implemented. OLB assigns each task in the job, in arbitrary order, to the next available node, regardless of the task’s expected execution time on that resource. In the distribution of

GRASP package, HTC plugin and MPI plugin is included for each type of jobs in addition to the default plugin.

The Reservation Agent takes selected by scheduling plugin and tries to reserve resources for the certainty of the schedule. When the reservation trials are not complete, it asks available node resource capacity to the resource candidates and repeats scheduling and reservation keeping succeeded reservations.

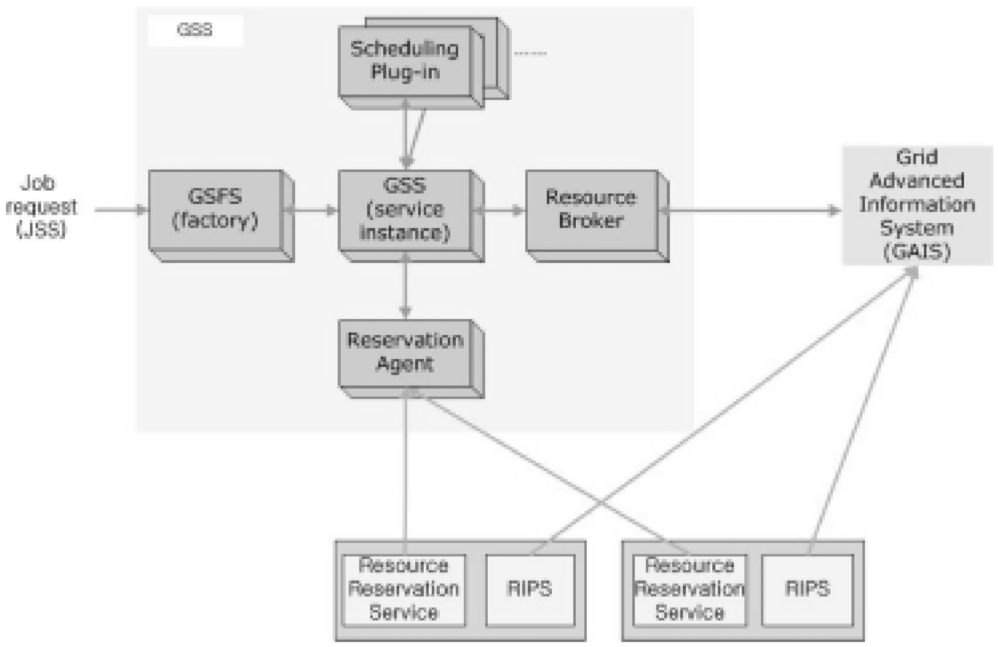


Figure 1-3 Architecture of GSS

1.1.1.4 RMS (Resource Manager Service)

A. Key concepts

RMS is a Grid service to enable subjobs to allocate resources and be executed by the local batch scheduler such as PBS. Resources are computational nodes to be managed by the local batch scheduler. The service has the statuses of subjobs which are provided as service data.

B. Architecture

Local resource allocation and execution process is illustrated in Figure 1-4. When RMS receives the execution request for subjobs, the service must allocate local resources. This service can allocate resources when the service gets the permission from RRS, which has established the reservation by the request of Grid scheduling service. RMS then invokes JMS (Job Manager Script) to submit the subjobs to designated local batch scheduler. While the subjobs are running, the service manages the status of each subjob. Because RMS is managed by Job submission service, this service notify the status of subjob to JSS whenever the status changes.

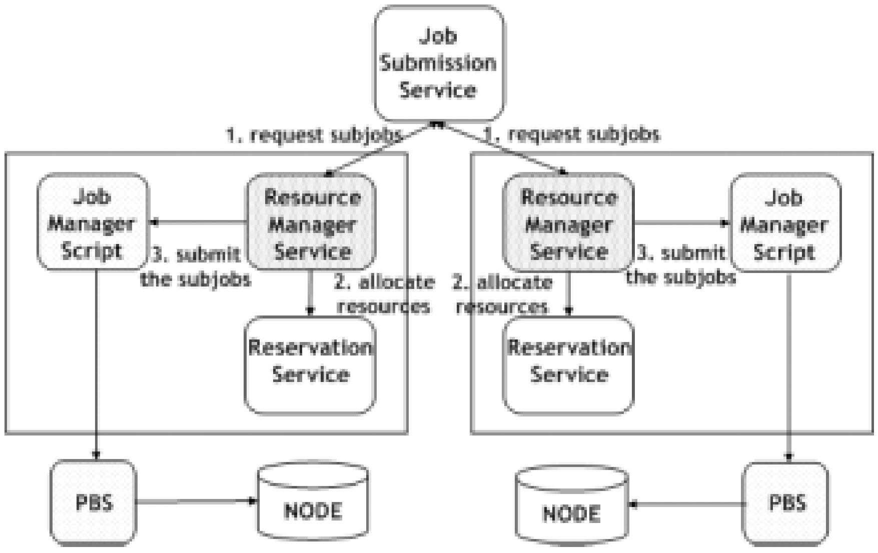


Figure 1-4 Local Resource Allocation and Execution Process

JMS (Job Manger Script)

JMS module processes file stage-in, file stage-out, submit, poll, and kill requests instead of RMS. Job manager script is written in PHP language, and can be executed by the java Runtime.exec() method. The requests from the RMS is delivered to JMS as an XML document form. JMS parses the XML and processes the requested function.

JMS is installed under $GLOBUS_LOCATION/libexec/grasp-jms-php

JMS can be executed manually in a command line prompt:

```
  $ jms -file < filename>
```

The filename is a path name of an XML file, which has the format:

```
 <xml>
 <action>ACTION</action>
 <manager>MANAGER</manager>
 <jobtype>JOBTYPE</jobtype>
 ...
 </xml>
```

where,

```
  ACTION  =  proxy_relocate | submit | poll | stage_in |
stage_out
  MANAGER = pbs | fork
  JOBTYPE = single | htc | xmpi
```

File stage-in and stage-out actions use globus-url-copy command to copy files between local file system and remote server. To use PBS manager, OpenPBS must be installed in the local system. The configuration file (config.php) sets up these path information.

1.1.1.5 RRS (Resource Reservation Service)

A Grid resource is composed of many kinds of resources, such as CPUs and memory, storage space, network bandwidth, special purpose instruments. RRS manages reservation of resources which are able to be reserved on the Grid. As a simple case, computing nodes of a cluster system is a kind of a resource which can be reserved. RRS makes a reservation to only computing nodes of a cluster.

In general, to make a reservation to resources, a user should specify the followings:

- The start time of reservation
- The end time of reservation (or duration from the start time)
- The kind of resource to reserve
- The identity of reservation maker
- Amount of resource to reserve

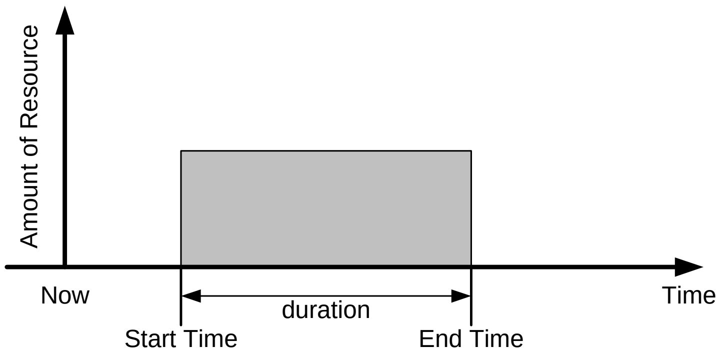


Figure 1-5 Reservation information: start time, duration, amount of resource, the type of resource and the identity of reservation maker

Reservation Status

Figure 1-6 and Figure 1-7 show the status change of a reservation item. It starts from the 'unknown' status. Until the start time, the reservation is in 'waiting' status, which means that the reservation is valid but it is not ready to be allocated yet. Immediately after the start time the status of the reservation changes to be 'wait_alloc' status, which means the reservation is valid and it is available for allocation now. After the job runs on the resources, the status of the reservation changes to be 'allocated'. Finally, when the job finished successfully, the status changes to be 'done'. If the valid reservation interval is over with no job allocated, the reservation status becomes to 'invalid' status. Reservations can be canceled if the status is one of 'unknown', 'waiting', or 'wait_alloc' status.

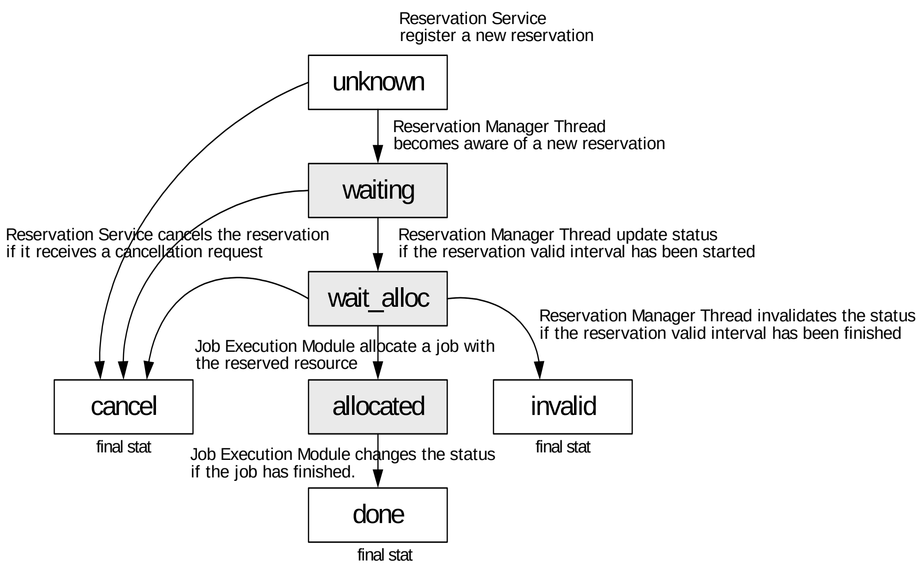

Reservation Service
register a new reservation
unknown
Reservation Manager Thread
becomes aware of a new reservation
waiting
Reservation Service cancels the reservation
if it receives a cancellation request
Reservation Manager Thread update status
if the reservation valid interval has been started
wait_alloc
Reservation Manager Thread invalidates the status
if the reservation valid interval has been finished
Job Execution Module allocate a job with
the reserved resource
cancel
allocated
invalid
final stat
Job Execution Module changes the status
if the job has finished.
final stat
done
final stat

Figure 1-6 Status changes of a reservation

The 'cancel', 'invalid', and 'done' are final status. The 'waiting', 'wait_alloc' and 'allocated' status are valid status, which means that reserved resources are not be reserved or available by other users.

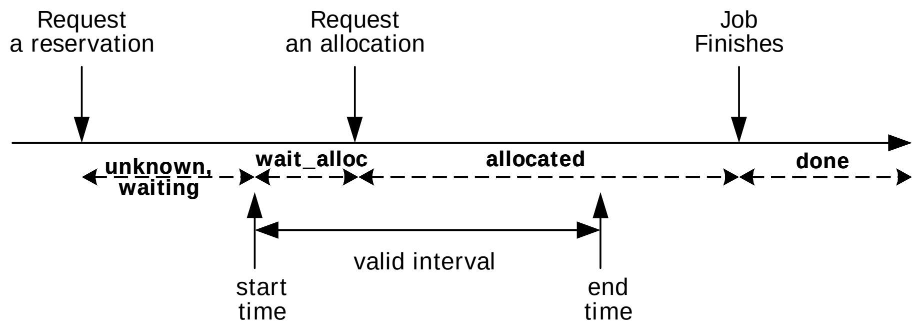


Figure 1-7. Reservation status changes in a time line

The Figure 1-7 depicts the status changes of a reservation in a time line.

1.1.1.6 SRB enabled globus-url-copy

Overview

`globus-url-copy`, which is an application of Globus toolkit, copies a file specified by source URL to a location specified by destination URL, using the GASS transfer API. It is used to stage in/out files from/to storage device for executing jobs. All protocols supported by GASS (local file, http, https, ftp, and gsiftp) are supported. Piping to/from stdin/stdout (setting source/dest argument = '-') is also supported. However, it could not retrieve/save data from/to storage not to be able to use protocol supported by GASS. The Storage Resource Broker (SRB) is client-server middleware that provides a uniform interface for connecting to heterogeneous data resources over a network and accessing replicated data sets. SRB support a lot of interfaces for data resources including HRM, HPSS, DB2, Oracle, Illustra, ObjectStore, ADSM, UniTree, UNIX, NTFS, and HTTP. Therefore, we modify `globus-url-copy` application to support SRB protocols as well as GASS protocols for accessing various data resources and replicated data sets.

SRB URI

The location of data file should be described with URL format to use `globus-url-copy`. Thus, the location of data in SRB could be described with URI format as showed in Figure 1-8. Actually, both replica and resource are not included in “http://www1.ietf.org/proceedings_new/04nov/IDs/draft-gilbert-srb-uri-00.txt”. `replica` might be used for accessing replicated data sets. resource might be used to specify the resource name for creating new data to SRB.

```
srb:// [username.mdasdomain [.zone] [:password] @]
host [:port]
[?replica=replica_id][?resource=resources_name]
[/path]
```

where square brackets [...] delineate optional components, the characters :, /, @, and . stand for themselves, and spaces should be

Figure 1-8 Syntax for SRB URI

As mentioned above, the data could be retrieved from SRB server or be saved to SRB server by specified SRB URI format. If there are no attributes except replica and path in specified format, default configuration will be read in ~/.srb/.MdasEnv file. The ~/.srb/.MdasEnv file includes following default configuration information to connect to SRB server.

- mdasCollectionName: default collection name
- mdasDomainName: default domain name
- srbUser: default SRB user id
- srbHost: default host IP of SRB server
- srbPort: default host port of SRB server
- defaultResource: default storage resource name
- AUTH_SCHEME: default authentication mechanism: PASSWD_AUTH, GSI_AUTH, and ENCRYPT1
- SERVER_DN: server DN of proxy to invoke SRB server in case of GSI authentication

SRB Authentication

SRB server accepts ENCRYPT1 or GSI authentication. If `password` exists, it authenticates to SRB server via ENCRYPT1 mechanism. Otherwise, by default, it uses GSI authentication. Because the server DN of proxy to invoke SRB server must be specified in case of GSI authentication, the server DN could be read via `–s, -ss,` and `–ds` among options of `globus-url-copy`. If the option is not specified, the server DN should be described by SERVER_DN in ~/.srb/.MdasEnv file.

1.1.1.7 Client Tools

GRASP provides client tools. They provide three user interfaces: a command line interface (CLI), a graphic user interface (GUI), and web interface (WI). They have same functionality for creating and modifying JRDL for a job, submitting the job to JSS, and controlling and monitoring the job. The detail usage of these client tools will appear in another document about GRASP, users' guide.

Command Line Interface (CLI): `grasprun`

The CLI lets you execute commands via `grasprun` at the shell prompt. The CLI could be run at Linux or Windows environment. The user should install the library and certificates to use `grasprun` and know the syntax of JRDL to describe a job.

Graphic User Interface (GUI)

The GUI is a graphic interface based on Java SWING, which is OS independent. While the user must write a JRDL manually in case of `grasprun`, GUI provides convenient interface to load and write the JRDL.

Web Interface (WI): Job Submission Portlet

The WI is a web interface based on Gridsphere, which provides an open-source portlet based Web portal. While the user should install the library and certificates in case of both CLI and GUI, he/she does not have to care about installation as well as the syntax of JRDL in web interface. We have implemented Job submission portlet enabling the user to easily make a JRDL, load the JRDL, submit a job to JSS, and monitor the submitted job.

1.2 Installation and Configuration

1.2.1 Support software

1.2.1.1 Required

- OS: Linux (RedHat 7.3 or more are recommended)
- J2SDK 1.4 (developed under 1.4.2_04, 2.4.2_06)
- ANT (developed under 1.6.2)
- Globus Toolkit 3 (developed under 3.2.1)

Following softwares are required only for RMS and RRS

- MySQL Database (tested under 3.23.49, 4.0.16, and 4.0.20)
- JDBC Driver: MySQL-Connector/J (tested under 3.0.14)
- PHP4 (4.3.4 or latest)

1.2.1.2 Optional

- Apache Web server (optional, for reservation status monitoring)

1.2.2 Installing support softwares

1.2.2.1 Installing Java SDK

Required for: GT3 Webservices components

Recommended Versions: 1.4.x

Download Link: http://java.sun.com/j2se

1.2.2.2 Installing Globus Toolkit

1. Download all source code from http://www.globus.org
2. As globus, untar the source installer.
3. Make sure that ANT_HOME and JAVA_HOME are set, and that ant and java are on your PATH.
4. Run

```
# ./install-gt3 /path/to/install
```

7. Configure the Globus Toolkit 3.2, looking through
   http://www-unix.globus.org/toolkit/docs/3.2/installation/install_config.html

1.2.2.3 MySQL Database

Download a latest MySQL distribution from http://www.mysql.com/.
You can find a copy of MySQL distribution in software archive directory of KISTI Grid Testbed web site :
http://testbed.gridcenter.or.kr/software/index.php?dir=./DBMS/mysql

Move to a temporary directory and extract the distribution file.

```
# cd /usr/local/src       (download the distribution file in this directory)
# tar zxvf mysql-4.0.16.tar.gz
# cd mysql-4.0.16
```

Configure and compile the source

```
# ./configure --prefix=/usr/local/mysql --with-mysqld-user=root
# make
```

Copy the compiled binaries to the install location.

```
# make install
```

Make a symbolic link for 'mysql' command line client, or add it to the $PATH variable.

```
# ln -s /usr/local/mysql/bin/mysql /usr/local/bin/mysql
```

Database initialization

```
   # /usr/local/mysql/bin/mysql_install_db
```

Start MySQL server daemon

```
   # /usr/local/mysql/bin/mysqld_safe -u root &
```

To start MySQL server daemon during system startup, add a line to the rc.local file.

```
   # vi /etc/rc.d/rc.local
...
/usr/local/mysql/bin/mysqld_safe -u root &
...
```

Refer to other books or documents about managing and using MySQL.

1.2.2.4 MySQL-Connector/J 3.0 (JDBC Driver)

Download it from http://dev.mysql.com/downloads/connector/j/3.0.html

```
   # tar zxvf mysql-connector-java-3.0.14-production.tar.gz
   # cp    mysql-connector-java-3.0.14-production/mysql-connector-java-
3.0.14-production-bin.jar   $JAVA_HOME/jre/lib/ext/
```

1.2.2.5 PHP4

PHP4 (command line interface) is required for Job Manager Script module in GRASP.

PHP4 compiled with Apache web server is optionally required for monitoring reservation database table.

The libxml2 module must be compiled with PHP.

Download the latest version of libxml2 from http://xmlsoft.org/sources/.

```
   # tar zxvf libxml2-2.6.16.tar.gz
   # cd libxml2-2.6.16/
   # ./configure --prefix=/usr/local/libxml2 &> configure.log
   # make &> make.log
   # make install &> install.log
```

The zlib library must be installed.

Download a latest PHP distribution from http://www.php.net/

```
   # cd /usr/local/src
   # tar zxvf php-4.3.9.tar.gz
   # cd php-4.3.9
   # ./configure \
--enable-pcntl \
--with-dom=/usr/local/libxml2 --with-zlib-dir=/usr --disable-cgi
   # make clean
   # make
   # make install
```

The configure option '--enable-pcntl', which is for process control in PHP, is required in job manager script module. The '--with-dom' is required for XML processing in PHP.
The '--with-zlib-dir' is required for libxml2 in PHP.

1.2.2.6 PHP4 + Apache Web Server (optional)

Apache should be configured before compiling PHP.
Download a latest apache distribution from http://www.apache.org/

```
   # cd /usr/local/src
   # tar zxvf apache_1.3.33.tar.gz
   # cd apache-1.3.33/
   # ./configure
```

Download a latest PHP distribution from http://www.php.net/

```
   # cd /usr/local/src
   # tar zxvf php-4.3.9.tar.gz
   # cd php-4.3.9
   # ./configure --with-apache=../apache_1.3.33/ \
   --with-config-file-path=/etc/httpd \
--with-mysql=/usr/local/mysql --enable-pcntl \
--with-dom=/usr/local/libxml2 --with-zlib-dir=/usr --disable-cgi
   # make clean
   # make
   # make install
```

Compile the Apache web server and install it.

```
   # cd /usr/local/src/apache-1.3.33/
   # ./configure --prefix=/usr/local/apache \
   --activate-module=src/modules/php4/libphp4.a
   # make clean
   # make
   # make install
```

Setup the PHP installation

```
   # cd /usr/local/src/php-4.3.9
   # mkdir /etc/httpd; cp   php.ini-dist   /etc/httpd/php.ini
```

Setup the Apache web server

```
   # vi /usr/local/apache/conf/httpd.conf
      ...
```

LINE 808(approx.): add a line

```
      # PHP
      AddType application/x-httpd-php .php
```

```
</IfModule>
        ...
        :wq
```

{Start | stop | restart} the apache web server

```
# /usr/local/apache/bin/apachectl {start | stop | restart}
```

1.2.2.7 OpenPBS and Cluster Configuration

Computing nodes in a cluster should be configured for rsh and ssh. The job manager script module uses ssh for executing remote program in other computing nodes in the cluster. The rsh have a problem to be used for this purpose. To configure ssh add host keys of all the computing nodes to /etc/ssh/ssh_known_hosts of each computing nodes. The hostname in the known_hosts file should be fully qualified domain name(FQDN).

1.2.3 Installing GRASP

JSS enables a Grid job to submit to resources managed by RMS. This service could be installed at Linux based server. Even though JSS could be deployed with RMS at the same service container, we recommend separate installation.

RMS enables a Grid job to allocate resources and be executed at computational nodes in local resource. This service could be deployed at front node of each Linux based cluster.

GSS selects best-fit resources for a Grid job automatically. It uses GAIS, the information service, to find out resources' status and RRS in selected resources to make reservations.

In addition, we provide two kinds of packages: one is a package containing both a command line interface (CLI) and a graphic user interface (GUI), and the other is a package providing a web interface (WI) based on Gridsphere portlet.

Download

http://kmi.moredream.org/downloads/index.php

You can download the whole package of GRASP from the web site written above. And then you can get following files of each components of GRASP.

```
Grasp-0.9
|-- jobsubmissioin-0.3.tar.gz
|-- mrmfs-0.3.tar.gz
|-- gridscheduling-0.3-src.tar.gz
|-- globus_gass_copy-srb-0.1.tar.gz
|-- grasp-client-0.2.tar.gz
`-- jobsubmission-portlet-0.3.tar.gz
```

1.2.3.1 JSS (Job Submission Service)

A. Installation

As the globus container administrator’s account,

```
$ tar zxvf jobsubmission-0.3.tar.gz
$ cd ./jobsubmission
$ ./install-gt3-jobsubmission $GLOBUS_LOCATION
$ su -
# $GLOBUS_LOCATION/bin/setperm.sh
```

B. Configuration

1. Check if there are hosts to be installed resource manager system in /etc/hosts file.

1.2.3.2 GSS (Grid Scheduling Service)

A. Installation

As the globus container administrator's account,

```
$ tar zxvf gridscheduling-0.1-src.tar.gz
$ cd ./gridscheduling-0.1
$ ./gss-install $GLOBUS_LOCATION
```

B. Configuration

$GLOBUS_LOCATION/etc/base-info-service.xml

This file contains the information of a Grid information service which GSS will contact to query resource information. The administrator has to indicate the address of the information service, service data name of resource information, and namespace of the service data.

1.2.3.3 RMS (Resource Manager Service) and RRS (Resource Reservation Service)

Because both RMS and RRS must be installed simultaneously on same container, both services are packaged to one file: mrmfs-0.11.tar.gz

A. Required software

- MySQL Database (tested under 3.23.49, 4.0.16, and 4.0.20)
- PHP4 (4.3.4 or latest)
- JDBC Driver: MySQL-Connector/J (tested under 3.0.14)

B. Optional software

- PHP4 + Apache Web server (for reservation status monitoring)
- OpenPBS (Portable Batch System)
- SRB enabled globus-url-copy

C. Installation of SRB enabled globus-url-copy

```
$ tar zxvf globus_gass_copy-srb-0.1.tar
$ cd globus_gass_copy-srb
$ mkdir /usr/local/srb
$ tar zxvf SRB3_2_1e.tar.gz –C /usr/local/srb
$ export SRB_LOCATION=/usr/local/srb/SRB3_2_1e
$ ./install.sh
```

D. Configuration of SRB enabled globus-url-copy

You should edit the ~/.srb/.MdasEnv file to use SRB server. The ~/.srb/.MdasEnv file includes following default configuration information to connect to SRB server.

- mdasCollectionName: default collection name
- mdasDomainName: default domain name
- srbUser: default SRB user id
- srbHost: default host IP of SRB server
- srbPort: default host port of SRB server
- defaultResource: default storage resource name
- AUTH_SCHEME: default authentication mechanism: PASSWD_AUTH, GSI_AUTH, and ENCRYPT1 (You have to specify AUTH_SCHEME.)
- SERVER_DN: server DN of proxy to invoke SRB server (If you choose GSI_AUTH for AUTH_SCHEME, you should specify.)

E. Testing of SRB enabled globus-url-copy

After configuring the above instructions, you should be able to execute `globus-url-copy.`

As the globus container administrator’s account,

```
$ grid-proxy-init
$ globus-url-copy \
srb://username.userdomain@IPADDRESS/collectaioname/filen
ame \
file:////tmp/filename
```

```
$ more /tmp/filename
```

F. Installation of RMS and RRS

As the globus container administrator’s account,

```
$ tar zxvf mrmfs-0.3.tar.gz
$ cd ./mrmfs
$ ./install-gt3-mrmfs $GLOBUS_LOCATION
$ su -
# $GLOBUS_LOCATION/bin/setperm.sh
```

G. Configuration of RMS and RRS

After building the service, we should do some configurations.

(a) Configuring Database

We provide SQL files to create or drop database in $GLOBUS_LOCATION/etc/reservation-sql.

Create a database named ‘moredream’ and make tables:

```
$ mysql [–u user] [–p]
mysql> create database moredream;
mysql> quit
$ cd $GLOBUS_LOCATION/etc/reservation-sql
$ mysql [–u user] [-p] moredream < create_tables.sql
```

Refer to other documents to use mysql command.

(b) Edit configuration file

Open $GLOBUS_LOCATION/etc/reservation.conf and edit the database connection values:

```
$ vi $GLOBUS_LOCATION/etc/reservation.conf
#
# reservation.conf
###
```

```
### database connection
###
dbhost=hostname.example.com
dbport=3306
dbuser=root
dbpass=password
dbname=moredream
###
### reservation service
###
res.resid_prefix=hostname.example.com
res.interval=3000
res.total_nodes=10
# 86400 = 3600*24   = 1 day
# 604800 = 3600*24*7 = 1 week
# 10800 = 3600 * 3   = 3 dyas
res.default_duration=1800
res.default_start_before=10800
res.max_duration=86400
res.start_not_before=60
res.start_not_after=604800
```

(c) Starting and Testing of RMS and RRS

Now, you are ready to start reservation service. Start the globus container.

```
$ globus-start-container
...
http://...:8080/ogsa/services/base/grasp/ReservationService
...
```

To test if RRS is correctly deployed and configured, run a test client program:

```
$ $GLOBUS_LOCATION/bin/test-rrs
 http://127.0.0.1:8080/ogsa/services/base/grasp/ReservationSer
vice test
Database connection was successful
The service is correctly deployed
```

1.2.3.4 Client Tools

A. A client package containing both the CLI and the GUI: grasp-client-

0.1.tar.gz

This package could be run on both Windows and Linux. This package is also included in JSS package.

(a) Required

- Globus Toolkit 3.2.1 WS Core
  (http://www-unix.globus.org/toolkit/downloads/3.2.1/#core)

(b) Download

http://kmi.moredream.org/downloads/index.php

(c) Linux Installation

Note: Before installing, you must set environment variable GLOBUS_LOCATION and copy grasp-client-0.1.tar.gz to $GLOBUS_LOCATION.

```
$ cd $GLOBUS_LOCATION
$ tar zxvf grasp-client-0.2.tar.gz
```

(d) Linux Configuration

You can specify default factory address in configuration file:

`$HOME/.globus/.grasprun`.

```
factory=http://ipaddress:port
```

(e) Windows Installation

Note: Before installing, you should set environment GLOBUS_LOCATION

1. unzip grasp-client-0.2.zip to %GLOBUS_LOCATION%

(f) Windows Configuration

You can specify default factory address in configuration file: `%HOME%\.globus\.grasprun`, where %HOME% is home directory. In case of Windows XP and 2000, home directory is "C:\Documents and

Settings\username\"

```
factory=http://ipaddress:port
```

B. A Job submission portlet package providing the WI: jobsubmission-portlet-0.1.tar.gz

(a) Required

- Gridsphere 2.0.1
- Gridportlets portlet

(b) Download

http://kmi.moredream.org/downloads/index.php

(c) Installation

```
 $ cd $GRIDSPHERE_LOCATION/projects
 $ tar zxvf jobsubmission-portlet-0.3.tar.gz
 $ cd jobsubmission-portlet
 $ ant install
```

1.2.3.5 Testing

A. Running the first job

Now you can test that the services works properly with a simple job. This example executes a single job to echo some arguments by "FORK" local job manager. It determines the resources not by GSS but by user's assignment. Therefore, you need to edit the string rms_machine in $GLOBUS_LOCATION/schema/base/grasp/jobsubmission/examples/fork_single.xml to be actual hostname deployed RMS to wish to run a job. You should check if there is hostname of installed job submission machine in /etc/hosts file. Here we use a job submission client "grasprun" to make a job submitted to JSS.

```
$ grid-proxy-init
$ grasprun -factory
http://jobsubmission_machine:8080/ogsa/services/base/gra
sp/JobSubmissionFactoryService -file
$GLOBUS_LOCATION/schema/base/grasp/jobsubmission/example
s/fork_single.xml
```

Note: If you have configured the factory address in ~/.globus/.grasprun file, you do not have to specify –factory option.

If you want to make RMS use “PBS” instead of “FORK”, you should try pbs_single.xml instead of fork_single.xml

```
$ grasprun –factory
http://jobsubmission_machine:8080/ogsa/services/base/gra
sp/JobSubmissionFactoryService -file
$GLOBUS_LOCATION/schema/base/grasp/jobsubmission/example
s/pbs_single.xml
```

If you want to automatically determine resources by GSS, you should try single.xml.

```
$ grasprun -factory
http://jobsubmission_machine:8080/ogsa/services/base/gra
sp/JobSubmissionFactoryService -file
$GLOBUS_LOCATION/schema/base/grasp/jobsubmission/example
s/single.xml
```

1.2.4 Operation of GRASP services

As you might get an intuition where to install and use each service in GRASP from the architecture, each service of GRASP has to be properly installed and operated. Please understand the Figure 1-1 and the role of each service before deployment. Both JSS and GSS do not have to be installed together on a same computing node and they could be operated on the same machine or separated.
Followings are what you have to know to operate services properly.

1.2.4.1 JSS

JSS enables a Grid job to submit to resources by using RMS. This service could be installed at Linux based server. Even though JSS could be deployed with RMS at the same service container, we recommend separate installation.

A. Logging

JSS provide logging support by adding following three lines to **$GLOBUS_LOCATION/ogsilogging.properties** file where jobsubmission.log is a target file to append the log for job submission.

```
org.moredream.ogsa.impl.base.grasp.jobsubmission.JobSubmi
ssionThread=jobsubmission.log,info
org.moredream.ogsa.impl.base.grasp.jobsubmission.JobSubmi
ssionImpl=jobsubmission.log,info
org.moredream.ogsa.impl.base.grasp.jobsubmission.Multiple
JobSubmissionThread=jobsubmission.log,info
```

1.2.4.2 GSS

A. $GLOBUS_LOCATION/etc/sched-plugin-conf.xml

This file provides information of the scheduling plugins which is included in the GSS. GSS can have several scheduling plugins. Whenever a plugin is added, the administrator has to add required information in this file. The contents of this file will be provided to users in the form of service data of GSFS (Grid Scheduling Factory Service).

1.2.4.3 RMS

RMS enables a Grid job to allocate resources and be executed at computational nodes in local resource. This service could be deployed at front node of each Linux based cluster. If you want to use SRB server at machine installed RMS, you should install the SRB enabled globus-url-copy.

A. Logging

RMS provide logging support by adding following four lines to **$GLOBUS_LOCATION/ log4j.propertie** file. Logging information will be appended to ~/.globus/uhe-hostname/log file of each local account.

```
log4j.category.org.moredream.ogsa.impl.base.grasp.rms.job
manager.ResourceManagerImpl=DEBUG
log4j.category.org.moredream.ogsa.impl.base.grasp.rms.job
manager.JobManager=DEBUG
log4j.category.org.moredream.ogsa.impl.base.grasp.rms.job
manager.JobManagerScript=DEBUG
log4j.category.org.moredream.ogsa.impl.base.grasp.rms.job
manager.JobExecutionTimeHelper=DEBUG
```

1.2.4.4 RRS

RRS has one configuration file related to database connection and one module to help monitoring the reservation status in

$GLOBUS_LOCATION/etc directory.

A. Logging

RRS provide logging support by adding following two lines to **$GLOBUS_LOCATION/ogsilogging.properties** file where reservation.log is a target file to append the log for resource reservation.

org.moredream.ogsa.impl.base.grasp.reservation.impl.ReservationProvider =reservation.log,trace

org.moredream.ogsa.impl.base.grasp.reservation.impl.ReservationManager Thread=reservation.log,trace

B. Database Connection

Using $GLOBUS_LOCATION/etc/reservation.conf, you can configure the database connection for RSS.

```
#
# reservation.conf
###
### database connection
###
dbhost=hostname.example.com
dbport=3306
dbuser=root
dbpass=password
dbname=moredream
###
### reservation service
###
res.resid_prefix=hostname.example.com
res.interval=3000
res.total_nodes=10
# 86400 = 3600*24   = 1 day
# 604800 = 3600*24*7 = 1 week
# 10800 = 3600 * 3  = 3 dyas
res.default_duration=1800
res.default_start_before=10800
res.max_duration=86400
res.start_not_before=60
res.start_not_after=604800
```

C. Monitoring Reservation Status

Using $GLOBUS_LOCATION/etc/reservation-dumpdb module included in the distribution, you can monitor the reservation status.

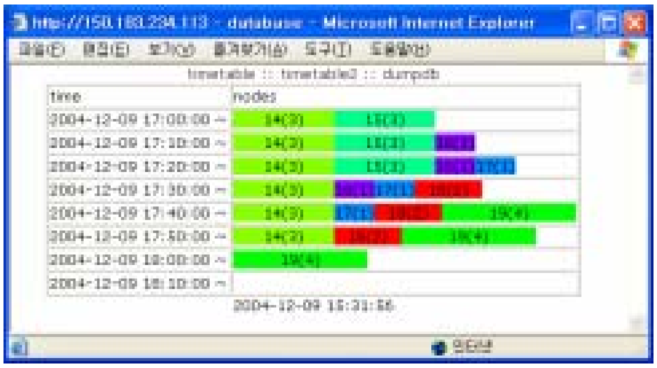
For that, you need to install Apache + PHP4 to a web server host.

Extract the distribution file under the web root directory (e.g. /usr/local/apache/htdocs) in your web server. Edit the config.php to configure database connection parameters:

```
 $ vi dumpdb/config.php
 ...

 # database connection
 $conf['dbhost']   = "localhost";
 $conf['dbuser']   = "root";
 $conf['dbpasswd'] = "";
 $conf['dbname']   = "moredream";
 ...
```

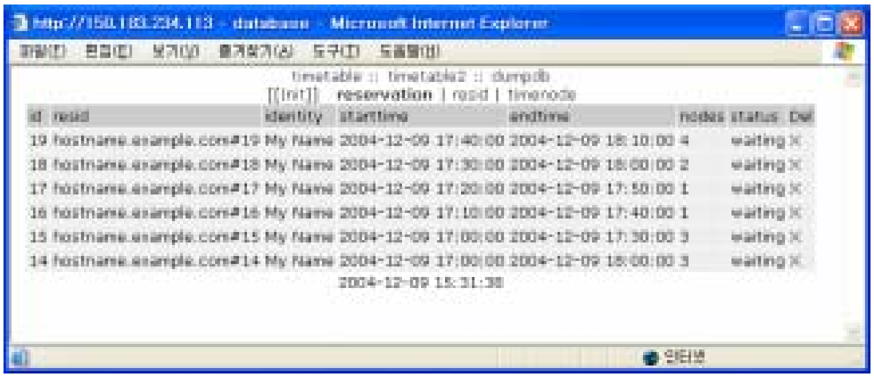
And open dumpdb.php using your web browser.


http://150.183.234.113 - database - Microsoft Internet Explorer
파일(F) 편집(E) 보기(V) 즐겨찾기(A) 도구(T) 도움말(H)
timetable :: timetable2 :: dumpdb
인터넷

time	nodes
2004-12-09 17:00:00 ~	14(3) 15(3)
2004-12-09 17:10:00 ~	14(3) 15(3) 16(1)
2004-12-09 17:20:00 ~	14(3) 15(3) 16(1) 17(1)
2004-12-09 17:30:00 ~	14(3) 16(1) 17(1) 18(2)
2004-12-09 17:40:00 ~	14(3) 17(1) 18(2) 19(4)
2004-12-09 17:50:00 ~	14(3) 18(2) 19(4)
2004-12-09 18:00:00 ~	19(4)
2004-12-09 18:10:00 ~	

2004-12-09 15:21:56

Figure 1-8 Monitoring reservation status using web browser



timetable :: timetable2 :: dumpdb

[[init]] **reservation** | resid | timenode

id	resid	identity	starttime	endtime	nodes	status	Del
19	hostname.example.com#19	My Name	2004-12-09 17:40:00	2004-12-09 18:10:00	4	waiting	×
18	hostname.example.com#18	My Name	2004-12-09 17:30:00	2004-12-09 18:00:00	2	waiting	×
17	hostname.example.com#17	My Name	2004-12-09 17:20:00	2004-12-09 17:50:00	1	waiting	×
16	hostname.example.com#16	My Name	2004-12-09 17:10:00	2004-12-09 17:40:00	1	waiting	×
15	hostname.example.com#15	My Name	2004-12-09 17:00:00	2004-12-09 17:30:00	3	waiting	×
14	hostname.example.com#14	My Name	2004-12-09 17:00:00	2004-12-09 18:00:00	3	waiting	×

2004-12-09 15:31:38

Figure 1-9 Database table of reservation items

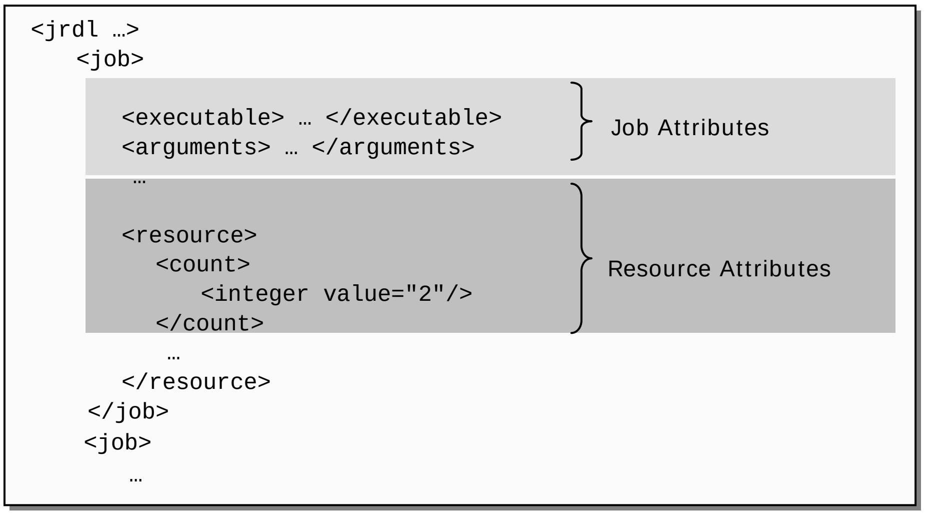
1.3 Using GRASP

1.3.1 JRDL (Job & Resource Description Language)

1.3.1.1 Overview

The Globus Resource Specification Language (RSL) 2 provides a common interchange language to describe a Grid job. However the RSL 2 does not contain user preferences to select automatically resources for allocating the job. Moreover the RSL 2 has no features to describe elements required to co-allocate the job and to represent sequent jobs. Therefore we provide the Job and Resource Description Language (JRDL) as a general language to describe a job and user preferences required allocating resources for the job in Grid environment based on XML.

JRDL has a collection of jobs, each of which is "an atomic task" of a workflow specification or other kinds of a complex, multi-step application. A job consists of job attributes and resource attributes as showed in Figure 1-11. Job attributes are elements to need to reserve resources in advance, allocate resources, and execute job. Resource attributes are user preferences to determine resources to execute a job. Here we cover what both kinds of attributes include and how each user should specify each attribute.



```
<jrdl …>
   <job>

      <executable> … </executable>
      <arguments> … </arguments>
       …

      <resource>
         <count>
            <integer value="2"/>
         </count>
          …
      </resource>
    </job>
    <job>
       …
```

Figure 1-11 JRDL containing a collection of jobs, each of which has both job and resource attributes

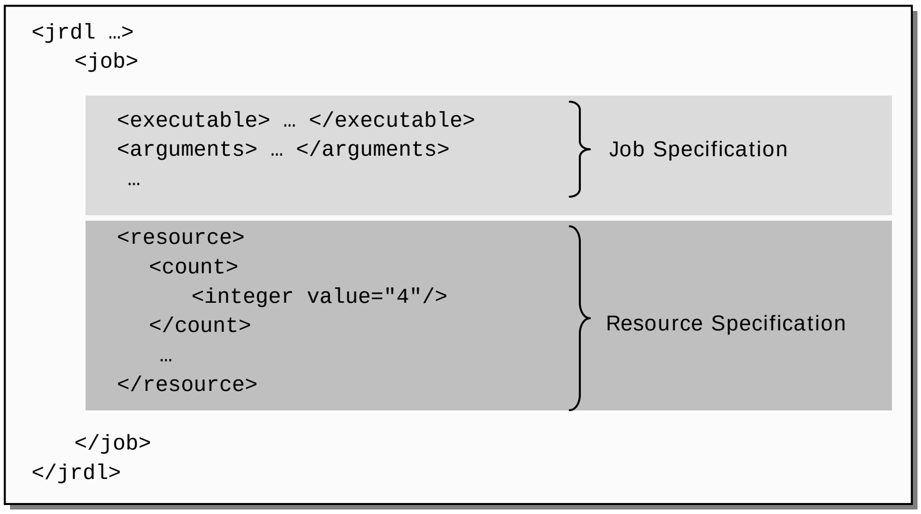
The job attributes includes executable attributes, job type attribute, file staging attributes, job termination attributes, clean up attributes and co-allocation attributes. Executable attributes are elements for executing a job, including executable, arguments, working directory, environment, standard input, output, and error, and library path. Job type attribute is element to specify the kind of job. File staging attributes are elements for staging in files to execute a job and staging out. Job termination attributes are elements to specify start and termination time of a job to reserve the resources in advance. Resource allocation attributes are related to local resource allocation including local resource address (`resourceManagerContact`) and job manager type (`jobManagerType`) as showed in Figure 1-12.

```
<jrdl …>
   <job>

      <executable> … </executable>
       …
      <subjob>
         <resourceManagerContact>
            <string>
              <stringElement value=
                 "http://eros01.gridcenter.or.kr:8080"/>
            </string>
         </resourceManagerContact>
         <jobManagerType>
              <enumeration>
                  <enumerationValue><pbs/></enumerationValue>
               </enumeration>
         </jobManagerType>
         <count>
             <integer value="2"/>
          </count>
          …
      </subjob>
```

Figure 1-12 Job Containing only the Job Specification

The resource specification is user preference to determine resources to submit a job, including total CPU count, OS type, processor type, size and availability of memory and storage, free CPU, processor load, local job manager type, and scheduler plug-in type. If user specifies the resource allocation attributes in the job specification, which means user want to determine the resources manually without scheduler, he/she does not have to describe the resource specification as showed in Figure 1-12. However he/she should specify total CPU count if he/she wants to use scheduler as showed in Figure 1-13.


```
<jrdl …>
   <job>

      <executable> … </executable>
      <arguments> … </arguments>
       …
      <resource>
         <count>
            <integer value="4"/>
         </count>
          …
      </resource>

   </job>
</jrdl>
```

Figure 1-13 Job Containing both the Job Specification and User Preferences to Select Automatically Resources by Scheduler

Basically, we use RSL2 schema to describe contents of each attribute. For example, job executable attribute must include path element to describe executable file as shown in Figure 1-14. In addition, as RSL2 provides, each element could include `substitutionRef` element replaced by the element where `substituionDef` element defines. For instance, job executable attribute showed in Figure 1-14 could be replaced with job executable attribute including `substitutionRef` element illustrated in Figure1-15.

```
<jrdl …>
   <job>

       <executable>
         <path>
          <stringElement value="/home/user/executable"/>
        </path>
       </executable>
       …
   </job>
</jrdl>
```

Figure 1-14 Job executable attribute

```
<jrdl …>

   <substitutionDef name="HOME">
     <stringElement value="/home/user"/>
   </substitutionDef>

   <job>
       <executable >
         <path>
           <substitutionRef name="HOME"/>
          <stringElement value="/executable"/>
          </path>
       </executable >…
   </job>

</jrdl>
```

Figure 1-15 Job executable attribute including substituionRef element

By default, as illustrated Figure 1-15, if you want to use substitutionRef element, substituionDef element must be specified except reserved substituionDef elements to be defined at local resources as shown in Table 1-1.

Table 1-1 Reserved substitution definition

Substitution Definition	Meaning
HOME	Home directory path of user account
LOGNAME	Log name
GLOBUS_LOCATION	Globus location
X509_CERT_DIR	Certificate directory
GLOBUS_HOST_CPUTYPE	Host CPU type
GLOBUS_HOST_MANUFACTURER	Host manufacturer
GLOBUS_HOST_OSNAME	Host OS name
GLOBUS_HOST_OSVERSION	Host OS version
GLOBUS_RMS_JOB_CONTACT	The contact address of RMS
GLOBUSRUN_GASS_URL	The address of GASS server that a job submission client invoke automatically

1.3.1.2 Job attributes

Job attributes are elements to need to reserve resources in advance, allocate resources, and execute job, including executable attributes, job type attribute, file staging attributes, job termination attributes, clean up attributes and co-allocation attributes. Executable attributes are elements for executing a job, including executable, arguments, working directory, environment, standard input, output, and error, and library path. Job type attribute is element to specify the kind of job. File staging attributes are elements for staging in files to execute a job and staging out. Job termination attributes are elements to specify start and termination time of a job to reserve the resources in advance. Co-allocation attributes are related to local resource allocation including local resource addresses, job manager type and CPU count.

Basically, a user might want to automatically determine resources by meta-scheduler as illustrated in Figure 1-11. However If user wants to determine resources manually, co-allocation attributes must be used as showed in Figure 1-16.

```
<jrdl …>
   <job>

      <executable> … </executable>
       …
      <subjob>
         <resourceManagerContact>          Co-allocation attributes
            <string>
              <stringElement value=
                 "http://eros01.gridcenter.or.kr:8080"/>
            </string>
         </resourceManagerContact>
         <jobManagerType>
              <enumeration>
                 <enumerationValue><pbs/></enumerationValue>
               </enumeration>
         </jobManagerType>
         <count>
             <integer value="2"/>
         </count>
          …
      </subjob>
      <subjob> … </subjob>

   </job>
```

Figure 1-16 Co-allocation attributes to specify local resource to submit a job

When a job is submitted to resources, the job should be divided into several subjobs, each of which might has different job attributes. Therefore, you can specify different job attributes for each subjob as illustrated in Figure 1-17. In this job, there are two subjobs, which have different executable file. One is “a.out,” and the other is “b.out”.

```
<jrdl …>
   <job>
      <executable>
         <path><stringElement value=”a.out”/></path>
      </executable>
       <jobType>
          <enumeration>
             <enumerationValue><htc/></enumerationValue>
          </enumeration>
       </jobType>

       <subjob>
          <executable>
             <path><stringElement value=”b.out”/></path>
          </executable>
       </subjob>
       <resource>
         <count>
           <integer value="2"/>
         </count>
       </resource>
   </job>
</jrdl>
```

Figure 1-17 Job containing different job attributes for a subjob

A. Executable attributes

(a) Job executable attribute

The source of executable file is local or remote file. If executable file is a form of GASS-compatible URL like “gsiftp://ip/path/file”, executable file could be staged from the GASS-compatible file server.

An element in your document might look like this:

```
<executable>
   <path>
      <stringElement value=”EXECUTABLE”/>
    </path>
</executable>
```

(b) Job arguments attribute

```
<arguments>
  <stringArray>
    <string>
      <stringElement value="arg1"/>
    </string>
    <string>
      <stringElement value="arg2"/>
    </string>
  </stringArray>
</arguments>
```

An element in your document might look like this:

(c) Job directory attribute

An element in your document might look like this:

```
<directory>
  <path>
     <stringElement value="/path/to"/>
   </path>
</directory>
```

(d) Environment attribute

```
<environment>
  <hashtable>
    <entry name="HOME">
      <stringElement value="/path/to"/>
    </entry>
  </hashtable>
</environment>
```

An element in your document might look like this:

(e) Standard input attribute

The source of standard input file is `STDIN`. `STDIN` is local or remote file. If STDIN is a form of GASS-compatible URL, `STDIN` could be received from the

GASS-compatible file server.

An element in your document might look like this:

```
<stdin>
  <path>
    <stringElement value=”STDIN”/>
  </path>
</stdout>
```

(f) Standard output attribute

The destination of standard output file is STDOUT. Standard output file might have multiple destinations and each destination is local or remote file.

An element in your document might look like this:

```
<stdout>
  <pathArray>
    <path>
      <stringElement value="STDOUT"/>
    </path>
  </pathArray>
</stdout>
```

(g) Standard error attribute

The destination of standard error file is STDERR. Standard error file might have multiple destinations and each destination is local or remote file.

An element in your document might look like this:

```
<stderr>
  <pathArray>
    <path>
      <stringElement value="STDERR"/>
    </path>
  </pathArray>
</stderr>
```

(h) Library path attribute

Job might need to specify library paths. Each library path must be local path.

An element in your document might look like this:

```
<libraryPath>
  <pathArray>
    <path>
      <stringElement value="/librarypath/to"/>
    </path>
  </pathArray>
</libraryPath>
```

B. Job type attributes

(a) Job type attribute

Job type attribute is element to specify the kind of job. JRDL has three kinds of job type: single, xmpi, and htc.

An element in your document might look like this:

```
<jobType>
  <enumeration>
    <enumerationValue>
       <htc/>
    </enumerationValue>
  </enumeration>
</jobType>
```

C. File staging attributes

(a) File staging in attribute

You can specify a list of ("remote URL" "local file") pairs which indicate files to be staged into the cache. Symbolic link from the cache to the "local file" path will be made.

```
<fileStageIn>
   <fileInputArray>
      <fileInput>
         <url>
            <urlElement value="gsiftp://ip/path/file"/>
         </url>
         <path>
            <stringElement value="file"/>
         </path>
      </fileInput>
   </fileInputArray>
</fileStageIn>
```

An element in your document might look like this:

(b) File staging out attribute

You can specify a list of ("local file" "remote URL") pairs which indicate files to be staged from the job to a GASS-compatible file server.

```
<fileStageOut>
   <fileOutputArray>
       <fileOutput>
          <path>
             <stringElement value="file"/>
          </path>
          <url>
             <urlElement
value="gsiftp://ip/path/file"/>
          </url>
       </fileOutput>
   </fileOutputArray>
```

An element in your document might look like this:

D. Job lifetime attributes

These attributes are attributes related to the start time and end time of a job. Job start time and Job start before are mutually exclusive. Therefore, if you want to specify start time of a job, you have to determine between Job start time and Job start before.

(a) Job start time

If a job should start at a specific time, you should describe a time by Job start time. The dateTime data type is used to specify a date and a time.

The dateTime is specified in the following form "YYYY-MM-DDThh:mm:ss" where:

- YYYY indicates the year
- MM indicates the month
- DD indicates the day
- T indicates the start of the required time section
- hh indicates the hour
- mm indicates the minute
- ss indicates the second

Note: All components are required.

To specify a time zone, you can either enter a dateTime in UTC time by adding a "Z" behind the time.

An element in your document might look like this:

```
<jobStartTime>2004-10-21T01:10:00.000Z</jobStartTime>
```

(b) Job start before

If a job should start before a specific duration, you should describe a time interval by Job start before. The duration data type is used to specify a time interval.

The time interval is specified in the following form "PnYnMnDTnHnMnS" where:

- P indicates the period (required)
- nY indicates the number of years
- nM indicates the number of months
- nD indicates the number of days
- T indicates the start of a time section (required if you are going to specify hours, minutes, or seconds)
- nH indicates the number of hours
- nM indicates the number of minutes
- nS indicates the number of seconds

An element in your document might look like this:

```
<jobStartBefore>PT10H3M</jobStartBefore>
```

(c) Job duration

If a job should execute during a specific interval, you should describe a time interval by Job duration. The duration data type is used to specify a time interval.

An element in your document might look like this:

```
<jobDuration>PT10H3M</jobDuration>
```

E. Clean up attributes

(a) Clean up attribute

This attribute specifies files to clean up after a job has completed.

An element in your document might look like this:

```
<fileCleanUp>
  <pathArray>
    <path>
      <stringElement value="cleanUpFile"/>
    </path>
  </pathArray>
</fileCleanUp>
```

F. Co-allocation attributes

If you want to manually determine the resources, you should specify co-allocation attributes.

(a) Resource manager contact attribute

You should specify the contact address of RMS.

An element in your document might look like this:

```
<resourceManagerContact>
  <string>
    <stringElement value="http://service-container"/>
  </string>
</resourceManagerContact>
```

(b) Job manager attribute

You should specify the type of local job manager. We are supporting two kinds of type: fork and pbs.

An element in your document might look like this:

```
<jobManagerType>
    <enumeration>
        <enumerationValue>
          <pbs/>
        </enumerationValue>
    </enumeration>
</jobManagerType>
```

(c) Count attribute

You should specify the count of CPU to be allocated at RMS.

An element in your document might look like this:

```
<count>
   <integer value="5" />
</count>
```

1.3.1.3 Resource attributes

The resource attributes are user preferences to determine resources to submit a job, including total CPU count, OS type, processor type, size and availability of memory and storage, free CPU, processor load, local job manager type, and scheduler plug-in type.

A. Count attribute

You must specify the total count of CPU to be allocated to submit a job.
An element in your document might look like this:

```
<count>
   <integer value="5" />
</count>
```

B. Operating system attribute

You might need to describe the specific name of operating system of nodes to be selected in resource pools.
An element in your document might look like this:

```
<operatingSystem>
   <name>
      <string>
         <stringElement value="Linux"/>
      </string>
   </name>
</operatingSystem>
```

C. Processor attribute

You might need to describe the minimum clock speed of processor of nodes to be selected in resource pools. The unit of clock speed is megahertz.
An element in your document might look like this:

```
<processor>
   <clockSpeed>
     <integer value="1000" />
   </clockSpeed>
</processor>
```

D. Minimum main memory attributes

(a) Minimum RAM available attribute

You might need to describe the minimum available RAM size of nodes to be selected in resource pools. The unit of RAM size is mega byte.

An element in your document might look like this:

```
<minMainMemory>
  <minRAMAvailable>
    <integer value="100" />
  </minRAMAvailable>
</minMainMemory>
```

(b) Minimum RAM size attribute

You might need to describe the minimum RAM size of nodes to be selected in resource pools. The unit of RAM size is mega byte.

An element in your document might look like this:

```
<minMainMemory>
  <minRAMSize>
    <integer value="256" />
  </minRAMSize>
</minMainMemory>
```

E. Minimum storage attribute

You might need to describe the minimum available storage size of nodes to be selected in resource pools. The unit of storage size is mega byte.

An element in your document might look like this:

```
<minStorage>
  <minStorageAvailable>
    <integer value="1000" />
  </minStorageAvailable>
</minStorage>
```

F. Minimum free CPU attribute

You might need to describe the minimum available CPU number of nodes to be selected in resource pools.

An element in your document might look like this:

```
<minFreeCPU>
  <integer value="4" />
</minFreeCPU>
```

G. Processor load attributes

(a) last15Min attribute

You might need to describe the average processor availability during last 15 minutes of nodes to be selected in resource pools. The average processor availability is expressed as a percentage.

An element in your document might look like this:

```
<processorLoad>
  <last15Min>
    <integer value="10" />
  </last15Min>
</processorLoad>
```

(b) last5Min attribute

You might need to describe the average processor availability during last 5 minutes of nodes to be selected in resource pools. The average processor availability is expressed as a percentage.

An element in your document might look like this:

```
<processorLoad>
  <last5Min>
    <integer value="10" />
  </last5Min>
</processorLoad>
```

(c) last1Min attribute

You might need to describe the average processor availability during last 1 minute of nodes to be selected in resource pools. The average processor availability is expressed as a percentage.

An element in your document might look like this:

```
<processorLoad>
  <last1Min>
    <integer value="10" />
  </last1Min>
</processorLoad>
```

H. Scheduling type attribute

You might need to describe the type of local job scheduler of nodes to be selected in resource pools. The type of scheduler must be either `fork` or `scheduler`.

An element in your document might look like this:

```
<schedulingType>
  <string>
    <stringElement value="scheduler"/>
  </string>
</schedulingType>
```

I. Scheduling plug-in attribute

You might need to describe the name of scheduling plug-in to be selected in resource pools. The name of plug-in must be either `Default Plugin` or another plugin-provider-defined name. The plugin name could be referenced by querying to the GAIS.

An element in your document might look like this:

```
<schedulingPlugin>
  <string>
    <stringElement value="Default Plugin"/>
  </string>
</schedulingPlugin>
```

1.3.1.4. JRDL Examples

Here are some typical JRDL examples to be used in job submission. There are three kinds of job types in JRDL: single, XMPI, and htc. For each job type, we are giving several examples.

A. Single job examples

1. This example is about a single job to use “FORK” local job manager and be submitted to dedicated host “rms_machine”

```
<?xml version="1.0" encoding="UTF-8"?>
<jrdl
xmlns="http://www.moredream.org/namespaces/2003/09/jr
dl">
  <job>
     <!-- executable attribute -->
    <executable>
      <path>
        <stringElement value="/bin/echo"/>
      </path>
    </executable>
    <!-- arguments attribute -->
```

```
      <arguments>
        <stringArray>
          <string>
            <stringElement value="arg1"/>
          </string>
          <string>
            <stringElement value="arg2"/>
          </string>
        </stringArray>
       </arguments>
       <!-- stdout attribute -->
       <stdout>
         <pathArray>
           <path>
             <stringElement value="stdout"/>
           </path>
         </pathArray>
       </stdout>
       <!-- stderr attribute -->
       <stderr>
         <pathArray>
           <path>
             <stringElement value="stderr"/>
           </path>
         </pathArray>
       </stderr>
       <!-- job type attribute-->
      <jobType>
        <enumeration>
          <enumerationValue>
            <single/>
          </enumerationValue>
        </enumeration>
      </jobType>
      <subjob>
         <resourceManagerContact>
             <string>
                <stringElement
value="http://rms_machine"/>
             </string>
</resourceManagerContact>
         <jobManagerType>
           <enumeration>
```

```
  <enumerationValue><fork/></enumerationValue>
             </enumeration>
         </jobManagerType>
         <count>
             <integer value="1"/>
         </count>
      </subjob>
   </job>
</jrdl>
```

2. This example is about a single job to use “PBS” local job manager and be submitted to dedicated host “rms_machine”

```
<?xml version="1.0" encoding="UTF-8"?>
<jrdl
xmlns="http://www.moredream.org/namespaces/2003/09/jrd
l">
  <job>
     <!-- executable attribute -->
    <executable>
      <path>
        <stringElement value="/bin/echo"/>
      </path>
    </executable>
    <!-- arguments attribute -->
    <arguments>
      <stringArray>
        <string>
          <stringElement value="arg1"/>
        </string>
        <string>
          <stringElement value="arg2"/>
        </string>
      </stringArray>
     </arguments>
     <!-- stdout attribute -->
     <stdout>
       <pathArray>
         <path>
           <stringElement value="stdout"/>
         </path>
```

```
          </pathArray>
       </stderr>
       <!-- job type attribute -->
      <jobType>
        <enumeration>
          <enumerationValue>
            <single/>
          </enumerationValue>
        </enumeration>
      </jobType>
      <subjob>
         <resourceManagerContact>
             <string>
                <stringElement
value="http://rms_machine"/>
             </string>
         </resourceManagerContact>
         <jobManagerType>
            <enumeration>

<enumerationValue><pbs/></enumerationValue>
            </enumeration>
         </jobManagerType>
         <count>
             <integer value="1"/>
         </count>
      </subjob>
    </job>
 </jrdl>
```

3. This example is about a single job to allocate resources automatically by meta-scheduler.

```
<?xml version="1.0" encoding="UTF-8"?>
<jrdl
xmlns="http://www.moredream.org/namespaces/2003/09/jr
dl">
  <job>
     <!-- executable attribute -->
    <executable>
    <path>
       <stringElement value="/bin/echo"/>
     </path>
  </executable>
       <!-- arguments attribute -->
       <arguments>
         <stringArray>
           <string>
             <stringElement value="arg1"/>
           </string>
           <string>
             <stringElement value="arg2"/>
           </string>
         </stringArray>
       </arguments>
       <!-- stdout attribute -->
       <stdout>
         <pathArray>
           <path>
             <stringElement value="stdout"/>
           </path>
         </pathArray>
       </stdout>
       <!-- stderr attribute -->
       <stderr>
         <pathArray>
           <path>
             <stringElement value="stderr"/>
           </path>
         </pathArray>
       </stderr>
       <!-- job type attribute -->
       <jobType>
         <enumeration>
           <enumerationValue>
             <single/>
           </enumerationValue>
         </enumeration>
      </jobType>
      <resource>
         <count>
            <integer value="1"/>
          </count>
       </resource>
    </job>
</jrdl>
```

1.3.2 Client Program Providing Command Line Interface (CLI) : grasprun

`grasprun` is a client program providing CLI to submit, monitor, and control a job as well as validate a job description language called JRDL. Here we describe the usage of `grasprun` for each functionality.

1.3.2.1 Validate a JRDL

`grasprun` can parse a job description language called JRDL, validate parsed JRDL, and then show each attribute of JRDL. You might specify like this:

```
$ grasprun -parse -f cpi_spec.xml
Job Type: XMPI
Executable: /home/guest01/kmi-test/cpi/cpi[local]
Environment: LD_LIBRARY_PATH[/usr/local/gt3.2.1/lib]
Stdout: stdout
Stderr: stderr
Subjob [0]
  Resource Manager Contact: http://vega01.gridcenter.or.kr:8080
  Job Manager Type: pbs
  Count: 10
```

, where –p or –parse option is parsing operation, and –f or –file option is JRDL file name.

1.3.2.2 Job Submission

grasprun provides two kinds of job submission modes: batch and interactive mode. If you want to submit, monitor, and control a job interactively, you might specify like this:

```
$ grasprun –f a.xml –factory http://factory_address:8080
-o Job ID: http://
factory_address:8080/ogsa/services/base/grasp/JobSubmissio
nFactoryService/hash-23449824-1112770816197
WAITING FOR JOB TO FINISH
=============== Job Status =================
Job Status: Pending
[vega01.gridcenter.or.kr, PBS] Unsubmitted
============================================
=============== Job Status =================
Job Status: Active
[vega01.gridcenter.or.kr, PBS] Active(vega03+vega02)
============================================
pi   is   approximately   3.1416009869231249,   Error   is
0.0000083333333318
wall clock time = 4.702783
Process 0 on vega03.gridcenter.or.kr
=============== Job Status =================
Job Status: Done
[vega01.gridcenter.or.kr, PBS] Done(vega03+vega02)
============================================
It takes 87.0 seconds.
```

, where –f or –file option is JRDL file name, –factory option is a service container address including JSS service, and –o option let standard output of job to print the console. If you configure the default setting for grasprun in ~/.globus/.grasprun file as following, you do not have to specify –factory option. Additionally, the message of job status is fully shown, as property “full” set to “true”.

```
factory=http://factory_address:8080
full=true
```

If you want to submit a job in a batch mode, you might specify like this:

```
$ grasprun -file cpi_spec.xml \
-b Job ID:
http://factory_address:8080/ogsa/services/base/grasp/JobSu
bmissionFactoryService/hash-28099439-1112773501104
```

1.3.2.3 Job List and Information

grasprun can list the submitted job. Especially for batch job, it is essential to get the list. You might specify like this:

```
$ grasprun -list
Job ID:
http://factory_address:8080/ogsa/services/base/grasp/JobSu
bmissionFactoryService/hash-23449824-1112770816197
Job ID: http://
factory_address:8080/ogsa/services/base/grasp/JobSubmissio
nFactoryService/hash-28099439-1112773501104
```

, where –list or –l option is list operation.

And also information of the job could be checked like this:

```
$ grasprun -info
http://factory_address:8080/ogsa/services/base/grasp/JobSubm
issionFactoryService/hash-23449824-1112770816197
Job ID:
http://150.183.234.231:8080/ogsa/services/base/grasp/JobSubm
issionFactoryService/hash-23449824-1112770816197
Subbmited Time: Thu Apr 07 09:40:41 KST 2005
Job Type: XMPI
Executable: /home/guest01/kmi-test/cpi/cpi[local]
Environment: LD_LIBRARY_PATH[/usr/local/gt3.2.1/lib]
Stdout: stdout, /dev/stdout[local]
Stderr: stderr, /dev/stderr[local]
Subjob [0]
   Resource Manager Contact:
http://vega01.gridcenter.or.kr:8080
   Job Manager Type: pbs
   Count: 10
```

, where –info or –i option is job information operation.

1.3.2.4 Job Monitoring and Controlling

Submitted job might be checked the status of the job like this:

```
$ grasprun -status
http://factory_address:8080/ogsa/services/base/grasp/JobSubm
issionFactoryService/hash-23449824-1112774942696
=============== Job Status =================
Job Status: Done
[eros01.gridcenter.or.kr, FORK] Done
============================================
```

, where –status or –s option is status operation.

And also, submitted job might be killed like this:

```
$ grasprun -kill
http://factory_address:8080/ogsa/services/base/grasp/JobSubm
issionFactoryService/hash-23449824-1112774942696
```

, where –kill or –k option is kill operation.

2. GAIS

2.1 Introduction

Grid information system is a critical component for Grid computing, by which all types of Grid resources are virtually integrated and their information can be effectually managed and accessed. Furthermore, the efficiency of Grid computing is dependent on the functionalities supported by Grid information system. But the existing information system such as MDS (Monitoring and Discovery System) of GT (Globus Toolkit), which is currently received wide publicity in Grid community, is not appropriate for a production-mode service or a long-lived service because it supports only basic functions. That is why we developed a new Grid information system named Grid Advanced Information System (GAIS), which is a versatile information system that provides information about the available resources on Grids and their status.
GAIS is the information services component of the MoreDream and is composed of a collection of OGSI-compliant services which add and extend the functionalities of GT3 MDS3. It is differentiated from the dynamic management and the flat network of directory servers mentioned below.

2.1.1 Components

GAIS is composed of three grid services and two information providers. Each service is related to manage and search information in a Grid, whereas two providers play information sources for the GAIS.

2.1.1.1 Datacan Factory Service (DFS)

Datacan (a compound word of “data” and “can”) is an enhanced version of GT3.x index service. Like an index service, it aggregates *Service Data* from Resource Services such as RIPS (Resource Information Provider Service) or other Grid service instances by means of the *Aggregator* mechanism. It also registers Grid service instances using the *ServiceGroup* mechanism. For these aggregation and registration, it uses the *RegistryPublishPrivder* mechanism. Additionally, it provides the following functionalities:

1) It removes stale data to assure data accuracy using the *Data Sweep* mechanism. When a datacan is created, the mechanism in the datacan calls a *ServiceDataSweeper*, which periodically checks the available time of registered service data and deletes old service data.
2) It has two types. The one is a public datacan (*pubcan*) to announce its information to a VO, and the other is a private datacan (*prican*) to share it only in a domain. A DFS administrator can configure a pubcan suitable for a VO according to her policy and she can also set up a prican to serve some users’ purpose in her domain. It operates together with CAS (Community Authority Service) to control access to a pubcan or prican (not implemented).

DFS manages the lifecycle of a datacan using the *Factory* mechanism and maintains the snapshot of DFS status (the list of published datacans) through the *Configuration* mechanism. The snapshot is stored in a configuration file. Figure 1-18 shows the structure of DFS.

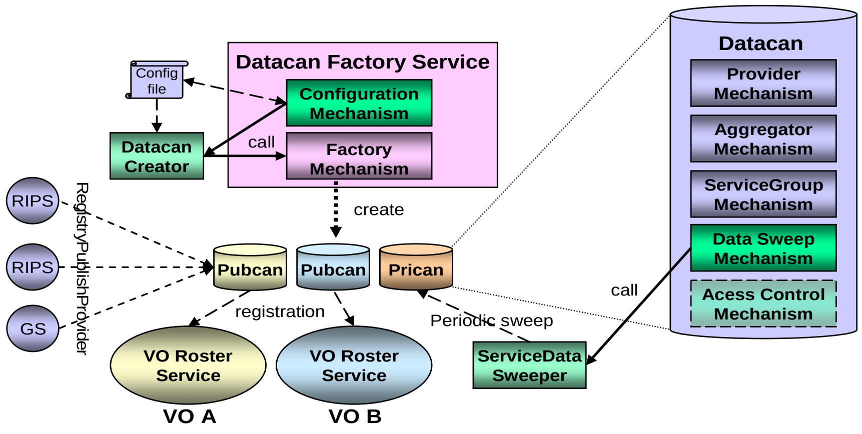


Figure 1-18 The structure of Datacan Factory Service

2.1.1.2 VO Roster Service (VRS)

Only one VRS exists in a VO because it typifies a VO. It manages the participants of VO and provides a registration interface to the VO. The structure of VRS is as Figure 1-19.

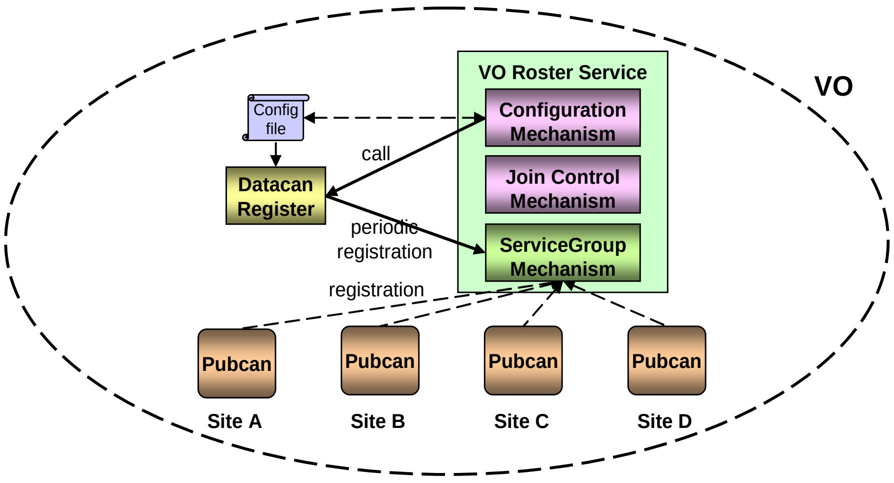


Figure 1-19 The structure of VO Roster Service

It provides the following functionalities:

1) It uses the *ServiceGroup* mechanism to register/unregister a datacan to its own VO.
2) It admits only a pubcan. The registration of a prican is rejected. The *Join Control* mechanism does this.
3) It makes use of the *Configuration* mechanism to store the snapshot of VO status (the list of registered datacan). But the status of resources in a VO changes dynamically. This may make the maintenance of the VO snapshot difficult. A *DatacanRegister* executes periodic registrations to preserve this.

2.1.1.3 VO Crawler Factory Service (VCFS)

VCFS provides a user with VO information. Only one VCFS exists in a VO because it is basically a service for a VO like VRS, but we recommend a site-based deployment of this service to avoid heavy load from plenty of users in a VO. This enables the load to be decentralized to each site in the VO. Figure 1-20 illustrates the structure of DFS.

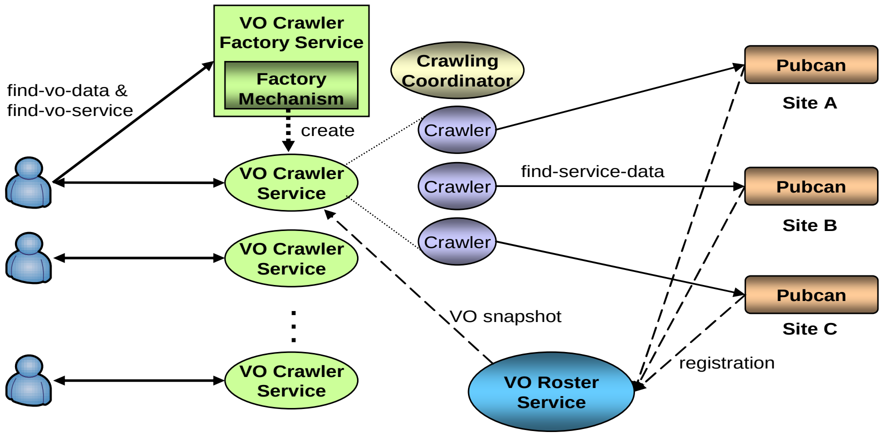


Figure 1-20 The structure of VO Crawler Factory Service

It provides the following functionalities:

1) This service has two query options. The one of two options is the *find-vo-data*, which crawls on VO information for a user. The other is the *find-vo-service*, which provides the location (GSH: Grid Service Handle) of a Grid service in a VO for a user. Actually, the *find-vo-service* is a special form of the *find-vo-data* to serve the convenience of a user.
2) It also creates the VO Crawler Service (VCS) using the Factory mechanism to protect a user session. VCS gains a VO snapshot from VRS. To achieve the efficiency of query, VCS creates the *Crawlers* corresponding to each participant (pubcan) using the Thread mechanism. Each crawler uses the OGSI *find-service-data* to query its own pubcan. The *CrawlingCoordinator* orchestrates each crawler's behavior.

2.1.1.4 MoreDream Providers

MoreDream Information Providers provide lots of information about data replication as well as computing resource. It is based on the use of provider execution mechanism. They are composed of McsScriptProvider and MseScriptProvider. MceScriptProvider provides lots of resource information used in K*Grid. It conforms to Glue schema and extends it. MseScriptProvider provides information about data replications. It defines a new information schema related to storage elements. You can easily obtain information that is produced in MCAT-enabled SRB (Storage Resource Broker) Server. If you'd like to add new information, you have only to create your own provider and register it to RIPS.

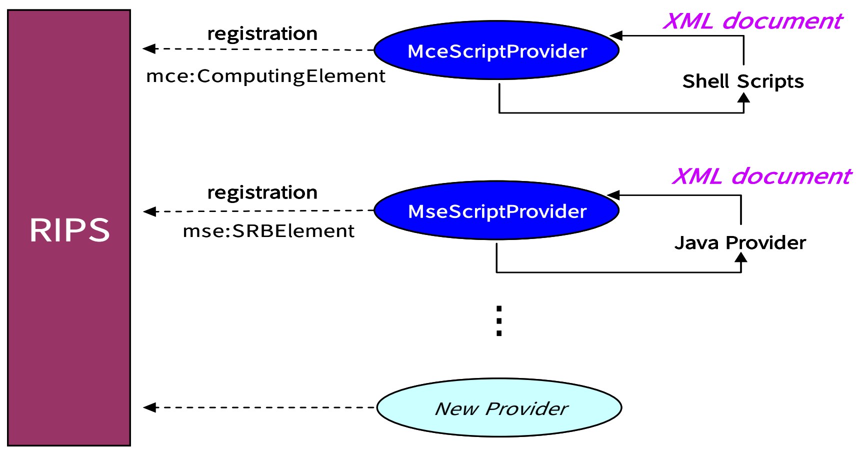


Figure 1-21 The registration of MoreDream Information Providers

2.1.2 Schema

GAIS uses the MoreDream schema, which adds and extends GLUE (Grid Laboratory Uniform Environment) schema. The schema is categorized into two element; MoreDream Computing Element (MCE) and MoreDream Storage Element (MSE). MCE enhances the computing element of GLUE schema 1.1 for supporting GRASP (Grid Resource Allocation Services Package), a resource management component of MoreDream. MSE is formed by processing the data replication information of SRB and it will be changed to agree to the storage element of GLUE schema later.

Table 1-2 shows the content of MCE.

Table 1-2 MoreDream Computing Element

Category	Object	Description	Unit
ComputingElement	Name	ComputingElement name	
	UniqueID	ComputingElement ID	
Info	LRMSType	Local Resource Manager type	
	LRMSVersion	Local Resource Manager version	

	GRAMVersion	GRAM version	
	HostName	Host name	
	GateKeeperPort	GateKeeper port	
	TotalCPUs	Total CPUs	
State	Staus	Queue status	
	TotalJobs	Total Jobs	
	RunningJobs	Running Jobs	
	WaitingJobs	Waiting Jobs	
	FreeCPUs	Free CPUs	
Policy	HostName	Host name	
UserStorage	LocalID	Local user ID	
	DN	User DN	
	Quota	Local user Quota	MB
	DefaultCapacity	Local user default Quota	MB
Job	GlobalID	Global Job ID	
	LocalID	Local Job ID	
	LocalOwner	Local Owner ID	
	GlobalOwner	Global Owner ID	
	Status	Job status	
Cluster	Name	Cluster name	
	UniqueID	Cluster ID	
SubCluster	Name	SubCluster name	
	UniqueID	SubCluster ID	
Filesystem	Name	File system name	
	Root	File system root	Path
	Size	Total size	MB

	AvailableSpace	Available space	MB
	ReadOnly	Read only or not	T/F
	Type	File system type	eg. NFS
Processor	Vendor	CPU vendor name	
	Model	Model name	
	Version	CPU version	
	Clockspeed	CPU Clock speed	MHz
	OtherProcessorDescription	Other description	
MainMemory	RAMSize	RAM size	MB
	RAMAvailable	Available RAM size	MB
	VirtualSize	Virtual RAM size	MB
	VirtualAvailable	Available virtual RAM size	MB
ProcessorLoad	Last1Min	1-minute average processor availability	%
	Last5Min	5-minute average processor availability	%
	Last15Min	15-minute average processor availability	%
OperatingSystem	Name	OS name	
	Release	OS Release #	
	Version	OS version	
NetworkAdapter	Name	Interface name	
	IPAddress	IP address	IP addr
	MTU	MTU size	Byte
	OutboundIP	OutboundIP or not	T/F

	InboundIP	InboundIP or not	T/F
Host	Name	Host name (Computation Element)	
	UniqueID	Host ID	
ProcessorLoad	Last1Min	1-minute average processor availability	%
	Last5Min	5-minute average processor availability	%
	Last15Min	15-minute average processor availability	%
MainMemory	RAMSize	RAM size	MB
	RAMAvailable	Available RAM size	MB
	VirtualSize	Virtual RAM size	MB
	VirtualAvailable	Available virtual RAM size	MB

Table 1-3 describes the content of MSE.

Table 1-3 MoreDream Storage Element

Category	Object	Description	Unit
SRBElement	CollectionName	Collection name	
	UserName	User name	
	ServerLocation	SRB server location	IP addr
SRBResources	CollectionName	Collection name	
	UserName	User name	
	ServerLocation	SRB server location	IP addr
SRBResource	ResourceName	Resource name	
	ResourceLocation	Resource location	IP addr
	ResourceType	Resource type	

	ResourceClassName	Resource class name	
	AdminName	Admin name	
	DomainDesc	Domain description	
	ZoneID	MCAT Zone ID	
SRBReplicas	CollectionName	Collection name	
	UserName	User name	
	ServerLocation	SRB server location	IP addr
SRBReplica	CollectionName	Collection name	
	UserName	User name	
	ServerLocation	SRB server location	IP addr
	FileName	File name	
	FileSize	File size	Byte
	FileType	File type	
ReplicaDetail	FileReplicationID	replica ID	
	ResourceLocation	Resource location	IP addr
	ResourceName	Resource name	

2.1.3 User Interface

There are now ways in which you can view VO information collected by GAIS or manage GAIS itself: the GAIS portlets and the GAIS PortType panels.

1) GAIS portlets: They offer resource information, service information or data replication information of a VO to users.
2) GAIS PortType panels: They enable a system administrator to control GAIS services.

The user interfaces will be added continuously as the version of GAIS is up.

2.1.4 Features

GAIS whose aim is to facilitate the management of information in Grid has the following features.

1) Dynamic management of directory server (datacan): GAIS can create a datacan easily whenever needed and can also destroy it freely. This enables a resource owner to share his resource according to his policies. For example, he can publish a datacan, which contains the entire information of his resource, for VO A, whereas the other datacan, which holds half of the information, for VO B.
2) Flat network of directory servers: The network of directory servers in GAIS is not configured hierarchically. Instead, it is flat. This has some merit. First, information is not duplicated. In hierarchy, higher level directory overlaps the information of lower level. Second, consistent synchronization of information is guaranteed. Hierarchical structure may pollute the consistency of information when the fault or the subscription/unsubscription of a directory server.
3) Persistent configuration management: For a production-level service and a long-lived service, the configuration of an information system must be preserved persistently. GAIS provides a file-based configuration management.
4) Smart query processing: Simultaneous query using *Thread* mechanism alleviates the decline of the query performance which the flat network takes place. GAIS offers the *find-vo-service* operation, which can easily find a service in Grid, as well as the *find-vo-data* operation, which can search the information of a service in detail.
5) Rich information providers: GAIS supplies plenty of information about data replication as well as computing resource through providers conforming to MoreDream schema.

2.1.5 GAIS in actions

Figure 1-22 shows GAIS which configures 2 VOs (VO-A and VO-B) through the combination of 4 sites. VO-A is composed of site A, B and C, whereas VO-B consists of site B, C and D. A user has two query types. For VO query, he uses the *find-vo-data* and the *find-vo-service*. He also utilizes the *find-service-data* for Site query.

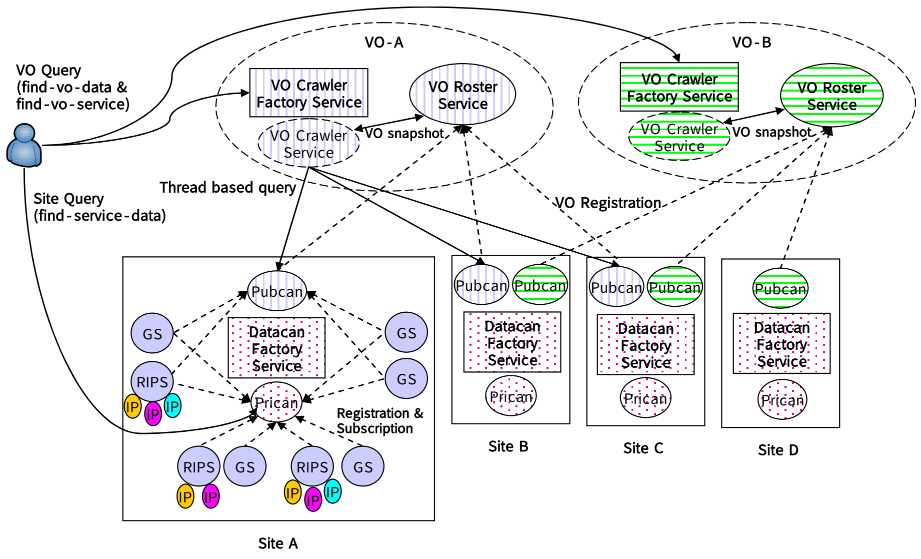


Figure 1-22 GAIS in actions

2.2 Installation and Configuration

2.2.1. Requirements

To install and use GAIS, you need a Linux system and the following softwares.

1) Hardware
  * Linux System
2) Software
  * OS: Linux (Redhat 7.3 or more except Readhat 8.x are recommended)
  * Globus Toolkit 3.2.x
  * Gridsphere 2.0.x
  : If you want to use GAIS portlets, Gridsphere should be installed.
  * OpenPBS (Portable Batch System)
   : If you'd like to obtain the information about cluster, OpenPBS should be installed
  * SRB Account
   : If you'd like to obtain the information that is produced in MCAT-enabled SRB Server, contact the admin of MCAT-enabled SRB Server and obtain it.

2.2.2. Installing required software

2.2.2.1. Installing Globus Toolkit

The information about Globus Toolkit can be found at: http://www.globus.org

2.2.2.2 Installing Gridsphere

The information about Gridsphere can be found at: http://www.gridsphere.org

2.2.2.3 Installing OpenPBS

The information about OpenPBS can be found at: http://www.openpbs.org

2.2.3 Installing GAIS

2.2.3.1. Download and extract

Download gais_v1.0.tar.gz from GAIS web site:

http://kmi.moredream.org/MoreDream/GAIS/

Untar the distribution file and move to gais_v1.0.

```
$ tar xvfz gais_v1.0.tar.gz
$ cd gais_v1.0
```

You can find some files & directories as follows:

```
gais_v1.0
|-- INSTALL.txt
|-- README.txt
|-- build.xml                      Ant build script
|-- gais-datacanFactory            Datacan Factory Service
|-- gais-voRoster                  VO Roster Service
|-- gais-voCrawlerFactory          VO Crawler Factory Service
|-- gais-providers
          |-- mceScriptProvider    MCE Information Provider
          |-- mseScriptProvider    MSE Information Provider
|-- gais-portlets                  Portlets
```

2.2.3.2 Compile & Installation

Basic GAIS package includes source files. If you want to obtain binary files (coming soon), visit GAIS web site http://kmi.moredream.org/MoreDream/GAIS/. It is very simple to install. As we mentioned above, GAIS is composed of 3 Grid Services, 2 Information Providers and 1 Portlets. It is your choice whether whole components are installed or not.

Note 1: We assume that GT3.x is installed and GLOBUS_LOCATION is set

Note 2: Current directory is gais_v1.0

(1) Installation of GAIS Services & Providers

: First, must be the administrator of GT (ex. globus).

: Second, check $GLOBUS_LOCATION environment variable.

: Third, select the proper ant <target> according to your purpose and run it.

```
$ ant { deployAll | deployVoServices | deployDatacanWithVoCrawler |
        deployDatacanWithProviders | deployProviders }
```

: Next, edit the config files of each services and providers (See 2.3.3 Configuration section).

: Finally, run GT container.

```
$ cd $GLOBUS_LOCATION
$ bin/globus-start-container
```

: You should see the following line in the output.

```
http://<hostname>:<port>/ogsa/services/base/gais/DatacanFactoryService

http://<hostname>:<port>/ogsa/services/base/gais/VoCrawlerFactoryService
http://<hostname>:<port>/ogsa/services/base/gais/VoRosterService
```

(2) Installation of GAIS Portlets

: First, must be the administrator of Jakarta Tomcat (ex. root)

: Second, check $CATALINA_HOME environment variable

: Third, edit build.properties to modify location of Gridsphere source and build directory

```
$ edit build.properties
```

: Next, just run the following ant build script

```
$ ant install
```

: Finally, restart Jakarta Tomcat container.

```
$ cd $CATALINA_HOME
$ bin/shutdown.sh
$ bin/startup.sh
```

2.2.3.3 How to set up GAIS services

After 3 GAIS grid services and GAIS providers are installed, you can test your installation. Before test, you should edit some files. After installation of GAIS, you can see files that start with gais-* in $GLOBUS_LOCATI-ON/etc. Now, we will explain about the configuration files.

1) How to create a datacan

You can create a datacan which participates in a VO by editing gais-data-factory-config.xml and adding a **datacan** element in the **publishedDatacans** element. At below example, the “DomainIndexService” and “Sample-VoMember” datacan will be created. The type of datacan will be “PUBLIC” or “PRIVATE.” PUBLIC datacan is open to a VO. On the contrary, PRIVATE datacan is used in only local domain.

```
…
xmlns="http://www.moredream.org/namespaces/2004/12/dataca
n_factory"
…
<publishedDatacans>
   <datacan type="PRIVATE" name="DomainIndexService"
 desc="Index Service for my domain"/>
   <datacan type="PUBLIC" name="Sample-VoMember"
 desc="Index Service for sample VO"/>
</publishedDatacans>
…
```

2) Datacan setup

gais-datacan-config.xml contains **serviceDataSweeper**, **installedProviders** and **executedProviders** elements. The serviceDataSweeper element assigns the execution period (the unit is second) of MoreDream Service Data Sweeper. The **targetData** element, a child of serviceDataSweeper element**,** contains the name and namespace of a Service Data to be checked periodically. The installedProviders element specifies the core Service Data Providers. One or more piece(s) of service data is produced by each execution of each Service Data Provider specified in the executedProviders.

Note: For MoreDream Service Data Sweeper to operate correctly, you should synchronize the time clock of resource in a VO.

```
…
xmlns="http://www.moredream.org/namespaces/2005/01/dataca
n"
…
<serviceDataSweeper period="30">
  <targetData namespace="http://www.moredream.org/ce/1.0"
 name="ComputingElement"/>
  <targetData namespace="http://www.moredream.org/se/1.0"
 name="SRBElement"/>
</serviceDataSweeper>
…

<installedProviders>
  <providerEntry
class="org.moredream.ogsa.impl.base.providers.servicedata
.impl.MceScriptProvider" />
…
</installedProviders>
…
<executedProviders>
```

```
  <provider-exec:ServiceDataProviderExecution>
    <provider-exec:serviceDataProviderName>
      MceScriptProvider
    </provider-exec:serviceDataProviderName>
    <provider-exec:serviceDataProviderImpl>
      org.moredream.ogsa.impl.base.providers.servicedata.i
mpl.MceScriptProvider
    </provider-exec:serviceDataProviderImpl>
    <provider-exec:serviceDataProviderArgs>
    </provider-exec:serviceDataProvider Args>
    <provider-exec:serviceDataName
xmlns:mce="http://www.moredream.org/ce/1.0">
      mce:ComputingElement
    </provider-exec:serviceDataName>
    <provider-exec:refreshFrequency>30</provider-
exec:refreshFrequency>
    <provider-exec:async>true</provider-exec:async>
  </provider-exec:ServiceDataProviderExecution>
…
</executedProviders>
…
```

3) How to register datacans to GAIS-Vo-Roster Service

You can register some datacans by editing gais-vo-roster-config.xml. **datacan** element, a child of **registeredDatacans** element, specifies the domain, handle and description of a registered datacan. At below example, the Sample-VoMember datacan will be registered in the VO managed by this VO roster service. The **period** attribute in **datacanRegister** element means how often this VO roster service tries to register datacan entries to maintain registration information in spite of the fault and error of resource in the VO.

```
…
xmlns="http://www.moredream.org/namespaces/2005/01/vo_ros
ter"
…

<datacanRegister period="10"/>
<registeredDatacans>
<datacan domain="localhost.localdomain"
handle=http://127.0.0.1:8080/ogsa/services/base/gais/Data
canFactoryService/Sample-VoMember
desc="VoMember for Sample VO in localhost.localdomain"/>
</registeredDatacans>
```

4) VO Crawler Factory Service setup

You first should configure the location of VO roster service to query service data and find service location in a VO by editing gais-vo-crawler-config.xml. Register it by adding **voRoster** element. At below example, a local VoRosterService will be used.

```
…
xmlns="http://www.moredream.org/namespaces/2005/01/vo_cra
wler"
…
<voRoster
handle="http://127.0.0.1:8080/ogsa/services/base/gais/VoR
osterService"/>
...
```

5) MCE provider setup (lrms-info.conf)

Configure the type of your local scheduler by editing lrms-info.conf.

$ vi lrms-info.conf
```
    ...
    LRMSType=PBS            # PBS or FORK
    …
```

6) MSE provider setup.
When MSE information provider initiates, it need some information about GSI. They are the file path of user proxy and CA. This information is in gais-mse-proxy.properties file.

$ vi gais-mse-proxy.properties
```
    proxy=/tmp/x509up_<uid>
    gridcas=/etc/grid-security/certificates/<hash#>.0
```

7) Registering a Resource Service to an Datacan Factory Service
The Service Data of any Grid service can be registered to GAIS Datacan Factory Service using the core RegistryPublishProvider. The RegistryPublishProvider should be configured in the WSDD of each resource service (for example, RIPS or MMJFS) by the administrators of those services.

Note: The administrator of the Datacan Factory Service does not need to take action in order for a new resource service to register.

(1) Create an XML configuration file for the registration in $GLOBUS_LOCATION/etc/ data_registration_config.xml

```
<?xml version="1.0" encoding="UTF-8" ?>
<serviceConfiguration
```

```
  xmlns:ogsi="http://www.gridforum.org/namespaces/2003/03
/OGSI"
  xmlns:aggr="http://www.globus.org/namespaces/2003/09/da
ta_aggregator"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<registrations>
  <registration
registry="http://127.0.0.1:8080/ogsa/services/base/gais/D
atacanFactoryService/DomainIndexService"
  keepalive="true"
  lifetime="120"
  remove="true">
  <aggr:DataAggregation>
    <ogsi:params>
     <aggr:AggregationSubscription>
      <ogsi:serviceDataNames>
      <ogsi:name
xmlns:mce="http://www.moredream.org/ce/1.0">mce:Computing
Element</ogsi:name>
      </ogsi:serviceDataNames>
      <aggr:lifetime>60000</aggr:lifetime>
     </aggr:AggregationSubscription>
    </ogsi:params>
    </aggr:DataAggregation>
   </registration>
 </registrations>
</serviceConfiguration>
```

(2) Edit the fields as appropriate. Most importantly, edit the **registry** attribute

to refer to the Datacan Factory Service instance (datacan) you want to register with. **DataAggregation** element contains service data name which subscribes to the instance.

(3) You must add the RegistryPublishProvider operation provider to the resource service's deployment descriptor in the Server Configuration file (server-config.wsdd).

(4) Find **service** element (for example, `<service name="base/gram /ResourceInformationProviderService"`...) definition for a resource service.

(5) Then, add the following parameters in the **service** element:

```
    <parameter name="operationProviders"
      value="org.globus.ogsa.impl.core.registry.RegistryPublishProvider "/>
    <parameter name="registrationConfig"
       value="etc/data_registration_config.xml"/>
```

8) Registering a Grid Service to an Datacan Factory Service

Any Grid Service Handle (GSH) can be registered to GAIS Datacan Factory Service using the core RegistryPublishProvider. The RegistryPublishProvider should be configured in the WSDD of each Grid service (for example, PingService) by the administrators of those services.

Note: The administrator of the Datacan Factory Service does not need to take action in order for a grid service to register.

(1) Create an XML configuration file for the registration in $GLOBUS_LOCATION/etc/service_registration_config.xml

```
<?xml version="1.0" encoding="UTF-8" ?>
<serviceConfiguration
xmlns:ogsi="http://www.gridforum.org/namespaces/2003/03/O
GSI"
xmlns:aggr="http://www.globus.org/namespaces/2003/09/data
_aggregator"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">

<registrations>
  <registration
registry="http://127.0.0.1:8080/ogsa/services/base/gais/D
atacanFactoryService/ DomainIndexService "
  keepalive="true"
  lifetime="120"
  remove="true">
   </registration>
 </registrations>
</serviceConfiguration>
```

(2) Edit the fields as appropriate. Most importantly, edit the **registry** attribute to refer to the Datacan Factory Service instance (datacan) you want to register with.

(3) You must add the RegistryPublishProvider operation provider to the grid service's deployment descriptor in the Server Configuration file (server-config.wsdd).

(4) Find **service** element (for example, `<service  name="core/ping/ PingService"`…) definition for a grid service.

(5) Then, add the following parameters in the **service** element:

```
   <parameter name="operationProviders"
     value="org.globus.ogsa.impl.core.registry.RegistryPub
lishProvider "/>
   <parameter name="registrationConfig"
        value="etc/service_registration_config.xml"/>
```

9) Registering GAIS information providers to RIPS

GAIS information providers should be registered to RIPS as follows ($GLOBUS_LOCATION/etc/rips-service-config.xml). They produce `{http://www.moredream.org/ce/1.0}ComputingElement` and `{http://www.moredream.org/se/1.0}` SRBElement as Service Data.

(1) Register MCE Information Provider.

```
        $ vi $GLOBUS_LOCATION/etc/rips-service-config.xml
        ...
        <installedProviders>
           <providerEntry
           class="org.globus.ogsa.impl.base.providers.servi
           cedata.impl.ScriptExecutionProvider"
           handler="jobDataHandler"/>
            <providerEntry
class="org.globus.ogsa.impl.base.providers.servicedata.im
pl.HostScriptProvider" />
            <providerEntry
class="org.moredream.ogsa.impl.base.providers.servicedata
.impl.MceScriptProvider" />
         </installedProviders>
        ...
        <executedProviders>
        ...
        <provider-exec:ServiceDataProviderExecution>
               <provider-exec:serviceDataProviderName>
               MceScriptProvider
               </provider-exec:serviceDataProviderName>
               <provider-exec:serviceDataProviderImpl>
        org.moredream.ogsa.impl.base.providers.servicedata
.impl.MceScriptProvider</provider-
exec:serviceDataProviderImpl>
               <provider-exec:serviceDataProviderArgs>
              </provider-exec:serviceDataProviderArgs>
              <provider-exec:serviceDataName
xmlns:mce="http://www.moredream.org/ce/1.0">mce:Computing
Element
              </provider-exec:serviceDataName>
              <provider-exec:refreshFrequency>30
              </provider-exec:refreshFrequency>
              <provider-exec:async>true</provider-
exec:async>
          </provider-exec:ServiceDataProviderExecution>
        ...
        </executedProviders>
        ...
```

(2) Register MSE Information Provider.

```
        $ vi $GLOBUS_LOCATION/etc/rips-service-config.xml
        ...
        <installedProviders>
           <providerEntry
           class="org.globus.ogsa.impl.base.providers.servi
```

```
         cedata.impl.ScriptExecutionProvider"
         handler="jobDataHandler"/>
          <providerEntry
class="org.globus.ogsa.impl.base.providers.servicedata.im
pl.HostScriptProvider" />
          <providerEntry
class="org.moredream.ogsa.impl.base.providers.servicedata
.impl.SRBScriptProvider" />
       </installedProviders>
      ...
      <executedProviders>
      ...
      <provider-exec:ServiceDataProviderExecution>
            <provider-exec:serviceDataProviderName>
            SRBScriptProvider</provider-
      exec:serviceDataProviderName>
            <provider-exec:serviceDataProviderImpl>
      org.moredream.ogsa.impl.base.providers.servicedata
.impl.SRBScriptProvider
            </provider-exec:serviceDataProviderImpl>
            <provider-exec:serviceDataProviderArgs>
            </provider-exec:serviceDataProviderArgs>
            <provider-exec:serviceDataName
            xmlns:mse="http://www.moredream.org/mse/1.0"
            >mse:SRB
            </provider-exec:serviceDataName>
            <provider-
exec:refreshFrequency>30</provider-exec:refreshFrequency>
            <provider-exec:async>true</provider-
exec:async>
```

```
            </provider-exec:ServiceDataProviderExecution>
        ...
        </executedProviders>
        ...
```

10) Enabling OGSA Service Browser GUI

If you want to use the OGSA Service Browser GUI, you will need the GUI control panels for the GAIS Service, which is configured in a different file. Add the following lines to the client-gui-config.xml file in $GLOBUS_LOCATION

```
…
    <panel portType="DatacanFactoryPortType"
          class="org.moredream.ogsa.gui.DatacanFactoryPortTypePanel"/>
    <panel portType="VoRosterPortType"
            class="org.moredream.ogsa.gui.VoRosterPortTypePanel"/>
    <panel portType="VoCrawlerFactoryPortType"

class="org.moredream.ogsa.gui.VoCrawlerFactoryPortTypePanel"/>
…
```

2.2.3.4. Starting

A. Starting GAIS Service

Now, let's test your GAIS services installation. Verify whether the installation is okay or not as follows.

1) To start GT3.2.x container, run as GT administrator:

```
$ cd $GLOBUS_LOCATION
$ bin/globus-start-container
```

2) To start GT3.2.x service browser, run:

```
$ bin/globus-service-browser
```

3) Find a VO Crawler Factory Service at Service Group Entry Inspection of ContainerRegistry Servcie. By double clicking of that, the VO Crawler Factory Service browser will be displayed.

4) Query “ComputingElement” Service Data with “http://www.moredream.org/ce/1.0” namespace at *find-vo-data* tab of *VO Query*. If “mce:ComputingElement” is shown, your installation is successful.

5) Query with “service” pattern at *find-vo-service* tab of *VO Query*. In case of successful installation, registered GSH will be shown.

B. Starting GAIS Portlets

Next, let’s test your GAIS portlets installation. Verify whether the installation is okay or not as follows.

1) To start Jakarta Tomcat container, run as Tomcat administrator:

```
$ cd $CATALINA_HOME
$ bin/startup.sh
```

2) Browse the following URL

```
http://<hostname>:<port>/gridsphere/gridsphere
```

3) Login with the appropriate ID

4) Click the **Configuration** link of the **Information Service** tab

5) Configure the GSH of your VO Crawler Factory Service.

2.3 Using GAIS

How about your installation, successful or failed? We expect your successful installation & configuration. Now, let's use GAIS in real Grid environment. We assume that there is a KMI (Korea Middleware Initiative) VO at Figure 1-23. GAIS services can be deployed as like following Table 1-4.

Table 1-4. KMI VO configuration

Service/Provider	Machine name with the service/provider
DFS	sdd107, eros01, vega01
VRS	gais
VCFS	sdd107, eros01, vega01, gais
MCE provider	orin01,nova01, eros01, nova01 → Front node of cluster
MSE provider	sdd107

Note. To obtain the information that is produced in MCAT-enabled SRB Server, contact the admin of MCAT-enabled SRB Server and obtain a SRB account.

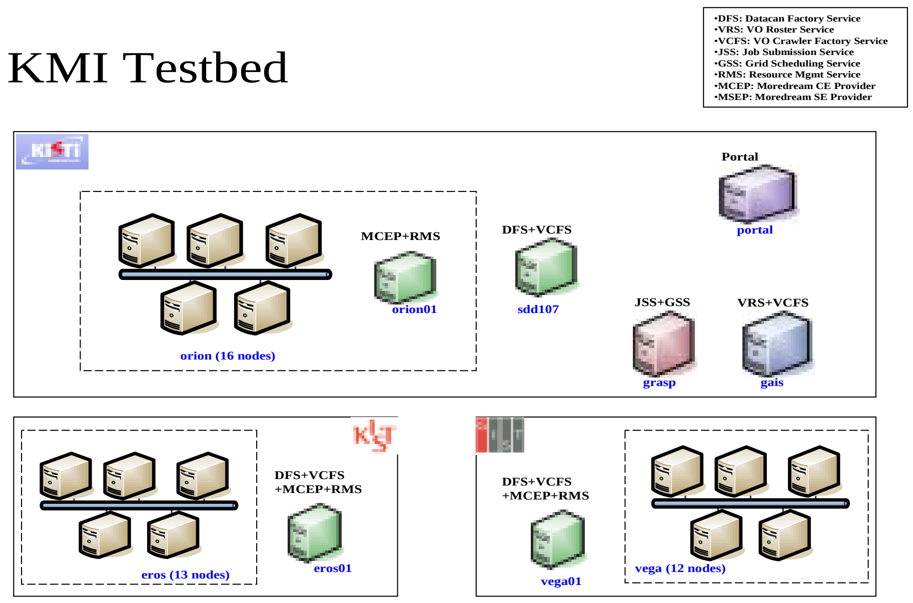

KMI Testbed
•DFS: Datacan Factory Service
•VRS: VO Roster Service
•VCFS: VO Crawler Factory Service
•JSS: Job Submission Service
•GSS: Grid Scheduling Service
•RMS: Resource Mgmt Service
•MCEP: Moredream CE Provider
•MSEP: Moredream SE Provider
Portal
portal
MCEP+RMS
orion01
orion (16 nodes)
DFS+VCFS
sdd107
JSS+GSS
grasp
VRS+VCFS
gais
DFS+VCFS
+MCEP+RMS
eros01
eros (13 nodes)
DFS+VCFS
+MCEP+RMS
vega01
vega (12 nodes)

Figure 1-23 KMI VO

2.3.1 Querying the GAIS

GAIS has two type of query. One is ***find-vo-data*** and the other is ***find-vo-service***. You can find Service Data in a VO using ***find-vo-data***, and get the GSH (Grid Service Handle) of a Grid Service in a VO through ***find-vo-service***.

2.3.1.1 Querying Service Data

The following code snippet describes the process to obtain the information in a VO. The type of result is the Element class. You can variously translate the format of this result through the AnyHelper class.

```
…
Element result = null;
VoCrawlerPortType voCrawler = null;

try {
   OGSIServiceGridLocator gridLocator
        = new OGSIServiceGridLocator();
   Factory factory
        = ridLocator.getFactoryPort(this.defaultEndpoint);
   GridServiceFactory voCrawlerFactory
         = new GridServiceFactory(factory);

   LocatorType locator
         = voCrawlerFactory.createService();
   VoCrawlerServiceGridLocator voCrawlerLocator
         = new VoCrawlerServiceGridLocator();
   voCrawler = voCrawlerLocator.getVoCrawlerPort(locator);

    ExtensibilityType queryResult
          = voCrawler.findVoData(queryExpression);
    if (queryResult.get_any() == null) {
     // a null any in the case of an xpath query means
     //results
    Object obj
       = AnyHelper.getAsSingleObject(queryExpression);
   if (obj instanceof
        ServiceDataXPathQueryExpressionType) {
     throw new Exception("XPath Query: No results found");
       }
    }

    result = AnyHelper.getAsParentElement(queryResult);

} catch (Exception e) {
    e.printStackTrace();
} finally {
    try {
       if(voCrawler != null) {
          voCrawler.destroy();
       }
    } catch (Exception e1) {
       e1.printStackTrace();
    }
}
…
```

2.3.1.2 Querying the GSH

find-vo-service is a wrapper of ***find-vo-data*** to facilitate the discovery of a Grid Service. The type of result is the array of the String class.

```
…
String[] result = null;
VoCrawlerPortType query = null;

try {
    OGSIServiceGridLocator gridLocator = new OGSIServiceGridLocator();
    Factory factory = gridLocator.getFactoryPort(this.defaultEndpoint);
    GridServiceFactory queryFactory = new GridServiceFactory(factory);

    LocatorType locator = queryFactory.createService();
    VoCrawlerServiceGridLocator queryLocator
              =    new VoCrawlerServiceGridLocator();
    query = queryLocator.getVoCrawlerPort(locator);

    result = query.findVoService(pattern);

} catch (Exception e) {
    e.printStackTrace();
} finally {
    try {
        if(query != null) {
            query.destroy();
        }
    } catch (Exception e1) {
        e1.printStackTrace();
    }
}
…
```

2.4. Writing out the MoreDream Providers

Before you read this material, visit http://www-unix.globus.org/toolkit/docs/3.2/infosvcs/ws/developer/servicedataproviders.html. This section is based on that document.

2.4.1 Service Data Providers

Service Data Provider components consist of the ServiceDataProviderManager Java class and one or more “plug-in” ServiceDataProvider classes, which are regularly executed by the Service Data Provider Manager (using Java TimerTasks). These provider plug-in programs can be the supplied providers that are part of GT3.2 or user-created, custom providers.

A valid provider is defined as any Java class that implements at least one of three predefined Java interfaces (SimpleDataProvider, DOMDataProvider, and AsyncDataProvider), and generates a well-formed, compatible XML document as the output of its execution.

"Well-formed" above means that the XML document can be parsed in any environment, i.e., any parsing tools written in any programming language can be used. “Compatible” above means a form compatible with the Service Data Provider Manager, i.e., a Java output stream or DOM representation.

2.4.2 Core GT3.2 Service Data Providers

GT3.2 supplies the following Service Data Providers:

SimpleSystemInformationProvider

HostScriptProvider

AsyncDocumentProvider

ScriptExecutionProvider

2.4.3 Provider interfaces

The Service Data Provider interfaces are designed to support execution in either a synchronous ("pull") mode or asynchronous ("push") mode. It is up to the developer to choose the appropriate provider interface to implement, based on specific application needs. There are three provider interfaces SimpleDataProvider, DOMDataProvider, and AsyncDataProvider.

2.4.4 Creating Custom Service Data Providers

Service Data Providers can be as simple or as complicated as the situation requires. The baseline case requires only that the provider developer create a Java class implementing the functions of one interface – SimpleDataProvider – whose purpose is to produce XML output in the form of a Java OutputStream as the result of its execution.
The following steps are the essence of creating a new Service Data Provider:

1) Choose the provider interface to be implemented, based on application needs or constraints.
2) Write code to produce your dataset as an XML document. This can either be in an OS-specific external program, or native Java code that is executed by the provider class itself.
3) Create an entry for the service in which you intend to run the provider in your auxiliary service configuration file. This service is assumed to have incorporated the functionality of the Service Data Provider Manager, which parses the provider configuration file property specified in the

service's deployment descriptor entry (in the default server configuration file, server.config.wsdd), loads the provider, and executes it according to parameters specified by a client service.

2.4.5 For example, MceScriptProvider

New information providers can be made easily by modifying some methods and member variables in sample information providers. For example, MceScriptProvider is very similar to HostScriptProvider that is supplied by GT3.x. But MceScriptProvider provides lots of information including the basic information about computing resources.

Let's make MceScriptProvider. First, choose AsyncDataProvider interface and implement it. If you intend to modify HostScriptProvider, you have only to change some member variables and method like composeDocument(). Second, write code to produce your dataset as an XML document. There are many script files to make XML document in MceScriptProvider. Then, you need to make a configuration file like gais-mce-providers.conf that defines the sequence of each script execution. Finally, there are some steps to register MceScriptProvider (See 3.8. Registering MoreDream information providers to RIPS).

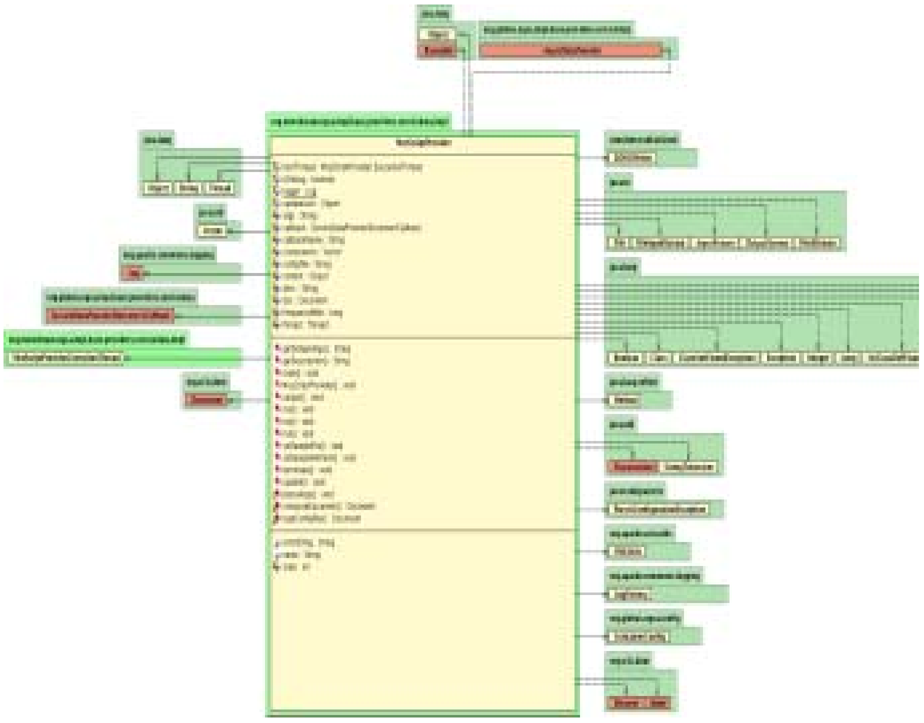


Figure 1-24 MceScriptProvider UML Diagram

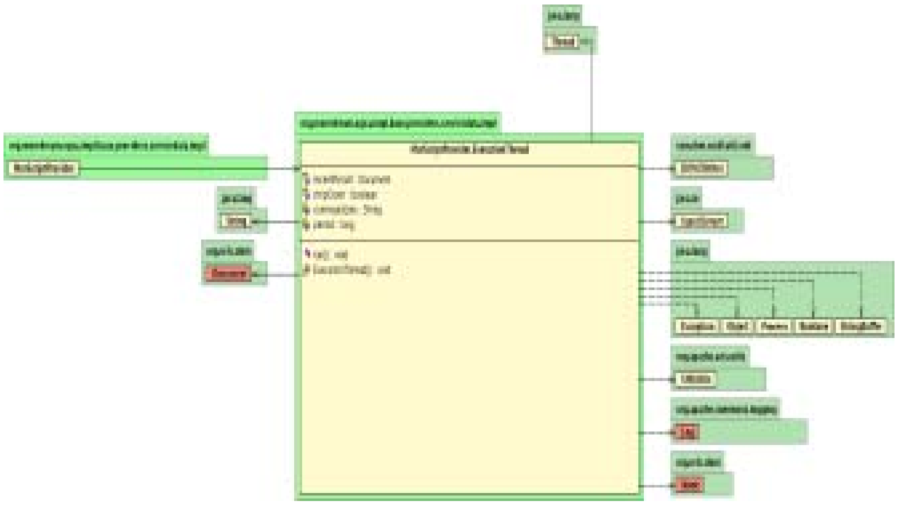


Figure 1-25 MceScriptProviderExecutionThread UML Diagram

2.4.6 Service data provider input

Input to Service Data Provider execution is specified via a set of string arguments to the run method. The argument string that gets passed to the provider is the serviceDataProviderArgs member of the ServiceDataProviderExecutionType structure that is passed to the executeProvider port type method. The getDefaultArgs method may be used to retrieve a default argument list for the provider. For Service Data Provider input, the following is an example of an XML serialized form of parameters to executeProvider :

```
<executedProviders>
...
<provider-exec:ServiceDataProviderExecution>
<provider-exec:serviceDataProviderName>MceScriptProvider
</provider-exec:serviceDataProviderName>
<provider-exec:serviceDataProviderImpl>
org.moredream.ogsa.impl.base.providers.servicedata.impl.M
ceScriptProvider</provider-exec:serviceDataProviderImpl>
<provider-exec:serviceDataProviderArgs>
</provider-exec:serviceDataProviderArgs>
<provider-exec:serviceDataName
xmlns:mce="http://www.moredream.org/ce/1.0">
mce:ComputingElement
</provider-exec:serviceDataName>
<provider-exec:refreshFrequency>30</provider-
exec:refreshFrequency>
<provider-exec:async>true</provider-exec:async>
</provider-exec:ServiceDataProviderExecution>
```

```
...
</executedProviders>
```

2.4.7 Service data provider output

The output of a Service Data Provider is XML – either in the form of a Java OutputStream or a Java org.w3c.dom document. This output becomes the value of a Service Data Element and hence available as part of the hosting service's Service Data Elements. These Service Data Elements can then be used for the various WS Information Services functions.

2.4.8 Registering MoreDream information providers to RIPS

GAIS information providers should be registered to RIPS as follows ($GLOBUS_LOCATION/etc/rips-service-config.xml). They produce {http://www.more dream.org/ce/1.0} ComputingElement and {http://www.moredream.org/se/1.0} SRBElement as service data.

2.4.8.1. Register MCE Information Provider

```
$ vi $GLOBUS_LOCATION/etc/rips-service-config.xml
...
<installedProviders>
<providerEntry
class="org.globus.ogsa.impl.base.providers.servicedata.im
pl. ScriptExecutionProvider" handler="jobDataHandler"/>
<providerEntry
class="org.globus.ogsa.impl.base.providers.servicedata.im
pl.HostScriptProvider" />
```

```
<providerEntry
class="org.moredream.ogsa.impl.base.providers.servicedata
.impl.
MceScriptProvider" />
</installedProviders>
...
<executedProviders>
...
<provider-exec:ServiceDataProviderExecution>
<provider-exec:serviceDataProviderName>MceScriptProvider
</provider-exec:serviceDataProviderName>
<provider-exec:serviceDataProviderImpl>
org.moredream.ogsa.impl.base.providers.servicedata.impl.M
ceScriptProvider</provider-exec:serviceDataProviderImpl>
<provider-exec:serviceDataProviderArgs>
</provider-exec:serviceDataProviderArgs>
<provider-exec:serviceDataName
xmlns:mce="http://www.moredream.org/ce/1.0">
mce:ComputingElement
</provider-exec:serviceDataName>
<provider-exec:refreshFrequency>30</provider-
exec:refreshFrequency>
<provider-exec:async>true</provider-exec:async>
</provider-exec:ServiceDataProviderExecution>
...
</executedProviders>
...
```

2.4.8.2 Register MSE Information Provider.

```
$ vi $GLOBUS_LOCATION/etc/rips-service-config.xml
...
<installedProviders>
<providerEntry
class="org.globus.ogsa.impl.base.providers.servicedata.im
pl. ScriptExecutionProvider" handler="jobDataHandler"/>
<providerEntry
class="org.globus.ogsa.impl.base.providers.servicedata.im
pl.HostScriptProvider" />
<providerEntry
class="org.moredream.ogsa.impl.base.providers.servicedata
.impl.SRBScriptProvider" />
</installedProviders>
...
<executedProviders>
...
<provider-exec:ServiceDataProviderExecution>
<provider-exec:serviceDataProviderName>SRBScriptProvider
</provider-exec:serviceDataProviderName>
<provider-exec:serviceDataProviderImpl>
org.moredream.ogsa.impl.base.providers.servicedata.impl.S
RBScriptProvider</provider-exec:serviceDataProviderImpl>
<provider-exec:serviceDataProviderArgs>
</provider-exec:serviceDataProviderArgs>
<provider-exec:serviceDataName
xmlns:mse="http://www.moredream.org/mse/1.0"> mse:SRB
</provider-exec:serviceDataName>
<provider-exec:refreshFrequency>30</provider-
exec:refreshFrequency>
<provider-exec:async>true</provider-exec:async>
```

```
</provider-exec:ServiceDataProviderExecution>
...
</executedProviders>
…
```

3. MPICH-GX

3.1 Introduction

MPICH-GX is a patch of MPICH-G2 to extend some required functionalities. MPICH-G2 is a well-defined implementation of Grid-enabled MPI, but it is needed to be modified for supporting some requirements of Grid applications. Thus, MPICH-GX provides useful functionalities for supporting the private IP and fault tolerance
The rest of this chapter is organized as follows. In section 1.1, we describe the architecture of MPICH-GX. Section 1.2 presents the functionalities supporting the private IP and fault tolerance. We introduce two initialization mechanism of MPICH-GX in section 1.3. Lastly, we provide client tools with Java library in section 1.4

3.1.1 Architecture of MPICH-GX

Basically, MPICH-GX is based on MPICH-G2. Thus, it has similar architecture of MPICH-G2 as shown in Figure1-26. It consists of the GX device, a proxy daemon named nproxy, a local job manager called local-job-manager, a package of Java library called CM (Coallocator for MPICH-GX) and client tools based on Java. The GX device modifies 'globus2 device' of MPICH to add required functions. The nproxy relays the messages of MPI processes when the process is located in private IP clusters. The local-job-manager invokes a process and monitors the status of the process. The CM is a package of Java library for supporting the middlewares which are executing MPICH-GX applications. Lastly, we bring client tools based on Java. Client tools compose of gxrun as a tool for job submission and gxlrm as a deamon for local resource managerorl of ontion toolools based on java library. The gxrun could submit a job through the gxlrm running in each distributed resource.

As shown in Figure1-26, application developer can make MPICH-GX applications by using standard MPI API. It can be mapped to the globus2 device passing through ADI layer. We modify the globus2 device, so that some functions in MPICH-GX are different from MPICH-G2.

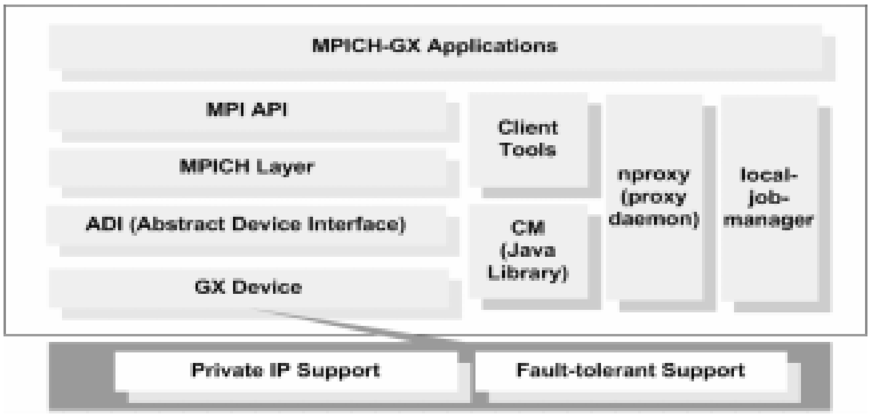


Figure 1-26 Architecture of MPICH-GX

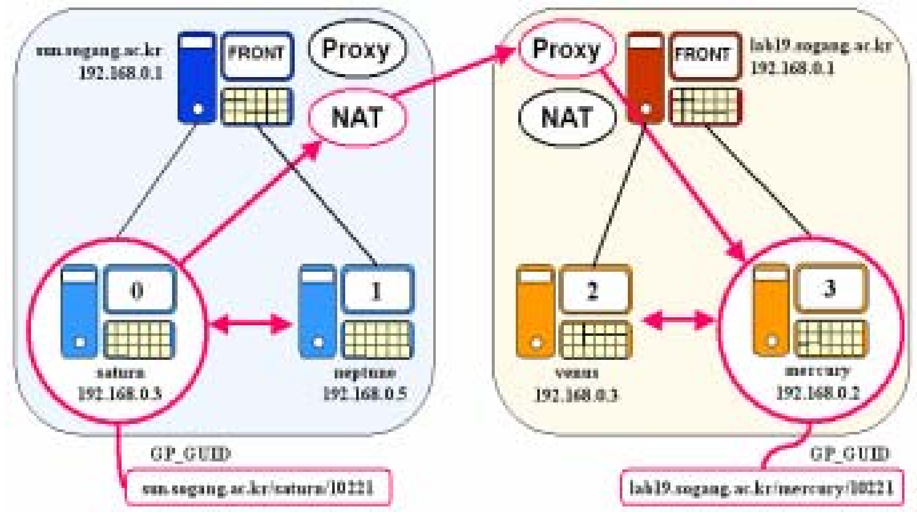
3.1.2 Functionalities of MPICH-GX

MPICH-GX provides mainly two functionalities for supporting the private IP and fault tolerance. In this section, we describe the details of two functionalities.

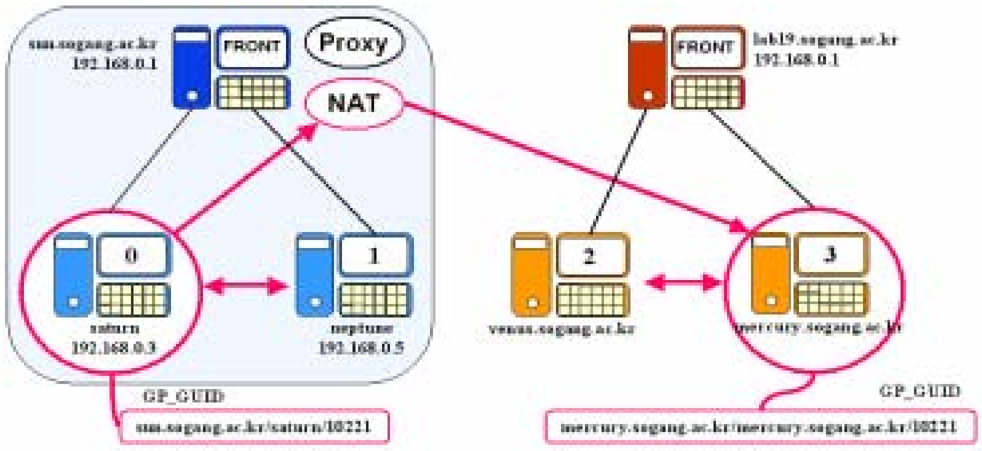
3.1.2.1 Private IP Support

It is a well-known problem that MPICH-G2 does not support private IP clusters. In MPICH-G2, processes communicate with each other based on IP addresses. Thus, it cannot support private IP clusters by the nature.

To support private IP clusters, MPICH-GX uses a communication relay scheme combining the NAT service with a user level proxy named ‘nproxy.’ In this approach, only incoming messages are handled by a user-level proxy to relay them into proper nodes inside the cluster, while the outgoing messages are handled by the NAT service at the front-end node of the cluster. Figure 1-27 shows the conceptual diagram of our relay scheme.



(a) Between two private IP clusters



(b) Between a private IP clusters + public IP cluster

Figure 1-27 Communication Relay Scheme in MPICH-GXs

3.1.2.2 Fault Tolerant Support

We provide a checkpointing-recovery system for Grids. Our library requires no modifications of application source codes, and it affects the MPICH communication characteristics as less as possible. The features are that it supports the direct message transfer mode and that all of the implementation has been done at the low level, that is, the abstract device level.

Figure 1-27 describes the library structure of MPICH-GX for fault tolerant support. Although fault-tolerance module has been implemented at the abstract device level, please note that it is still user-level. It contains a checkpoint toolkit, an atomic message transfer management, and a connection re-establishment module. The checkpoint toolkit dumps the user-level memory image into the stable storage on the request. Messages that are in kernel memory or at network are assumed as in-transit messages. The atomicity of message transfer at the abstract device level realizes fine grained checkpoint timing compared to the higher-level approach, because it narrows the code area that should be exclusive against the checkpoint procedure.

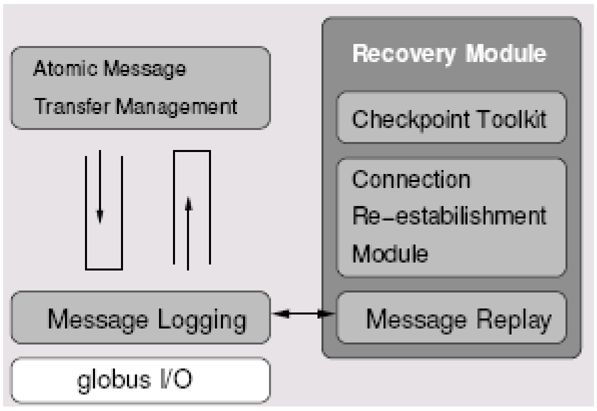


Figure 1-28 The Structure of MPICH-GX Device for Fault Tolerant Support

3.1.3 Initialization Mechanism

MPI applications need an initialization procedure that creates processes and prepares necessary information for passing messages with each other. During such procedure, two middleware-components should be involved; one is a central manager to submit a MPI job to local resources; the other is a local resource manager to launch the job to local resources via local batch scheduler such as PBS. Here, we introduce two kinds of mechanisms that initialize MPI processes: a file-based initialization that a central manager just sends a file containing information of processes to local resource managers, and a message-based initialization that the local resource manager and the central manager send and receive messages with each other.

3.1.3.1 File-based Initialization

An initialization procedure depends on the functions given by middlewares. For example, MPICH-G2 uses DUROC, which is a component of Globus toolkit, to initialize MPI processes. Sometimes it can be very efficient, but it makes the MPI library to be tied up by the middleware. Thus, the change of Globus toolkit results in inevitable change of MPI library. This is the reason why the MPICH-G2 cannot work with Globus toolkit 3.x. Therefore, we modify the initialization procedure of MPICH-G2 which depends on DUROC component to file-based initialization. It allows users to launch MPI applications without DUROC. To use file-based initialization, users have to make the file (we call it configuration file). As described in Figure1-29, middlewares, including the central manager and the local resource manager, could help you to run your MPI applications in convenient way. The central manager could automatically create a configuration file and stage the file to the local resource manager in each resource. But, you also can launch the applications manually without any launching program if you know the method to make the configuration file. The contribution of the file-based initialization is that it is independent of middlewares. Even though the Grid middleware is changed more and more, we can launch the MPI application in a same way when we use the file-based initialization.

Once the central manager sends the file to each local resource, because it does not receive messages, the central manager could not detect the failure of the job. Hence, you could not restart for failed job via file-based initialization.

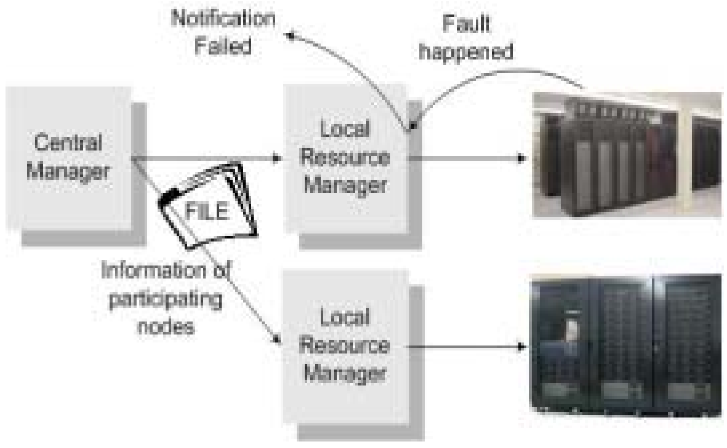


Figure 1-29 File-based Initialization

3.1.3.2 Message -based Initialization

File-based initialization is very simple and easy to apply to middlewares, including the central manager and the local resource manager, whereas it cannot support to restart for failed job. Therefore, we provide another mechanism called message-based initialization to support for fault-tolerance. Because a central manager sends messages to local resource managers and receives messages from local resource managers, the central manager could know the failure of the process by getting the messages from the local resource manager, as illustrated in Figure1-30.

While the central manager must know the channel information of all processes before job submission at file-based initialization, it could get the channel information along with the ‘CHANNEL_INFO’ message from each local resource manager after job submission. Once the central manager gains the all ‘CHANNEL_INFO’ messages from participating local resource managers, it sends the ‘CHANNEL_INFO_ACK’ message to each local resource manager. Then, initialization procedure gets completed. In other words, it gets ready for passing messages with each other.

We provide Java library called CM (Coallocator for MPICH-GX) to give a help to implement message-based initialization. When the central manager and the local resource manager transfer messages with each other via some message passing protocols such as socket API, SOAP and etc., they could be easily implemented through our Java library. You can refer the details of Java library at section 3.1.4

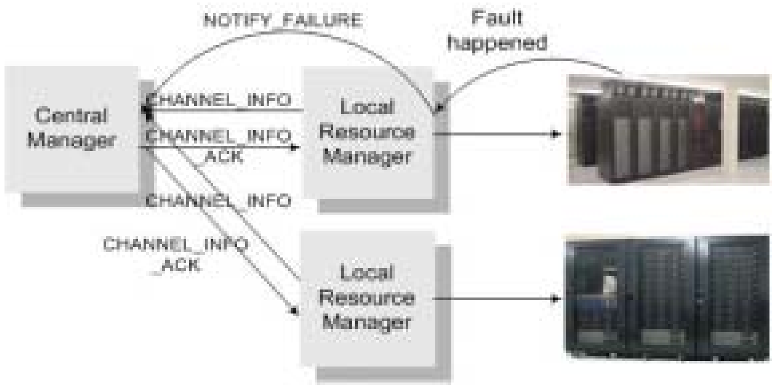


Figure 1-30 Message-based Initialization

3.1.4 Java Library and Client Tools

We provide Java library called CM (Coallocator for MPICH-GX) based on Java. The CM is some bundles of Java library for supporting the middlewares running MPICH-GX applications. Also, we bring some client tools to be implemented by Java library. Client tools contain gxrun which is both a client and a central manager, and gxlrm which is a local resource manager.

CM is mainly composes of two parts: one part is a bundle of packages related to the central manager as depicted in Figure 1-31, and the other is a bundle of packages related to the local job manager as illustrated in Figure 1-32. Developers could easily implement not only client tools but also services based on Globus Toolkit via CM.

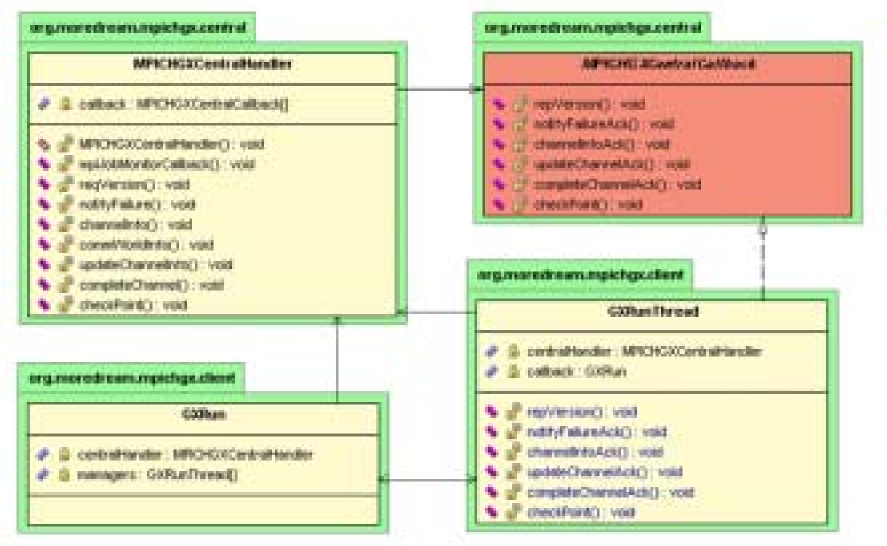

org.moredream.mpichgx.central
MPICHGXCentralHandler
callback : MPICHGXCentralCallback[]
MPICHGXCentralHandler() : void
repJobMonitorCallback() : void
reqVersion() : void
notifyFailure() : void
channelInfo() : void
commWorldInfo() : void
updateChannelInfo() : void
completeChannel() : void
checkPoint() : void
org.moredream.mpichgx.central
MPICHGXCentralCallback
repVersion() : void
notifyFailureAck() : void
channelInfoAck() : void
updateChannelAck() : void
completeChannelAck() : void
checkPoint() : void
org.moredream.mpichgx.client
GXRunThread
centralHandler : MPICHGXCentralHandler
callback : GXRun
repVersion() : void
notifyFailureAck() : void
channelInfoAck() : void
updateChannelAck() : void
completeChannelAck() : void
checkPoint() : void
org.moredream.mpichgx.client
GXRun
centralHandler : MPICHGXCentralHandler
managers : GXRunThread[]

Figure 1-31. UML Class Diagram Regarding to the Central Manager

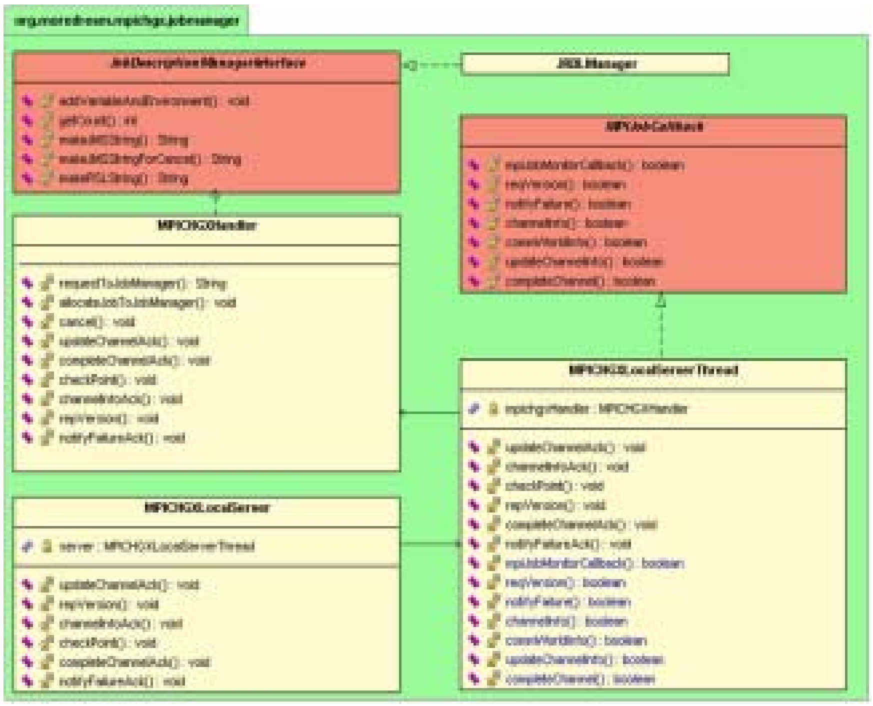

JobDescriptionManagerInterface
addVariableAndEnvironment() : void
getCount() : int
makeJMSString() : String
makeJMSStringForCancel() : String
makeRSLString() : String
JRDLManager
MPIJobCallback
mpiJobMonitorCallback() : boolean
repVersion() : boolean
notifyFailure() : boolean
channelInfo() : boolean
commWorldInfo() : boolean
updateChannelInfo() : boolean
completeChannel() : boolean
MPICHGXHandler
requestToJobManager() : String
allocateJobToJobManager() : void
cancel() : void
updateChannelAck() : void
completeChannelAck() : void
checkPoint() : void
channelInfoAck() : void
repVersion() : void
notifyFailureAck() : void
MPICHGXLocalServerThread
mpichgxHandler : MPICHGXHandler
updateChannelAck() : void
channelInfoAck() : void
checkPoint() : void
repVersion() : void
completeChannelAck() : void
notifyFailureAck() : void
mpiJobMonitorCallback() : boolean
repVersion() : boolean
notifyFailure() : boolean
channelInfo() : boolean
commWorldInfo() : boolean
updateChannelInfo() : boolean
completeChannel() : boolean
MPICHGXLocalServer
server : MPICHGXLocalServerThread
updateChannelAck() : void
repVersion() : void
channelInfoAck() : void
checkPoint() : void
completeChannelAck() : void
notifyFailureAck() : void

Figure 1-32. UML Class Diagram Regarding to the Local Resource Manager

Client tools are implemented using CM library. Client tools compose of gxrun as a tool for job submission and gxlrm as a deamon for local resource manager as described in Figure 1-31. The gxrun could submit a job through the gxlrm running in each distributed resource as illustrated in Figure 1-32. Once each gxlrm gets the request from gxrun, the gxlrm submit the job through local batch scheduler such as PBS. Then, PBS launches the local-job-manager, which invoke a process.

The job schema is JRDL (Job & Resource Description Language). JRDL is an extension of RSL2, which is a job description language used by Globus Toolkit 3.x. JRDL is mainly composes of two parts: one is elements related to a job, including executable, path, and etc, and the other is elements related to resources, which are preferences used to select proper resources by meta-scheduler. However, you do not have to use elements related to resources, because current gxrun does not use meta-scheduler to select resources. You can refer details of JRDL at user manual of GRASP

Currently, gxrun can support only for interactive job, not batch mode. Also, gxrun does not use any authentication mechanism.

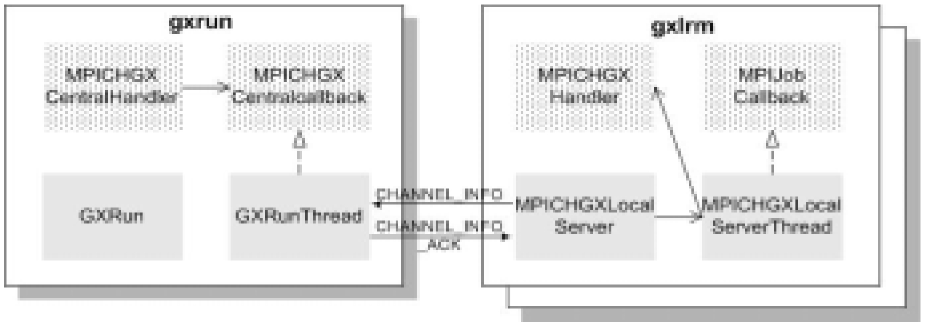


Figure 1-33 Client Tools to be Implemented via CM Library

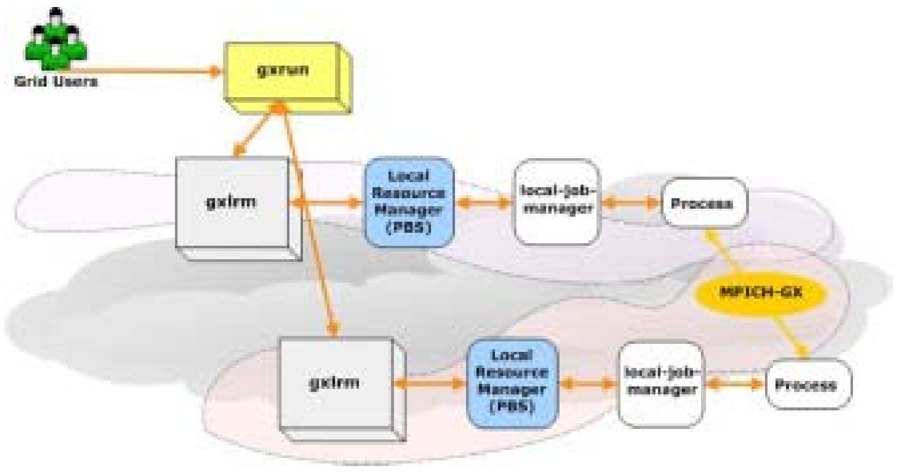


Figure 1-34 Job Submission by Client Tools

3.2 Installation and Configuration

3.2.1 Requirements

- ✓ OS: Linux (RedHat 7.3 or more are recommended)
- ✓ Installing Globus Toolkit 2.4.3 or more (But, 2.4.3 is required to use nproxy)
- ✓ Extracting MPICH 1.2.6 source code from a tar ball

3.2.2 Installing Required Softwares

3.2.2.1 Installing Java SDK

Required for: Client tools
Recommended Versions: 1.4.x
Download Link: http://java.sun.com/j2se

3.2.2.2 Installing Globus Toolkit

1. Download all source code from http://www.globus.org
2. As globus, untar the source installer.
3. Make sure that ANT_HOME and JAVA_HOME are set, and that ant and java are on your PATH.
4. Run

```
  # ./install-gt3 /path/to/install
```

7. Configure the Globus Toolkit 3.2, looking through http://www-unix.globus.org/toolkit/docs/3.2/installation/install_config.html

3.2.2.3 PHP4

PHP4 (command line interface) is required for Job Manager Script module in gxlrm.

The libxml2 module must be compiled with PHP.

Download the latest version of libxml2 from http://xmlsoft.org/sources/.

```
# tar zxvf libxml2-2.6.16.tar.gz
# cd libxml2-2.6.16/
#     ./configure     --prefix=/usr/local/libxml2     &>
configure.log
# make &> make.log
# make install &> install.log
```

The zlib library must be installed.

Download a latest PHP distribution from http://www.php.net/

```
# cd /usr/local/src
# tar zxvf php-4.3.9.tar.gz
# cd php-4.3.9
# ./configure \
--enable-pcntl \
--with-dom=/usr/local/libxml2   --with-zlib-dir=/usr   --
disable-cgi
# make clean
# make
# make install
```

The configure option '--enable-pcntl', which is for process control in PHP, is required in job manager script module. The '--with-dom' is required for XML processing in PHP.

The '--with-zlib-dir' is required for libxml2 in PHP.

3.2.2.4 OpenPBS and Cluster Configuration

Computing nodes in a cluster should be configured for rsh and ssh. The job manager script module uses ssh for executing remote program in other computing nodes in the cluster. The rsh have a problem to be used for this purpose. To configure ssh add host keys of all the computing nodes to /etc/ssh/ssh_known_hosts of each computing nodes. The hostname in the known_hosts file should be fully qualified domain name(FQDN).

3.2.3 Installing MPICH-GX

3.2.3.1 Download

http://kmi.moredream.org/downloads/index.php
You can download the file “mpich-gx-0.1.tar.gz” of MPICH-GX from the web site written above. The file includes following three components. You could install two packages(mpich-gx library and misc components) at local resources, and gxrun binary package at client side

- mpich_1.2.6_gx-0.1.tar.gz: mpich-gx library
- gx-0.1.tar.gz: misc components including local job manager, java library and client tools
- gxrun-0.1.tar.gz: gxrun binary package

3.2.3.2 Installation at Local Resource

As the globus account,

```
$ export GX_LOCATION=/usr/local/mpich-gx
$ tar zxvf mpich_1.2.6_gx-0.1.tar.gz
$ cd ./mpich-1.2.6
$ ./configure --with-device=ft_globus:-flavor=gcc32dbg -
-prefix=$GX_LOCATION
$ make
$ make install

$ tar zxvf gx-0.1.tar.gz
```

```
 $ cd ./gx
 $ ./install-gt3-gx –gx-dir $GX_LOCATION $GLOBUS_LOCATION
```

, where GX_LOCATION is a location of installation regarding to MPICH-GX and GLOBUS_LOCATION is a location of installation for Globus Toolkit.

3.2.3.3 Installation at Client

As a user account,

```
 $ tar zxvf gxrun-0.1.tar.gz
 $ cd ./gxrun
```

3.2.4 Configuration

3.2.4.1 Startup gxlrm on the front-end node for client tools

If you want to launch the job through gxlrun, you have to invoke a daemon called gxlrm at local resources. Before invoking the gxlrm, you have to configure the information related to the log and the globus location to “~/.gx.conf” file as follows.

```
$ vi ~/.gx.conf
log.level=error
#log.file=/usr/local/gt3.2.1/var/gxlrm.log
#log.append=true
globusLocation=/usr/local/gt3.2.1
```

Then, you can launch a gxrlm at local resources as follows:

```
$ cd $GLOBUS_LOCATION/sbin
$ ./gxlrm &
```

3.2.4.2 Startup NAT Service and nproxy on the front-end node

Our message relay scheme uses NAT service to send a message from a private IP node to others. You can startup Nat service by followings below commands. See [?] to learn more about NAT services.

As a root,

```
# vi /etc/rc.d/rc.local
Iptables –A POSTROUTING –t nat –o eth0 –j MASQURADE
echo 1> /proc/sys/net/ipv4/ip_forward
:wq

# /etc/init.d/xinetd restart
```

Once you startup NAT service, you have to launch a deamon called ‘nproxy’, where is located in $GLOBUS_LOCATION/sbin.

```
$ cd $GLOBUS_LOCATION/sbin
$ ./nproxy &> ../var/nproxy_log.txt &
```

3.2.4.3 Set environmental variables for File-based initialization

If you want to invoke a job by file-based initialization instead of our client tools, you have to follow following directions. Add variables “FILENAME” and “FRONT_NAME” in your shell configuration script. FILENAME represent the name of configuration file for file-based initialization. FRONT_NAME stands for the FQDN of front-end node of the cluster. If you use public IP clusters, you need not to specify FRONT_NAME in your shell configuration.

```
# vi ~/.bashrc

export FILENAME={the name of process file}
export FRONT_NAME={FQDN of front-end node}
export FILE_BASED=1
: wq

# source ~/.bashrc
```

3.3 Running MPI applications

In this Section, we describe the ways to launch MPI applications by using MPICH-GX. Assume that a user hope to run a simple CPI program on 4 machines. CPI is a program to calculate pi.

3.3.1 Compile your MPI program

You have to compile your MPI application by using MPICH-GX library. It is not different from the general compilation method of MPI programs.

```
# mpicc –o gx_cpi cpi.c
```

3.3.2 Launching your MPI applications by gxrun

Make sure that gxlrm is running in local resources.

3.3.2.1 Configuration

You might configure the information related to the log and the port range of socket server to "~/.gxrun" file as follows. You do not have to make a configuration file.

```
$ vi ~/.gxrun
log.level=error
#log.file=filename
#log.append=true
serverPortBegin=16000
serverPortEnd=17000
```

3.3.2.2 Writing a job

As mentioned above, gxlrm's job template is JRDL. Follows is an example to run a simple CPI on remote two clusters, where each cluster use two nodes. And the period to checkpoint is 30 sec.

```
$ vi cpi.xml
<?xml version="1.0" encoding="UTF-8"?>
<jrdl
xmlns="http://www.moredream.org/namespaces/2003/09/jrdl">
  <job>
    <executable>
      <path>
        <stringElement value="cpi"/>
      </path>
    </executable>
    <directory>
      <path>
        <stringElement value="/home/globus"/>
      </path>
    </directory>
```

```
          <environment>
            <hashtable>
              <entry name="LD_LIBRARY_PATH">
                <stringElement
      value="/usr/local/gt3.2.1/lib"/>
              </entry>
            </hashtable>
            <hashtable>
              <entry name="CKPT_PERIOD">
                <stringElement value="30000"/>
              </entry>
            </hashtable>
          </environment>
          <stdout>
            <pathArray>
              <path>
                <stringElement value="stdout"/>
              </path>
            </pathArray>
          </stdout>
          <stderr>
            <pathArray>
              <path>
                <stringElement value="stderr"/>
              </path>
            </pathArray>
          </stderr>
          <jobType>
            <enumeration>
              <enumerationValue>
            <xmpi/>
          </enumerationValue>
        </enumeration>
      </jobType>

      <subjob>
          <resourceManagerContact>
             <string>
                <stringElement
value="solar16.gridcenter.or.kr"/>
             </string>
          </resourceManagerContact>
          <jobManagerType>
            <enumeration>

<enumerationValue><pbs/></enumerationValue>
            </enumeration>
          </jobManagerType>
          <count>
             <integer value="2"/>
          </count>
       </subjob>
      <subjob>
          <resourceManagerContact>
             <string>
                <stringElement
value="solar21.gridcenter.or.kr“/>
             </string>
          </resourceManagerContact>
          <jobManagerType>
```

```
            <enumeration>

<enumerationValue><pbs/></enumerationValue>
            </enumeration>
         </jobManagerType>
         <count>
             <integer value="2"/>
         </count>
      </subjob>
   </job>
</jrdl>
```

3.3.2.3 Submitting the job

Staging executable to each cluster

```
$ scp /home/globus/cpi user@solar16:/home/globus/cpi
$ scp /home/globus/cpi user@solar21:/home/globus/cpi
```

Submitting the job

```
$ gxrun cpi.xml
Request a new job 700
Job is done.
$
```

3.3.3 Launching your MPI applications based on File-based initialization

You can launch your application in various ways. You can use original ‘mpirun’ or ‘globusrun’ or you can even launch your application manually without any launching program.

3.3.3.1 Manual Launching

Manual launching must be a very inconvenient way, but it can help you understand entire steps of launching MPI applications.

A. Making 'process_info' file:

As stated above, you should make a configuration file to help MPI processes with performing the initialization procedure. Following is an example when a user runs 'cpi' application on 2 clusters each of which has 2 nodes. Details of 'process_info' file are described in Section 4.

```
# vi process_info
4 2 9292
# Protocol information of each process
0 0 0 2 33501 36000 nova03.gridcenter.or.kr nova01.gridcenter.or.kr
1 0 1 2 33501 36000 nova04.gridcenter.or.kr nova01.gridcenter.or.kr
2 1 0 2 33501 36000 solar18.gridcenter.or.kr solar18.gridcenter.or.kr
3 1 1 2 33501 36000 solar19.gridcenter.or.kr solar19.gridcenter.or.kr

 # cp process_info FILE_NAME
```

B. Staging 'process_info' file to all execution nodes:

```
# echo $FILE_NAME
          /home/globus/process_info
# scp /home/globus/process_info ser@execution_node:FILE_NAME
```

C. Staging executables:

```
# scp /home/globus/cpi user@execution_node:/home/globus/cpi
```

D. Run executables on each remote machine:

```
nova03]# /home/globus/cpi RANK=0
nova04]# /home/globus/cpi RANK=1
solar18]# /home/globus/cpi RANK=2
solar19]# /home/globus/cpi RANK=3
```

3.3.3.2 Launching by 'mpirun'

You also can launch MPI application by using old 'mpirun.'

A. Configuration:

Make sure that two clusters are properly configured regarding to ssh and rsh with each other

B. Making and Staging 'process_info' file:

It is same with above direction of manual launching

C. Making 'machine file':

```
# vi machinefile

"cluster1/jobmanager-pbs" 2
"dccsun/jobmanager-pbs" 2
:wq
```

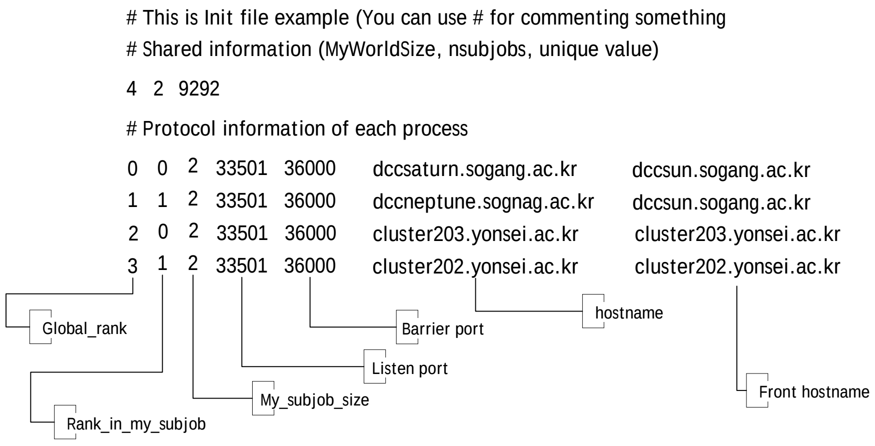
D. Launching executable by using 'mpirun':

```
# mpirun –np 4 –machinefile machinefile –s cpi
```

3.3.4 How to make 'process_info' file?

We will describe the details of 'process_info' file as depicted in Figure 1-35.

Both dccsaturn and dccneptune exist on private IP domiain, whereas both cluster203 and cluster202, where hostname is same domain name with front's, are running on public IP domain



```
# This is Init file example (You can use # for commenting something
# Shared information (MyWorldSize, nsubjobs, unique value)
4  2  9292
# Protocol information of each process
0  0  2  33501  36000    dccsaturn.sogang.ac.kr      dccsun.sogang.ac.kr
1  1  2  33501  36000    dccneptune.sognag.ac.kr     dccsun.sogang.ac.kr
2  0  2  33501  36000    cluster203.yonsei.ac.kr     cluster203.yonsei.ac.kr
3  1  2  33501  36000    cluster202.yonsei.ac.kr     cluster202.yonsei.ac.kr
```

Figure 1-35 An example of process_info file

,

Chapter 2

KGridCA

1. Introduction

1.1. What is KGridCA?

CA (Certificate Authority) is an entity in PKI (Public Key Infrastructure), which is responsible for establishing and vouching for the authenticity of public keys. KGridCA is a software for constructing a certificate authority in a simple manner. KGridCA can be accessed by web browsers, and generations of certificate are done by OpenSSL. Issued certificates are stored and managed by DBMS.

1.2. Architecture of KGridCA

Figure 2-1 is the architecture of KGridCA. A certificate requestor access to the public web server to upload his CSRs(Certificate Signing Request). Uploaded CSR are stored in a database. The administrator accesses to an internal web server to issue a certificate. The internal web server should be protected from outside world for security. Issued certificates are stored in the database, which can be downloaded by the certificate requestor through the public web server.

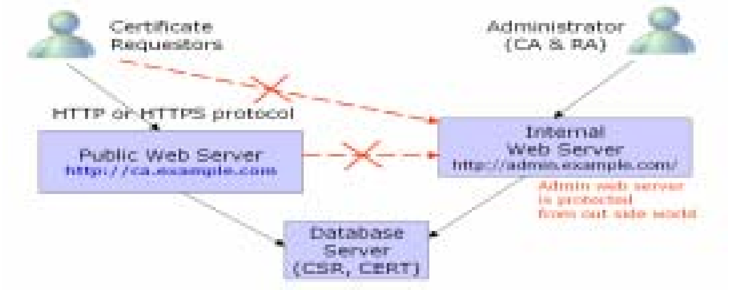


Figure 2-1 Architecture of KGridCA

In strict conditions, the public web server and the internal web server should be separated in different hosts, and the internal web server should be managed securely. But in a less strict condition, the public web server and the internal web server can share the same physical host depicted in Figure 2-2.

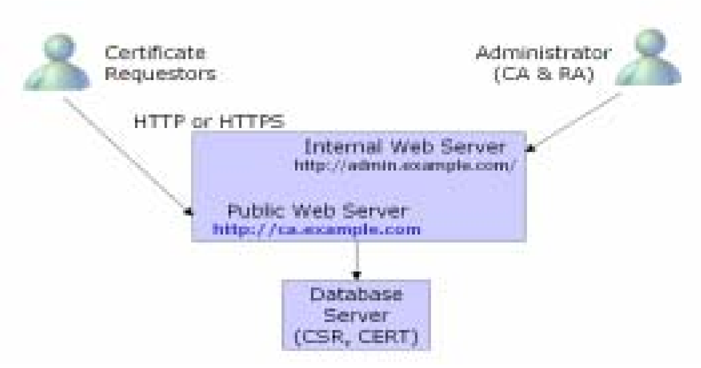


Figure 2-2 Architecture of KGridCA in a less strict condition

2. Installation and Configuration

2.1 Requirements

KGridCA is implemented in php language and use MySQL database to store certificates, CSRs, and other information. It is installed a web server such as Apache. OpenSSL is also required to generate certificate, CRL.

The following softwares are required:
- MySQL Database (3.23.x or 4.0.x)
- PHP4 + Apache Web server (PHP 4.3.x, Apache 1.3.x)
- OpenSSL (0.9.7e)

2.2. Installing required software

2.2.1. Installing MySQL Database

Download a latest MySQL distribution from http://www.mysql.com/.

Move to a temporary directory and extract the distribution file.

```
  # cd /usr/local/src      (download the distribution file in this directory)
  # tar zxvf mysql-4.0.16.tar.gz
  # cd mysql-4.0.16
```

Configure and compile the source

```
  # ./configure --prefix=/usr/local/mysql --with-mysqld-user=root
  # make
```

Copy the compiled binaries to the install location.

```
  # make install
```

Make a symbolic link for ‘mysql’ command line client, or add it to the $PATH variable.

```
  # ln -s /usr/local/mysql/bin/mysql /usr/local/bin/mysql
```

Database initialization

```
  # /usr/local/mysql/bin/mysql_install_db
```

Start MySQL server daemon

```
  # /usr/local/mysql/bin/mysqld_safe -u root &
```

To start MySQL server daemon during system startup, add a line to the rc.local file.

```
# vi /etc/rc.d/rc.local
...
/usr/local/mysql/bin/mysqld_safe -u root &
...
```

Refer to other books or documents about managing and using MySQL.

2.2.2. Installing PHP4 + Apache Web Server

Apache should be configured before compiling PHP.

Download a latest apache distribution from http://www.apache.org/

```
# cd /usr/local/src
# tar zxvf apache_1.3.33.tar.gz
# cd apache_1.3.33/
# ./configure
```

Download a latest PHP distribution from http://www.php.net/

```
# cd /usr/local/src
# tar zxvf php-4.3.11.tar.gz
# cd php-4.3.11
# ./configure --with-apache=../apache_1.3.33/ \
--with-config-file-path=/etc/httpd               --with-
mysql=/usr/local/mysql
# make clean
# make
# make install
```

Compile the Apache web server and install it.

```
# cd /usr/local/src/apache_1.3.33/
# ./configure --prefix=/usr/local/apache \
--activate-module=src/modules/php4/libphp4.a
# make clean
# make
# make install
```

Setup the PHP installation

```
  # cd /usr/local/src/php-4.3.11
  # mkdir /etc/httpd; cp  php.ini-dist  /etc/httpd/php.ini
```

Setup the Apache web server

```
  # vi /usr/local/apache/conf/httpd.conf
     ...
  LINE 808(approx.): add a line
     # PHP
     AddType application/x-httpd-php .php
  </IfModule>
     ...
     :wq
```

{Start | stop | restart} the apache web server

```
# /usr/local/apache/bin/apachectl {start | stop | restart}
```

2.3. Installing KGridCA

2.3.1. Download and Extract

You can download the distribution files from KMI web site http://kmi.moredream.org/.

Download and untar the distribution file under your web server root directory.

```
$ cd /usr/local/apache/htdocs
```

Download KGridCA-1.0.tar.gz from http://kmi.moredream.org/

```
$ tar zxvf KGridCA-1.0.tar.gz
$ cd KGridCA-1.0
```

Directory structure is as follows:

```
KGridCA-1.0
  |-- img
  |-- inc
  |-- rootca          # root ca repository
  |-- sql             # MySQL commands
  |-- ssl.conf        # OpenSSL configuration
  `-- tmp             # temporary file
```

2.3.2. Configuration

Create a database named ‘gridca’ and make tables:

```
$ mysql [–u user] [–p]
mysql> create database gridca;
mysql> quit
$ cd sql
$ mysql [–u user] [-p] gridca < create_tables.sql
```

Refer to other documents to use mysql command.

Open inc/config.php to edit the database connection parameters and others:

```
$ vi inc/config.php
```

```
# database access
$conf[dbhost]   = "localhost";  # database server
$conf[dbuser]   = "root";       # database user
```

```
$conf[dbpasswd] = "";                # database user's password
$conf[dbname]    = "gridca";         # database name

# path and location
$conf[openssl]       = "/usr/local/bin/openssl"; # openssl path
$conf[gridca_path] = "/www/html/GridCA";
$conf[rootca_path] = "$conf[gridca_path]/rootca";

# openssl config files
$conf[openssl_config_1] = "$conf[gridca_path]/ssl.conf/ssl.ca.conf";
$conf[openssl_config_2] = "$conf[gridca_path]/ssl.conf/ssl.general.conf";
$conf[tmpdir]      = "/www/html/GridCA/tmp"; # temporary directory
$conf[tmpdir_prefix] = "gridca_";
$conf[clear_files] = 1;                # if true, clear generated files
$conf[sitehome] = "https://ca.example.com/GridCA"; # home URL
$conf[managerhome]  =  "http://admin.example.com/GridCA";  #  home
URL
$conf[href_prefix] = "/GridCA";
$conf[https_only] = false;
$conf[crl_scp_prefix] = "host.example.com:/path/to/CRL";

# administration
$conf[admin_sendmail] = 0;           # if true, send emails to admin
$conf[admin_email] = "ca@example.com"; # administrator email address
$conf[project_name] = "GridCA";   # project name
$conf[allow_admin_login] = true;

# timezone
$conf[gmt_to_local]  =  3600*9;    #  local  time  shift  based  on  GMT  time  in
seconds
```

```
$conf[timezone_str] = 'KST[GMT+9]';       # time zone

# database tables (from/sql/db.mysql.sql)
$conf[dbtblcert]     = "gridca_cert";       # cert table name
$conf[dbtblcsr]       = "gridca_csr";         # csr table name
$conf[dbtblpasswd] = "gridca_passwd";    # passwd table name
$conf[dbtbllog]       = "gridca_log";         # log table name
$conf[dbtblsn]         = "gridca_sn";           # serial number table name
# cookies configuration
$conf[cookie_prefix] = 'GRIDCA_';    # cookie variable prefix
$conf[secure_cookie] = 1;                 # use hashed token cookie value
$conf[static_cookie] = "MY_COOKIE_STRING";

$conf[min_passwd_len] = 4;              # the minimum length of passwords
$conf[root_ca_valid_days] = 365*5;# valid period of root CA
$conf[cert_valid_days]       = 365;    # valid period of certificates
$conf[default_org1] = "Grid";      # default value of organization name 1
$conf[default_org2] = "Globus";# default value of organization name 2
$conf[default_country] = "KR"; # default value of country code
$conf[newtime] = 3600*24;    # displayed as new for newtime in seconds
$conf[ipp] = 10;                       # items per page
$conf[session_check_period] = 60;
```

2.3.3. Configure Administration Login Name

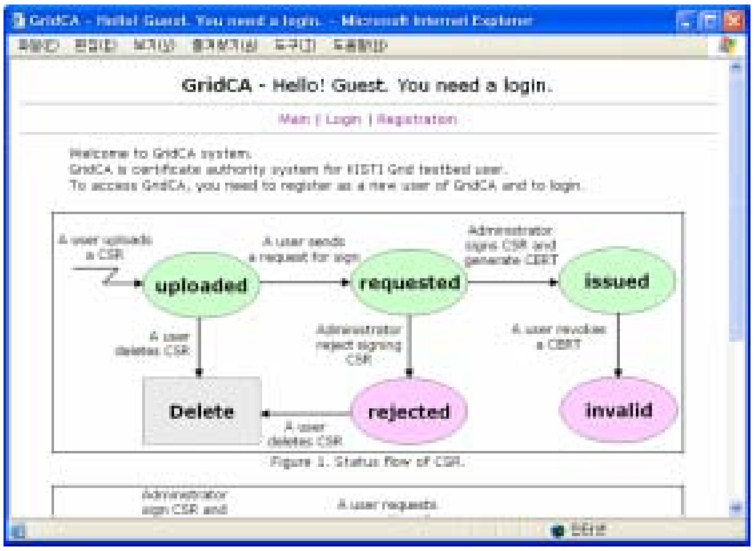
As an administrator, you should add an admin account to login KGridCA.

```
  $ cd sql
  $ php insert_admin.php "admin" "password" "admin@example.com"
> sql
```

where “admin” is the administrator’s account name, “password” is his password, and the last one is the email address.

```
$ mysql [-u user] [-p] gridca < sql
```

Open a web browser and load index.php.



GridCA - Hello! Guest. You need a login. - Microsoft Internet Explorer

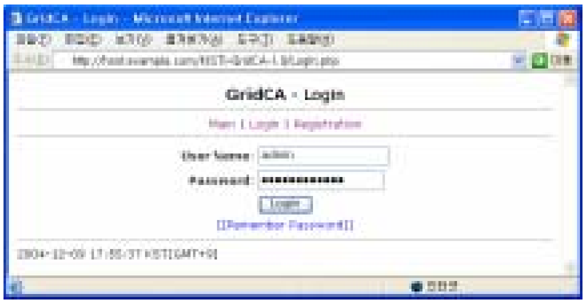
GridCA - Hello! Guest. You need a login.

Main | Login | Registration

Welcome to GridCA system.
GridCA is certificate authority system for KISTI Grid testbed user.
To access GridCA, you need to register as a new user of GridCA and to login.

Figure 1. Status flow of CSR.

Click 'Login' and input the administrator's account and password created above.



GridCA - Login - Microsoft Internet Explorer

http://host.example.com/KISTI-GridCA-1.0/Login.php

GridCA - Login

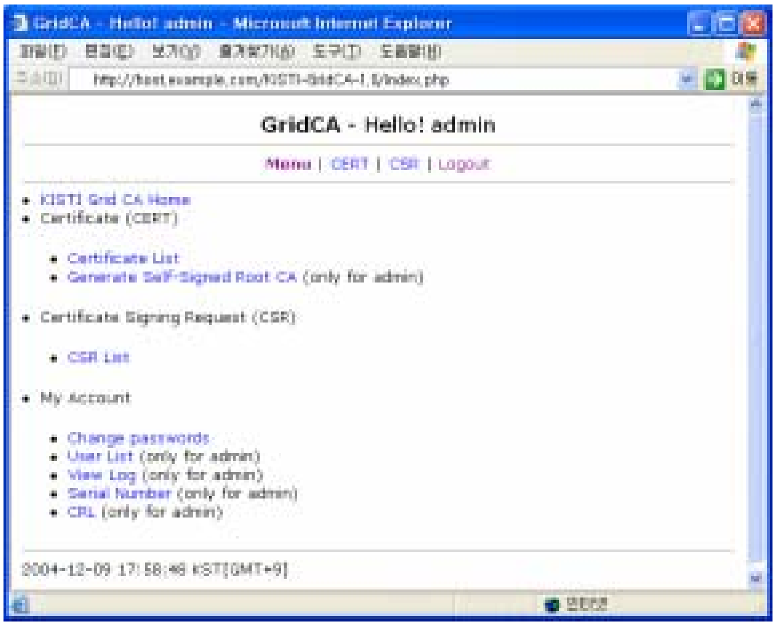
Main | Login | Registration

User Name : admin

Password : ••••••••••••

2004-12-09 17:55:37 KST(GMT+9)

If the login was successful, You will see the following page:


GridCA - Hello! admin - Microsoft Internet Explorer
http://host.example.com/KISTI-GridCA-1.0/index.php

GridCA - Hello! admin

Menu | CERT | CSR | Logout

- KISTI Grid CA Home
- Certificate (CERT)
    - Certificate List
    - Generate Self-Signed Root CA (only for admin)
- Certificate Signing Request (CSR)
    - CSR List
- My Account
    - Change passwords
    - User List (only for admin)
    - View Log (only for admin)
    - Serial Number (only for admin)
    - CRL (only for admin)

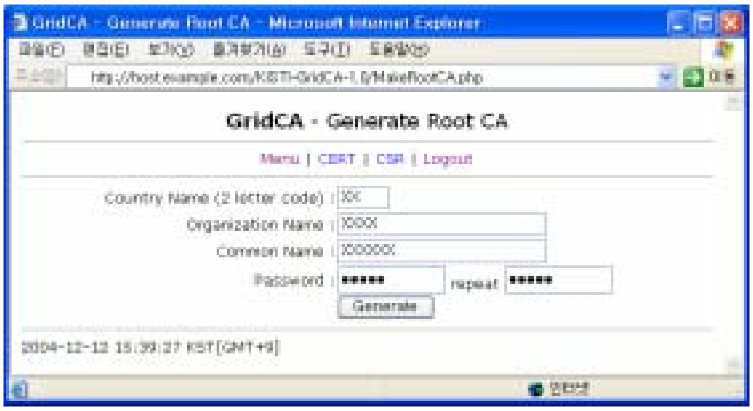
2004-12-09 17:58:48 KST[GMT+9]

2.3.4. Generating Root Certificate

Click ‘Generate Self-Signed Root CA’ in the main menu.

The ‘rooca’ directory should be writable by the web server daemon.

Temporary change the mode 777 in this step. (chmod 777 rootca)


GridCA - Generate Root CA - Microsoft Internet Explorer
http://host.example.com/KISTI-GridCA-1.0/MakeRootCA.php
Generate

GridCA - Generate Root CA

Menu | CERT | CSR | Logout

Country Name (2 letter code) :	XX
Organization Name :	XXXX
Common Name :	XXXXXX
Password :	****** repeat ******

2004-12-12 15:39:27 KST[GMT+9]

.crt, .key, .info files are generated.

Chapter 3

KMI-GridSphere

1. Introduction

1.1 What is Gridsphere?

GridSphere is the open-source porltet based portal framework which is part of the Gridlab project funded by the European Commission under the Fifth Framework Programme of the Information Society Technology. Gridsphere is compliant 100% JSR 169 Portlet API and supports higher-level model for building complex portlets using visual beans and the GridSphere User Interface tag lib

We develop the basic portlets for using Grid environment to support implementation of Grid portal and implement Bio Informatics Grid Portal and Data Grid portal for Belle Code using Gridsphere. Also, we implement MoreDream Grid service portlets - GRASP job submission porlet, GAIS information

We have modified bannaer and GuestLayOut Pages. This product includes software developed by and/or derived from the GridSphere Project (http://www.gridsphere.org/).

2. Installation and Configuration

2.1 Requirements

- OS : Linux (RedHat 7.3 or more are recommended)
- Java 2 Platform, Standard Edition 1.3.1 or 1.4.2+
- Ant 1.5.3-1+

- Tomcat 4.1+ (not tested in Tomcat 5.+)

2.2. Installing required software

2.2.1. Installing Java 2Platform, Standard Edition

You can download Java 2 SDK from http://java.sun.com. Following is described about binary installation in Redhat Linux.

1. Login as root

```
$ su –
```

2. Download and extract the downloaded file.

```
# cd $JDK_DOWNLOAD_DIRECTORY
# chmod 755 j2sdk-1_X_X-linux-i586.bin
# ./j2sdk-1_X_X-linux-i586.bin
    Sun Microsystems, Inc.
                  Binary Code License Agreement
                               for the

  JAVATM 2 RUNTIME ENVIRONMENT (J2RE), STANDARD EDITION,
  VERSION 1.X.X_X
  ...
  Do you agree to the above license terms? [yes or no] yes
```

3. Run the rpm command to install. It is installed in /usr/java/ j2sdk1.X.X by default.

```
# rpm –ivh j2sdk-1_X_X-linux-i586.rpm
```

4. Set Java environment variables.

```
$ vi ~/.bashrc
  export JAVA_HOME=/usr/java/j2sdk1.X.X
export PATH=$JAVA_HOME/bin:$PATH
```

2.2.2 Installing Ant

You can download Ant from http://ant.apache.org.

1. Login as root.
```
$ su –
```
2. Extract the downloaded file.
```
# cd $ANT_DOWNLOAD_DIRECTORY
# tar zxvf apache-ant-1.X.X-X-bin.tar.gz
```
3. Move to the extracted files installation directory.
```
# mv apache-ant-1.X.X-X /usr/local/
```
4. Set Ant environment variables.
```
# vi ~/.bashrc
export ANT_HOME=/usr/local/apache-ant-1.X.X-X
export PATH=$ANT_HOME/bin:$PATH
```

2.2.3. Installing Tomcat

You can download Ant from http://jakarta.apache.org/tomcat.

1. Login as root.
```
$ su – tomcat
```
2. Extract the downloaded file.
```
# cd $TOMCAT_DOWNLOAD_DIRECTORY
# tar zxvf jakarta-tomcat-4.X.X.tar.gz
```
3. Move to the extracted files installation directory.
```
# mv jakarta-tomcat-4.X.X /usr/local/
```
4. Set Ant environment variables.
```
# vi ~/.bashrc
export CATALINA_HOME=/usr/local/ jakarta-tomcat-4.X.X
```

2.3. Installing Gridsphere

2.3.1. Downloading and extraction

You can download from http://www.gridcenter.or.kr/kmi and http://www.gridsphere.org. We recommend to download from http://www.gridcenter.or.kr/kmi. Gridsphere is being developed and modified continually, to use the portlets in KMI packages you must download KMI version.

2.3.2. Installation

1. Extract the downloaded file.

```
  $ cd $GRIDSPHERE_DOWNLOAD_DIRECTORY
  $ tar xvzf gridsphere-kmi.1.X.X.tar.gz
```

From now on, $GRIDSPHERE_HOME is $GRIDSPHERE_DOWNLOAD_DIRECTORY/gridsphere.

2. Install Gridsphere

Using Ant, you can install Gridsphere to Tomcat Web Application. $GRIDSPHERE_HOME/build.xml supports the following tasks:

```
  install -- builds and deploys GridSphere, makes the
documentation and installs the database
  clean -- removes the build and dist directories
including all the compiled classes
  compile -- compiles the GridSphere source code
  deploy -- deploys the GridSphere framework and all
portlets to a Tomcat servlet container located at
$CATALINA_HOME
  create-database - creates a new, fresh database with
```

```
original GridSphere settings, this wipes out your current
database!
  docs -- compiles all GridSphere docbook documentation
and builds the Javadoc documentation from the source code
  run-tests -- runs all Junit tests inside the Tomcat
container using the Jakarta Cactus framework

  $ cd gridsphere
  $ ant install
```

Type ”y” about question of Gridsphere License Agreement and Gridsphere is installed to $CATALINA_HOME/webapp/gridsphere.

2.3.3. Configuration of Tomcat Environment

To manages the portlets, Gridsphere uses Tomcat Manager Web Application. So, you must insert gridsphere user with manager role to Tomcat User. Edit $CATALINA_HOME/conf/tomcat-user.xml.

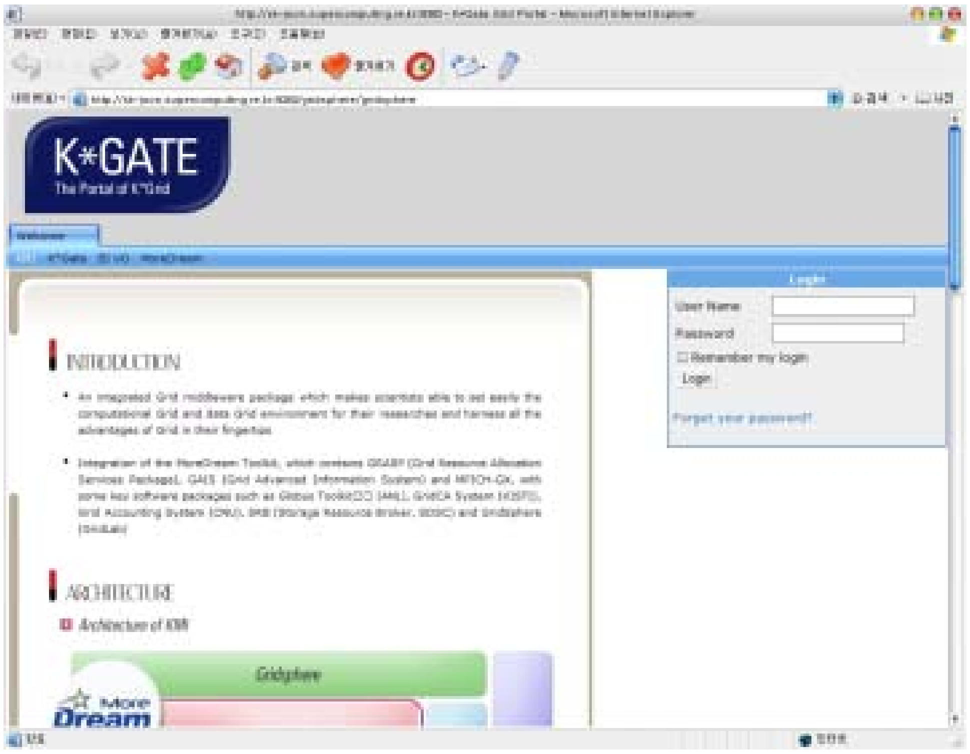
```
<user name=”gridsphere” password=”gridsphere” role=”manager” />
```

To prevent the portal users access Tomcat Manager Web Application, edit $CATALINA_HOME/webapp/manager.xml like following.

```
<Context path=”/manager” debug=”0” privileged=”ture”
docBase=”$CATALINA_HOME/server/webapps/manager”>
<valve className=”org.apache.catalina.valves.RemoteAddrValve”
allow=”127.0.0.1”/>
</Context>
```

2.3.4. Starting Gridsphere

You just restart Tomcat container and connect to http://localhost:8080/gridsphere/gridshere. You can see following web page.



INTRODUCTION

- An integrated Grid middleware package which makes scientists able to use easily the computational Grid and data Grid environment for their researches and harness all the advantages of Grid in their fingertips.
- Integration of the MoreDream Toolkit, which contains GRASP (Grid Resource Allocation Services Package), GAIS (Grid Advanced Information System) and MPICH-GX, with some key software packages such as Globus Toolkit(3.2) [4.0], GridCA System (KISTI), Grid Accounting System (CNU), SRB (Storage Resource Broker, SDSC) and GridSphere (GridLab)

ARCHITECTURE

Architecture of KMI

2.4. Installing Gridportlets

We just use certification portlets and applet(including web start), so to use full function of Gridportlets you modify xml files in $GRIDPORTLETS_HOME/webapp/WEB-INF/.

2.4.1. Downloading and extraction

Like Gridsphere, you can download from http://www.gridcenter.or.kr/kmi and

Gridsphere CVS repository. We recommend to download from http://www.gridcenter.or.kr/kmi. Gridsphere is being developed and modified continually, to use the portlets in KMI packages you must download KMI version.

After download the package, you extract file to $GRIDSPHERE_HOME/projects. From now on, $GRIDPORTLETS_HOME is $GRIDSPHERE_HOME/projects/gridportlets.

2.4.2. Configuration of Gridportlets

Before you install Gridportlets, you must install Gridsphere and modify $GRIDPORTLETS_HOME/build.properties file and $GRIDPORTLETS_HOME/webapp/WEB-INF/Resources.xml.

1. Modify build.properties

   1.1. Set OGAS Library version

```
#ogsa.version=ogsa-3.0.2
  ogsa.version=ogsa-3.2.1
```

   1.2. Set keystore properties. “Keystore” is a path of keyStore file generated by keytool. “storealias” is the value of “–alias” option.

```
CN=K*GRID
OU=
O=KISTI
C=KR

keystore=/usr/local/tomcat/portalcert/testKeyStore
storetype=JKS
storepass=gridsphere
signalias=gridsphere
```

This version supports just keytool but next version supports keytool and openssl. Above keystore directory must be made before installation.

※ Generation of keyStore using keytool

```
$ keytool –genkey –keystore testKeyStore –alias gridsphere
$ keytool –selfcert –alias gridspher –keystore testKeyStore
$ keytool –list –keystore testKeyStore
```

1.3. Set hostname and MyProxy Server

```
# CA email address.
install.ca.email.address=
# default MyProxy server to use.
install.myproxy=nstargate.gridcenter.or.kr
# host name
install.hostname=sk-joon.supercomputing.re.kr
# host port
install.port=8080
```

2. Modify Resources.xml

You must set Myproxy server information in $GRIDPORTLETS_HOME/webapp/WEB-INF/Resources.xml.

```
<grid-resources>
    <hardware-resource label="K*Grid Myproxy machine"
                       description="Myproxy resource"
                       hostname="nstargate.gridcenter.or.kr">
        <myproxy-resource label="KISTI Myproxy Service"
                          description="The KISTI Myproxy service"
                          authorizedProxyFile=""
                          authorizedCertFile=""
                          authorizedKeyFile=""/>
    </hardware-resource>
</grid-resources>
```

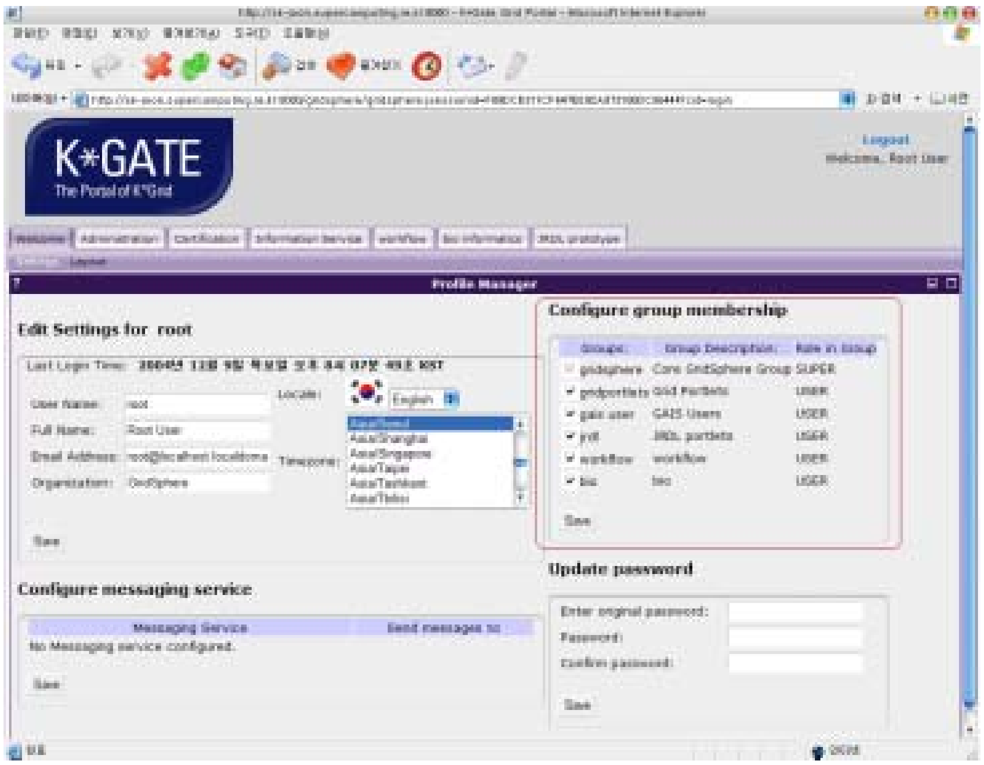
2.4.3. Installation

Using ant, you just run command "ant install" and the package is installed in $CATALINA_HOME/webapp/gridportlets.

```
$ ant install
```

2.4.4. Starting GridPortlets

You just restart Tomcat container and log in http://localhost:8080/gridsphere/gridshere. In "Welcome->Settings->Configure group memebership", you check gridportlets and click "Save" button.



Edit Settings for root

Last Login Time: 2004년 12월 9일 목요일 오후 4시 07분 49초 KST

User Name:	root	Locale:	English
Full Name:	Root User		
Email Address:	root@localhost.localdoma	Timezone:	Asia/Seoul
Organization:	GridSphere		

Save

Configure messaging service

Messaging Service	Send messages to
No Messaging service configured.	

Save

Configure group membership

	Groups	Group Description	Role in Group
	gridsphere	Core GridSphere Group	SUPER
✓	gridportlets	Grid Portlets	USER
✓	gais user	GAIS Users	USER
✓	jrdl	JRDL portlets	USER
✓	workflow	workflow	USER
✓	bio	bio	USER

Save

Update password

Enter original password:
Password:
Confirm password:

Save

Chapter 4

AIServie

(Acccount Information Service)

1. Introduction

The object of this document describes how to install and configure AIService, an accounting service which is efficient, flexible and OGSI-compliant service. Here, we illustrate the schematics of this accounting service and its main functionalities.

For purposes of this document, it is assumed that
  -You are familiar with Unix or Linux.
  -You have some understanding of the concepts underlying computational grids.
  -You have some understanding of the concepts of traditional Unix (or Linux) accounting.
  -You have basic knowledge of XML.

1.1. What is AIService?

This project is intended to develop an OGSI-compliant service which gather accounting information from heterogeneous platforms and provide accounting information as a standard form. We named it as 'AIService' (Accounting Information Service).

There are two topics:
  Gathering grid accounting information
  Service of grid accounting information

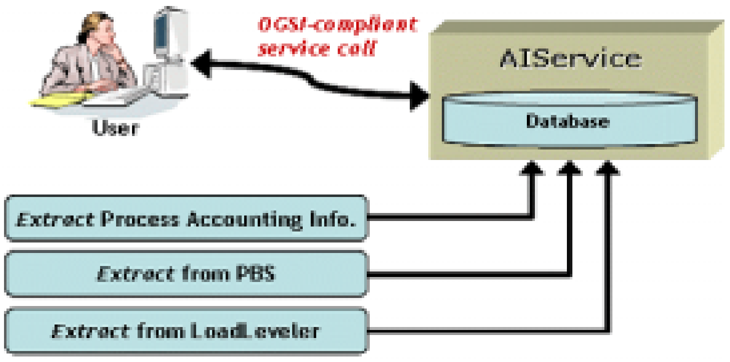


Figure 4-1 A schematic view of AIService

Accounting in the grid environment is very different from that in the traditional computing environment, because the concept of the user is different from the traditional local user and the format of accounting data of each system is different from each other. Accounting information in the grid environment is not produced by the local user but by the grid user. And the format of accounting data is different from platform to platform. By the use of AIService, these problems can be resolved.

Development of this project focuses on the GT3. To provide accounting information to grid users, AIService is developed to be OGSI-compliant. Anyone who uses GT3 client can retrieve his accounting information via AIService.

1.2. Architecture of AIService

Figure 4-1 shows a schematic view of AIService. This system is divided into two major parts: AIT and AIS. AIT (Accounting Information Tracker) gathers local accounting information at each site, converts into grid accounting information format, and accumulate in database. AIS (Accounting Information

Service) serves as OGSI-compliant interface against user's GT3 request. Figure 4-2 shows more detail view of AIService.

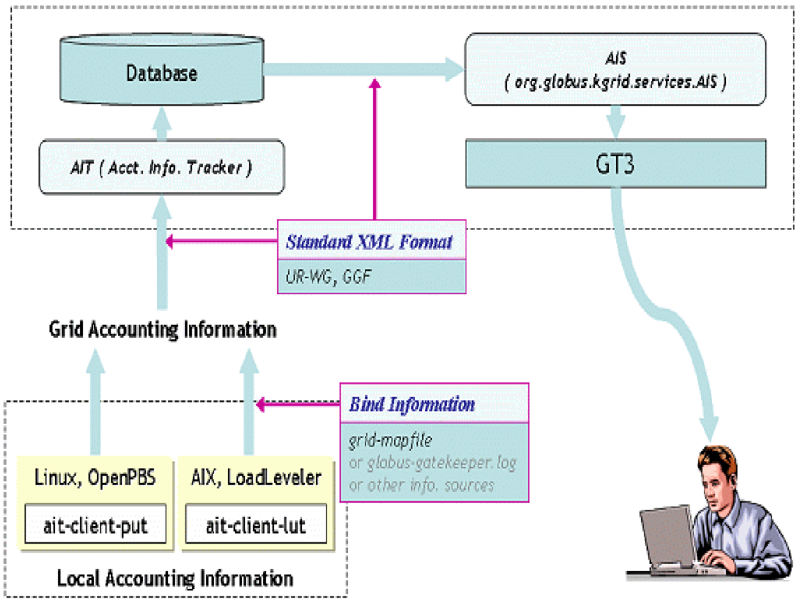


Figure 4-2 AIService Architecture

- **AIT-server**
  - Accumulates grid accounting information into database for AIS
    - ■ We use MySQL as DBMS.
    - ■ For the future expansion, we will use Xindice
    - ■ MySQL
- **AIT-client-***
  - ait-client-put for OpenPBS
    - ■ We use PBS XML Accounting Toolkit (http://pbsaccounting.sourceforge.net) to extract accounting information produced by PBS.

- ait-client-lut for LoadLeveler
    - ■ We use C API to get accounting information from LoadLeveler's history.
- Convert local accounting information at each site into grid-aware accounting information.
    - ■ Local accounting information does not include the real owner of each record. The owner of this record is not local account but grid user.
    - ■ The owner of accounting information can be tracked by using the information in 'grid-mapfile' or 'globus-gatekeeper.log' or other resource broker's. Each method has their own advantage and disadvantage.
    - ■ By default, we use the information in 'grid-mapfile'. To guarantee end-to-end user identity, we limit the mapping of user's subject and local account to 1-to-1 mapping (not n-to-1).
- Transform grid-aware accounting information to standard XML format suggested by UR-WG in GGF.
    - ■ At each site, a client module against AIT is located. They are tries to find local accounting information from the local job manager and provides information as the standard XML format. If we need to include new platform, we just develop this client module for new platform.

● **AIService**
- Developed as an OGSI-compliant service.
- Select records that fill user's condition and provide.

● **AIS-portlets**
- A grid portlet working on gridsphere framework.
- Show some chart image extracted from accounting information data and summarized information

2. Installation and Configuration

2.1. Requirements

To manage extracted grid accounting information, you need to have DBMS. For AIService, the following environment is required:

OS : Linux (Redhat 7.3 or more are recommended)

Globus Toolkit 3.0 or later : required to provide OGSI-compliant service

MySQL Database : stores grid accounting information

J2SDK 1.4.0 or later : AIService is written in pure java language on GT3

JDBC Mysql driver : required to access MySQL Database from the java code

2.2. Installing required software

2.2.1. Installing Globus

AIService works on Globus Toolkit 3.0 or later.   So, you need to download it and install in usual scheme.

For the more detailed information, see

  http://www-unix.globus.org/toolkit/docs/3.0/index.html.

2.2.2. Installing MySQL Database

Download a latest MySQL distribution from http://www.mysql.com/.

You can find a copy of MySQL distribution in software archive directory of KISTI Grid Testbed

web site : http://testbed.gridcenter.or.kr/software/index.php?dir=./DBMS

Move to a temporary directory and extract the compressed file.

```
# cd /usr/local/src
# tar zxvf mysql-4.0.16.tar.gz
# cd mysql-4.0.16
```

Refer to the --help output for configure options

```
# ./configure –help
```

Configure and compile the source

```
# ./configure --prefix=/usr/local/mysql --with-mysqld-user=root
# make
```

Copy the compiled binaries to the install location.

```
# make install
```

Make a symbolic link for ‘mysql’ command line client, or add it to the $PATH variable.

```
# ln -s /usr/local/mysql/bin/mysql /usr/local/bin/mysql
```

Database initialization

```
# /usr/local/mysql/bin/mysql_install_db
```

Start MySQL server daemon

```
# /usr/local/mysql/bin/mysqld_safe -u root &
```

To start MySQL server daemon during system startup, add a line to the rc.local file.

```
# vi /etc/rc.d/rc.local
...
# mysql
/usr/local/mysql/bin/safe_mysqld -u root &
...
```

Refer to other books or documents about managing and using MySQL.

2.2.3. Installing J2SDK, Ant, JDBC driver

Install J2SDK 1.4.2 under /usr/java/.

Get it from http://java.sun.com/

```
  # mkdir /usr/java
  # cd /usr/java/
  # chmod 755 j2sdk-1_4_2-linux-i586.bin
  # ./j2sdk-1_4_2-linux-i586.bin
   ...
  Do you agree to the above license terms? [yes or no]
yes
```

Add a configuration to the .bashrc

```
  # vi ~/.bashrc
  ...
  # java
  export JAVA_HOME=/usr/java/j2sdk1.4.2
  export PATH=$JAVA_HOME/bin:$PATH
  ...
:wq
```

Install Jakarta Ant tool

Download ant from http://ant.apache.org/.

```
  # tar zxvf apache-ant-1.5.3-1-bin.tar.gz
  # mv apache-ant-1.5.3-1 /usr/local/
  # cd /usr/local
  # ln -s apache-ant-1.5.3-1 ant
```

Add a configuration to the .bashrc

```
  # vi ~/.bashrc
  ...
  # ant
  export ANT_HOME=/usr/local/ant
  export PATH=/usr/local/ant/bin:$PATH
  ...
:wq
```

Install JDBC driver MySQL-connector/J

Download it from http://www.mysql.com/.

```
  # tar zxvf mysql-connector-java-3.0.8-stable.tar.gz
  # cp mysql-connector-java-3.0.8-stable/mysql-connector-
java-3.0.8-stable-bin.jar $JAVA_HOME/jre/lib/ext/
```

2.3. Installing AIService

2.3.1. Downloading and extracting

For AIS and AIT, download aiservice-1.0.0.tgz from ftp://tea07.chonbuk.ac.kr.

In this document, we use /usr/local/aiservice-1.0.0 as the installation directory.

Move to /usr/local/ and extract the distribution file.

```
  # cd /usr/local/
  # tar zxvf aiservice-1.0.0.tgz
```

The directory structure is :

```
  aiservice-1.0.0
    |-- ais-server   source & binary files for AIS
    |-- ais-portlet  source & binary files for AIS portlet
    |-- ait-client   source & binary files for AIT clients
    |-- ait-server   source & binary files for AIT server
    \-- DB_Tool      tools for management of DBMS
```

For ait-client-put, download ait-client-put-1.0.0.tgz from http://kmi.moredream.org.

Move to your directory and extract the distribution file.

```
# cd ~/ait-client-put
# tar zxvf ait-client-put-1.0.0.tgz
```

The directory structure is :

```
ait-client-put-1.0.0
  |-- bin   runnable script files
  |-- etc   configuration files
  |-- lib   binary java archives
  |-- var   log files & temporary files
  |   \-- spool
  \-- other source & scripts
```

2.3.2. Compiling and Installing AIS & AIT

For AIT clients, source and binary files are provided. If you want to use source version, move to AIT client directory and execute a simple script named ‘build.sh’. To install compiled binaries, set environment variable $AIT_CLIENT_PUT and run a script named ‘install.sh’.

```
# cd ./ait-client-put-1.0.0
# ./build.sh
# export AIT_CLIENT_PUT=/usr/local/ait-client-put
# ./install.sh
```

For AIT server, move to AIT client directory and execute a simple script named ‘build.sh’. To install compiled binaries, set environment variable $AIT_SERVER and run a script named ‘install.sh’.

```
# cd ./ait-server-1.0.0
# ./build.sh
# export AIT_SERVER=/usr/local/ait-server
# ./install.sh
```

For AIS, you can use source and binary version.

If you want to use source version, move to AIS directory and execute a script named ‘build.sh’.

```
# cd ./ais-server
# ./build.sh
```

For AIS-portlet, move to AIS-portlet directory and execute ant.

```
# cd ./ais-portlet
# ant compile
# ant deploy
```

2.3.3. Creating database and tables

Move to ‘DB_Tool’, there are three files.

```
DB_Tool
  |-- README  : information and usage
  |-- create-add-host-sql : a script to create usage record table
  \-- init_db.sql : SQL statements to initialize db
```

To initialize database, use ‘init_db.sql’.

```
# mysql –u root –p < ./init_db.sql
```

Then, database and its management table will be created.

To add new site in this database, use script ‘create-add-host-sql’.

```
# ls
  README
  create-add-host-sql
  init_db.sql
# ./create-add-host-sql joker.chonbuk.ac.kr
# ls
```

```
    README
    add_joker_chonbuk_ac_kr.sql
    create-add-host-sql
    init_db.sql
```

Created file is an SQL statement to create usage record table for this site.

To add table, use this SQL statement

```
  # mysql –u root –p < ./add_joker_chonbuk_ac_kr.sql
```

2.3.4. Configuration

For AIT & AIS, there is no need to configure.

For AIT client, edit files in ‘etc’ directory.

```
  ait-client-put-1.0.0/etc
    |-- PbsUsageTracker.conf       : main configuration file
    |-- ur-config.xsl        : your host name
    \-- ur.xsl      : xsl for transformation from pbs to grid
```

In ‘PbsUsageTracker.conf’, there are following fields.

```
  # cat $AIT_CLIENT_PUT/etc/PbsUsageTracker.conf
    Interval=60      # a time period to check log
    PbsAcctLogDir=/usr/spool/PBS/server_priv/accounting
    # real path of pbs accounting log directory
    PUTInfoFile=./var/PbsUsageTracking.info
    # intermediate information of suspended log
    URXslFile=./etc/ur.xsl # xsl for transformation from
pbs to grid
    OutHost=tea07.chonbuk.ac.kr
    # database server
    OutHostPort=2410 # database server port
    GridMapfile=/etc/grid-security/grid-mapfile
    # real path of grid-mapfile
```

In ‘ur-config.xsl’, the host name which is registered in the database server. (Each host is registered by using ‘create-add-host-sql’. See 2.3.3) So, you must put your host name which is or will be registered in the database server.

For AIT client, edit files in ‘etc’ directory.

```
  ait-client-put-1.0.0/etc
    \-- ait-server.conf     : main configuration file
```

In ‘ait-server.conf’, there are following fields.

```
# cat $AIT_SERVER/etc/ait-server.conf
  Port=2410   # database server port
  DatabaseURL=jdbc:mysql://210.117.187.244:3306/AcctInfo
# A databse url of form « jdbc :subprotocol :subname »
  User=tr_venus   # database user name
  Passwd=tr_venus # password of database user ‘tr_venus’
```

For AIS, edit a configuration file ‘AIS.conf’ in $GLOBUS_LOCATION/etc directory.

In ‘AIS.conf’, there are following fields.

```
  # cat $GLOBUS_LOCATION/etc/AIS.conf
    DatabaseURL=jdbc:mysql://210.117.187.244:3306/AcctInfo
    # A databse url of form « jdbc :subprotocol :subname »
    User=tr_venus    # database user name
    Passwd=tr_venus # password of database user ‘tr_venus’
```

For AIS-portlet, edit a configuration file ‘ais-config’ in ‘webapp/WEB-INF’ of this portlet. Fill AIS-server and resource-list element.

```
  # cat webapp/WEB-INF/ais-config
  <ais-config>
     <ais-server>210.117.187.244</ais-server>
```

```
    <resource-list>
      <resource>vega01.gridcenter.or.kr</resource>
      <resource>eros01.gridcenter.or.kr</resource>
      <resource>venus.gridcenter.or.kr</resource>
    </resource-list>
  </ais-config>
```

2.3.5. Starting

For AIT client, just run a script named ‘run-ait-client-put’ in ‘$AIT_CLIENT_PUT/bin directory.

```
  # cd $AIT_CLIENT_PUT
  # ./bin/run-ait-client-put
```

For AIT server, just run a script named ‘run-ait-client-put’ in ‘$AIT_CLIENT_PUT/bin directory.

```
  # cd $AIT_SERVER
  # ./bin/run-ait-server
```

For AIS, deploy the service into a grid services container.

```
  # cd ./AIS
  # ant deploy \
    –Dgar.name=./build/lib/org_globus_kgrid_services_AIS.gar
```

Run grid services container.

```
  # cd $GLOBUS_LOCATION
  # globus-start-container
```

AIS-portlet is a portlet working on Gridsphere which is working as a servlet on tomcat. So, to run AIS-portlet, restart tomcat.

```
  # $CATALINA_HOME/bin/shutdown.sh
```

```
# $CATALINA_HOME/bin/startup.sh
```

2.4. Management of Database

To add new host,

1. Add hostname and its table name into ‘job_ur_tables’ table
2. Create table of new host

Above operations are performed by using ‘create-add-host-sql’ script.

If you want to add the host ‘joker.chonbuk.ac.kr’,

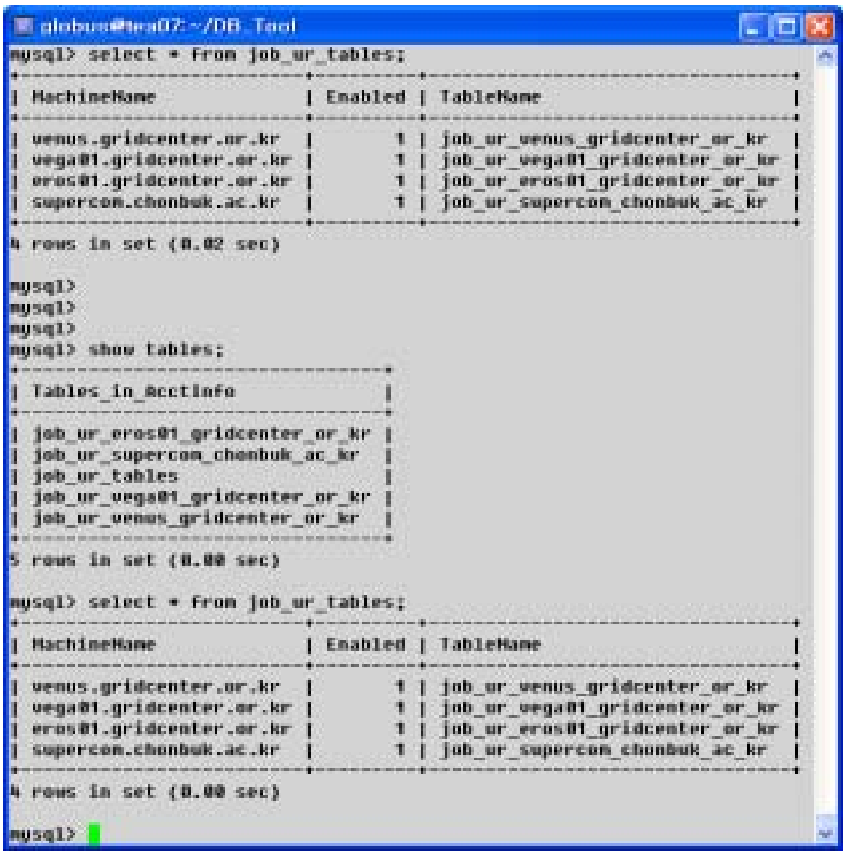
```
# ls -F
README
create-add-host-sql*
init_db.sql
# ./create-add-host-sql joker.chonbuk.ac.kr
# ls -F
README
add_joker_chonbuk_ac_kr.sql
create-add-host-sql
init_db.sql
```

The created file includes SQL statements to add item into ‘job_ur_tables’ table and create table of new host. To perform these operations, use this SQL statement

```
# mysql –u root –p < ./add_joker_chonbuk_ac_kr.sql
```

If you want to change the table name of new host, modify the created file and run SQL statement. (But, don’t change field name or properties.)

Following figure shows tables in the database and contents in ‘job_ur_tables’ table.



```
globus@tea07:~/DB_Tool
mysql> select * from job_ur_tables;
+--------------------------+---------+-------------------------------+
| MachineName              | Enabled | TableName                     |
+--------------------------+---------+-------------------------------+
| venus.gridcenter.or.kr   |       1 | job_ur_venus_gridcenter_or_kr  |
| vega01.gridcenter.or.kr  |       1 | job_ur_vega01_gridcenter_or_kr |
| eros01.gridcenter.or.kr  |       1 | job_ur_eros01_gridcenter_or_kr |
| supercom.chonbuk.ac.kr   |       1 | job_ur_supercom_chonbuk_ac_kr  |
+--------------------------+---------+-------------------------------+
4 rows in set (0.02 sec)

mysql>
mysql>
mysql>
mysql> show tables;
+--------------------------------+
| Tables_in_AcctInfo             |
+--------------------------------+
| job_ur_eros01_gridcenter_or_kr |
| job_ur_supercom_chonbuk_ac_kr  |
| job_ur_tables                  |
| job_ur_vega01_gridcenter_or_kr |
| job_ur_venus_gridcenter_or_kr  |
+--------------------------------+
5 rows in set (0.00 sec)

mysql> select * from job_ur_tables;
+--------------------------+---------+-------------------------------+
| MachineName              | Enabled | TableName                     |
+--------------------------+---------+-------------------------------+
| venus.gridcenter.or.kr   |       1 | job_ur_venus_gridcenter_or_kr  |
| vega01.gridcenter.or.kr  |       1 | job_ur_vega01_gridcenter_or_kr |
| eros01.gridcenter.or.kr  |       1 | job_ur_eros01_gridcenter_or_kr |
| supercom.chonbuk.ac.kr   |       1 | job_ur_supercom_chonbuk_ac_kr  |
+--------------------------+---------+-------------------------------+
4 rows in set (0.00 sec)

mysql>
```

Figure 4-3 Accounting Information Database

3. Using AIService

AIService is implemented to be a OGSI-compliant service. So, users must request using GT3-based service call. Therefore, client's system must have installed GT3 and related development tools (for example, Java SDK, GridSphere).

Figure 4-4 shows an example of service call to AIService.

```
import org.globus.kgrid.services.AIS.impl.*;
import
org.globus.kgrid.stubs.AIService.service.AIServiceGridL
ocator;
import org.globus.kgrid.stubs.AIService.AIPortType;
import org.globus.ogsa.impl.security.Constants;
import
org.globus.ogsa.impl.security.authorization.NoAuthoriza
tion;
import javax.xml.rpc.Stub;
import java.net.URL;

...

try  {
  // Get command-line arguments
  URL GSH = new java.net.URL(args[0]);
  int a = Integer.parseInt(args[1]);

  // Get a reference to the AIService instance
  AIServiceGridLocator aiServiceLocator= new
AIServiceGridLocator();
  AIPortType ai =
aiServiceLocator.getAIServicePort(GSH);

  QueryField qf = new QueryField();
  Try  {
    qf.set( QueryField.UID_GLOBALUSERDN,
            "/C=KR/O=KISTI/OU=Grid/CN=Globus" );
    qf.set( QueryField.RID_CREATETIME_FROM,
            "2004-08-22 00:00:00" );
    qf.set( QueryField.RID_CREATETIME_TO,
            "2004-08-24 05:00:00" );
    qf.set( QueryField.UR_MACHINENAME,
            "eros01.gridcenter.or.kr" );
  } catch( Exception qfe ) {
  }
  ai.search( qf.makeString() );
  String strResult = ai.getResult();
} catch(Exception e)  {
}
...
```

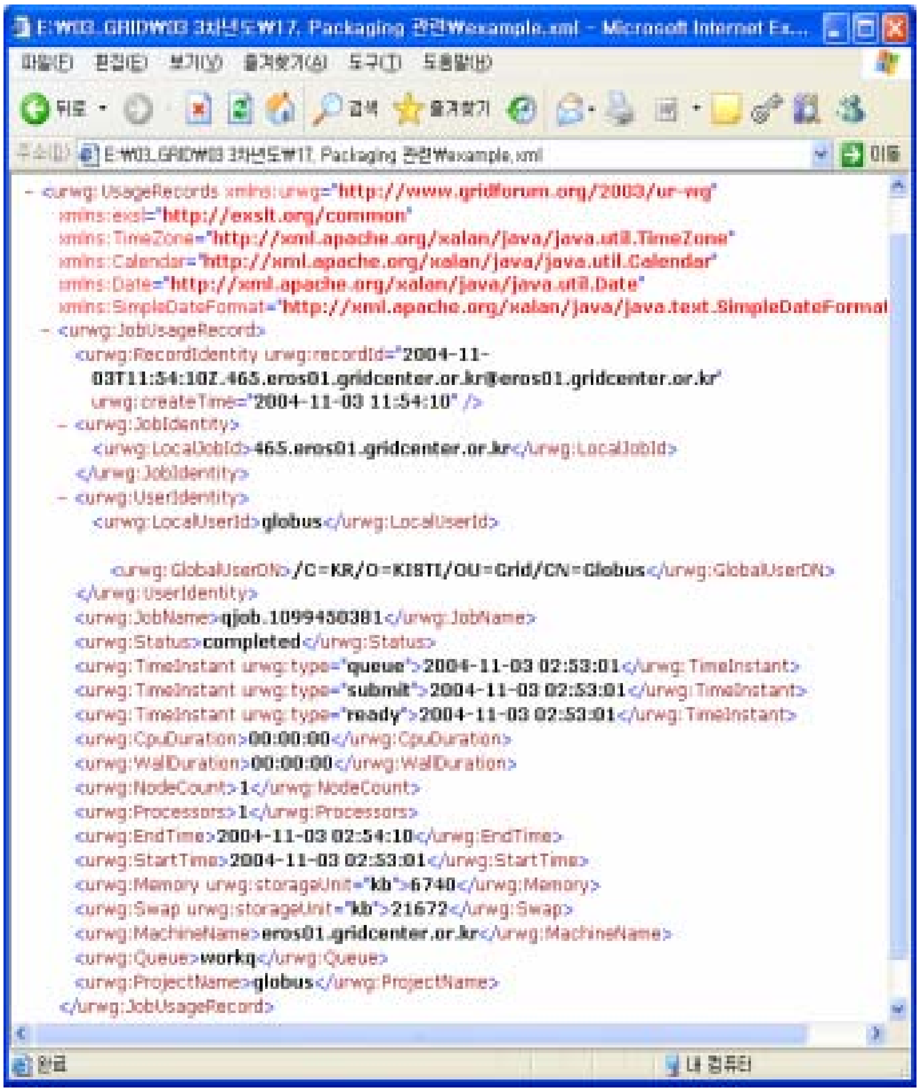
Figure 4-4 An example code to call AIService

In this example, class QueryField is used. QueryField used to build SQL statement in AIService to query database server. QueryField has following fields :

```
public class QueryField   {
   public static int UID_GLOBALUSERDN      = 0x00;
   public static int RID_CREATETIME_FROM   = 0x01;
   public static int RID_CREATETIME_TO     = 0x02;
   public static int JOBSTATUS             = 0x03;
   public static int TI_QUEUE_FROM         = 0x04;
   public static int TI_QUEUE_TO           = 0x05;
   public static int UR_MACHINENAME        = 0x06;
   ...
```

Figure 4-5 QueryField

If the query was success, the result may have following structure (Figure 4-6). The Usage Record Fields suggested by UR-WG in GGF is used. So, this result can be used to exchange information between other OGSI-compliant services, without conversion.

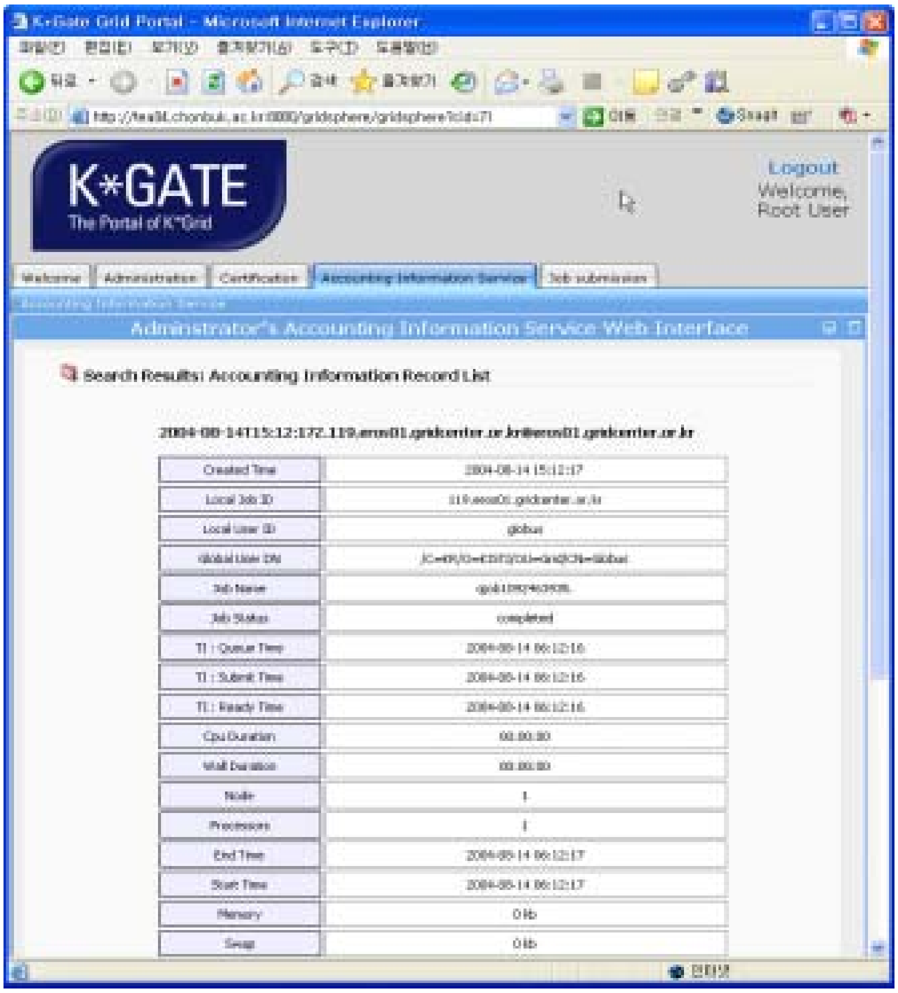


E:₩03_GRID₩03 3차년도₩17. Packaging 관련₩example.xml - Microsoft Internet Ex...
파일(F) 편집(E) 보기(V) 즐겨찾기(A) 도구(T) 도움말(H)
뒤로
검색
즐겨찾기
주소(D) E:₩03_GRID₩03 3차년도₩17. Packaging 관련₩example.xml
이동
완료
내 컴퓨터

```
- <urwg:UsageRecords xmlns:urwg="http://www.gridforum.org/2003/ur-wg"
    xmlns:exsl="http://exslt.org/common"
    xmlns:TimeZone="http://xml.apache.org/xalan/java/java.util.TimeZone"
    xmlns:Calendar="http://xml.apache.org/xalan/java/java.util.Calendar"
    xmlns:Date="http://xml.apache.org/xalan/java/java.util.Date"
    xmlns:SimpleDateFormat="http://xml.apache.org/xalan/java/java.text.SimpleDateFormat
  - <urwg:JobUsageRecord>
      <urwg:RecordIdentity urwg:recordId="2004-11-
        03T11:54:10Z.465.eros01.gridcenter.or.kr@eros01.gridcenter.or.kr"
        urwg:createTime="2004-11-03 11:54:10" />
    - <urwg:JobIdentity>
        <urwg:LocalJobId>465.eros01.gridcenter.or.kr</urwg:LocalJobId>
      </urwg:JobIdentity>
    - <urwg:UserIdentity>
        <urwg:LocalUserId>globus</urwg:LocalUserId>

          <urwg:GlobalUserDN>/C=KR/O=KISTI/OU=Grid/CN=Globus</urwg:GlobalUserDN>
      </urwg:UserIdentity>
      <urwg:JobName>qjob.1099450381</urwg:JobName>
      <urwg:Status>completed</urwg:Status>
      <urwg:TimeInstant urwg:type="queue">2004-11-03 02:53:01</urwg:TimeInstant>
      <urwg:TimeInstant urwg:type="submit">2004-11-03 02:53:01</urwg:TimeInstant>
      <urwg:TimeInstant urwg:type="ready">2004-11-03 02:53:01</urwg:TimeInstant>
      <urwg:CpuDuration>00:00:00</urwg:CpuDuration>
      <urwg:WallDuration>00:00:00</urwg:WallDuration>
      <urwg:NodeCount>1</urwg:NodeCount>
      <urwg:Processors>1</urwg:Processors>
      <urwg:EndTime>2004-11-03 02:54:10</urwg:EndTime>
      <urwg:StartTime>2004-11-03 02:53:01</urwg:StartTime>
      <urwg:Memory urwg:storageUnit="kb">6740</urwg:Memory>
      <urwg:Swap urwg:storageUnit="kb">21672</urwg:Swap>
      <urwg:MachineName>eros01.gridcenter.or.kr</urwg:MachineName>
      <urwg:Queue>workq</urwg:Queue>
      <urwg:ProjectName>globus</urwg:ProjectName>
    </urwg:JobUsageRecord>
```

Figure 4-6 An example of the result of AIService

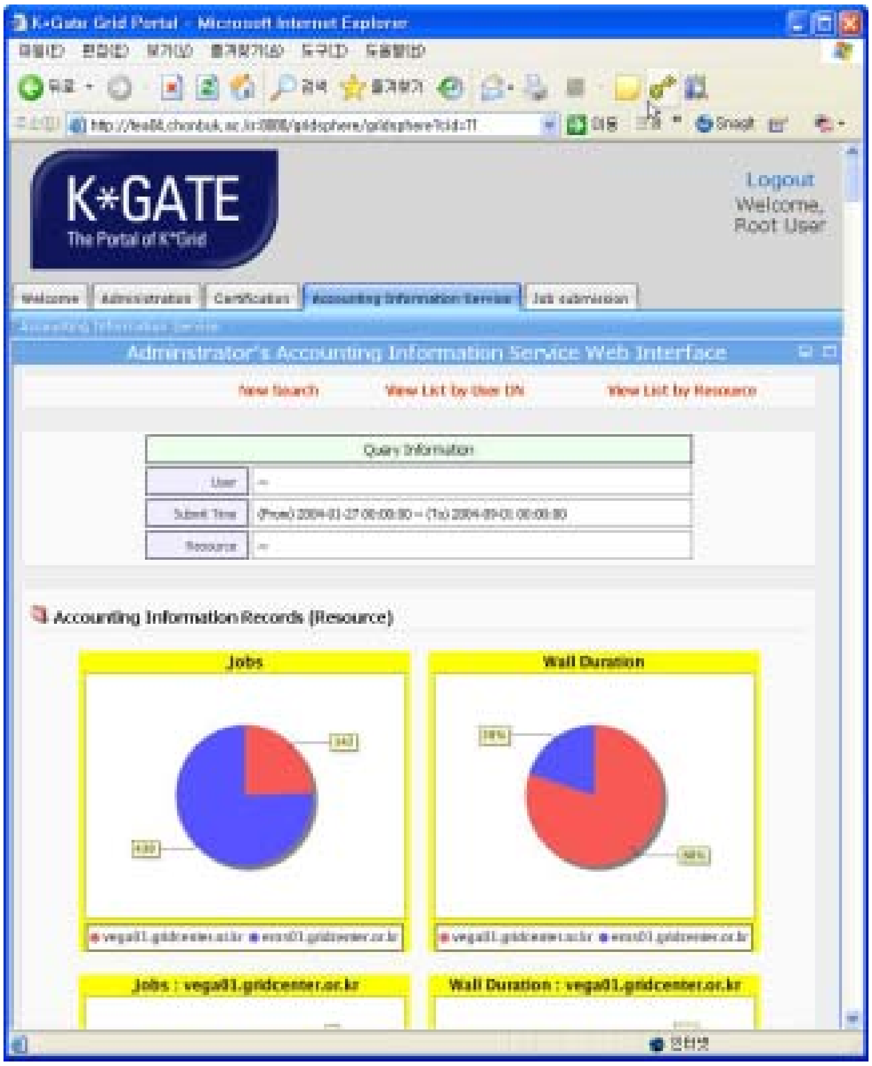

K*Gate Grid Portal - Microsoft Internet Explorer
K*GATE
The Portal of K*Grid
Logout
Welcome, Root User
Welcome
Administration
Certification
Accounting Information Service
Job submission
Administrator's Accounting Information Service Web Interface

Search Results: Accounting Information Record List

2004-08-14T15:12:172.119.eros01.gridcenter.or.kr@eros01.gridcenter.or.kr

Created Time	2004-08-14 15:12:17
Local Job ID	119.eros01.gridcenter.or.kr
Local User ID	globus
Global User DN	/C=KR/O=KISTI/OU=Grid/CN=Globus
Job Name	[illegible]
Job Status	completed
T1 : Queue Time	2004-08-14 06:12:16
T1 : Submit Time	2004-08-14 06:12:16
T1 : Ready Time	2004-08-14 06:12:16
Cpu Duration	00:00:00
Wall Duration	00:00:00
Node	1
Processors	1
End Time	2004-08-14 06:12:17
Start Time	2004-08-14 06:12:17
Memory	0 kb
Swap	0 kb

Figure 4-7. An example view of AIS-portlet



Administrator's Accounting Information Service Web Interface

Query Information	
User	--
Submit Time	(From) 2004-01-27 00:00:00 ~ (To) 2004-09-01 00:00:00
Resource	--

Accounting Information Records (Resource)

Figure 4-8. An example view of AIS-portlet with some charts

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