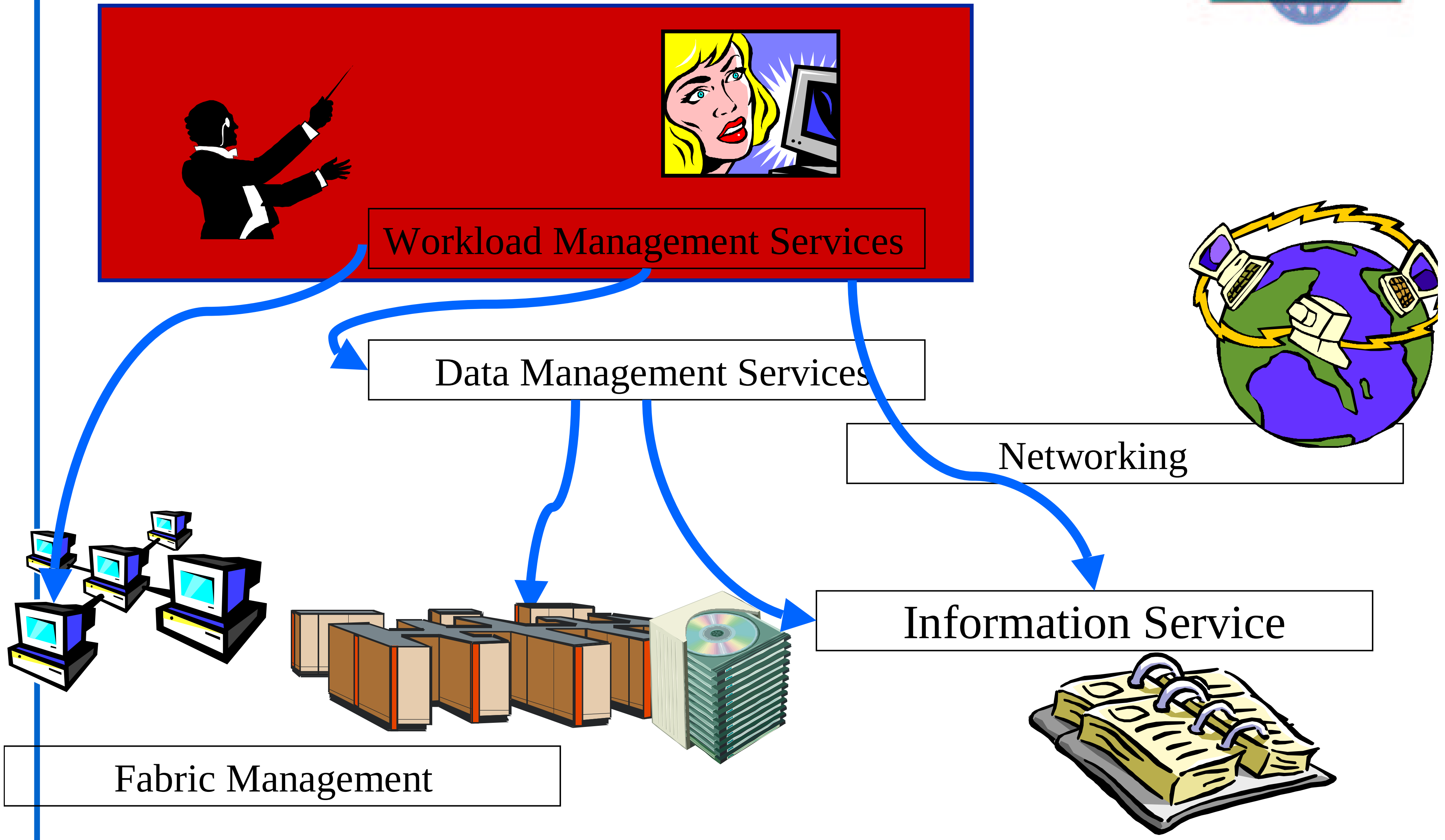
The EU DataGrid Job Submission Services (EDG release 1.4.x)

The European DataGrid Project Team

http://www.eu-datagrid.org

EDG Tutorial Overview



Contents

- The EDG Workload Management System (WMS)
- Job Submission to the EDG Testbed
  - Job Preparation
  - Job Description Language (JDL)
  - Job Submission & Monitoring
  - A simple program example: the job lifecycle

The EDG WMS

- The user interacts with Grid via a **Workload Management System**
- The Goal of WMS is the **distributed scheduling and resource management in a Grid environment**.
- What does it allow Grid users to do?
  - To submit their jobs
  - To execute them
  - To get information about their status
  - To retrieve their output
- The WMS tries to optimize the usage of resources

WMS Components

- WMS is currently composed of the following parts:

1. **User Interface** (UI) : access point for the user to the WMS
2. **Resource Broker** (RB) : the broker of GRID resources, responsible to find the "best" resources where to submit jobs
3. **Job Submission Service** (JSS) : provides a reliable submission system
4. **Information Index** (II) : a LDAP server used by the Resource Broker as a filter to the information service (IS) to select resources
5. **Logging and Bookkeeping** services (LB) : store Job Info available for users to query

Job Preparation: Let’s think the way the Grid thinks!

- Information to be specified
  - Job characteristics
  - Requirements and Preferences of the computing system
  - Software dependencies
  - Job Data requirements
- Specified using a Job Description Language (JDL)

Job Description Language (JDL) 1/5

- Based upon Condor's *CLASSified ADvertisement language (ClassAd)*
- ClassAd is a fully extensible language
- ClassAd is constructed with the classad construction operator []

  It is a sequence of attributes separated by semi-colons. An attribute is a pair (key, value), where value can be a Boolean, an Integer, a list of strings, …

  <attribute> = <value>;

So, the JDL allows to define a set of attribute, the WMS takes into account when making its scheduling decision

Job Description Language (JDL) 2/5

- The supported attributes are grouped in two categories:
  - *Job (Attributes)*

    Define the job itself
  - Resources
    - Taken into account by the RB for carrying out the matchmaking algorithm
    - *Computing Resource (Attributes)*

      Used to build expressions of Requirements and/or Rank attributes by the user

      Have to be prefixed with "other."
    - *Data and Storage resources (Attributes)*

      Input data to process, SE where to store output data, protocols spoken by application when accessing SEs

Job Description Language (JDL): relevant attributes 3/5

- **Executable** (mandatory)
  - The command name
- **Arguments** (optional)
  - Job command line arguments
- **StdInput, StdOutput, StdErr** (optional)
  - Standard input/output/error of the job
- **Environment** (optional)
  - List of environment settings
- **InputSandbox** (optional)
  - List of files on the UI local disk needed by the job for running
  - The listed files will automatically staged to the remote resource
- **OutputSandbox** (optional)
  - List of files, generated by the job, which have to be retrieved

Job Description Language (JDL): relevant attributes 4/5

- **Requirements**
  - Job requirements on computing resources
  - Specified using attributes of resources published in the Information Service
  - If not specified, default value defined in UI configuration file is considered
    - Default: other.Active (the resource has to be able to accept jobs)
- **Rank**
  - Expresses preference (how to rank resources that have already met the Requirements expression)
  - Specified using attributes of resources published in the Information Service
  - If not specified, default value defined in the UI configuration file is considered
    - Default: -other.EstimatedTraversalTime (the lowest estimated traversal time)

Job Description Language (JDL): “data” attributes 5/5

- **InputData** (optional)
  - Refers to data used as input by the job: these data are published in the Replica Catalog and stored in the SEs)
  - PFNs and/or LFNs
- ***ReplicaCatalog*** (mandatory if InputData has been specified with at least one LFN)
  - The Replica Catalog Identifier
- ***DataAccessProtocol*** (mandatory if InputData has been specified)
  - The protocol or the list of protocols which the application is able to speak with for accessing ***InputData*** on a given SE
- **OutputSE** (optional)
  - The Uniform Resource Identifier of the output SE
  - RB uses it to choose a CE that is compatible with the job and is close to SE

Example JDL File

```
Executable = “gridTest”;

StdError = “stderr.log”;

StdOutput = “stdout.log”;

InputSandbox = {“home/joda/test/gridTest”};

OutputSandbox = {“stderr.log”, “stdout.log”};

InputData = “LF:testbed0-00019”;

ReplicaCatalog = “ldap://sunlab2g.cnaf.infn.it:2010/ \
                   lc=test, rc=WP2 INFN Test, dc=infn,
 dc=it”;

DataAccessProtocol = “gridftp”;

Requirements = other.Architecture==“INTEL” && \
               other.OpSys==“LINUX” && other.FreeCpus >=4;

Rank = “other.MaxCpuTime”;
```

Job Submission

- **dg-job-submit [–r** *<res_id>]* **[–n** *<user e-mail address>]* **[-c** *<config file>]* **[-o** *<output file>]* **<job.jdl>**

  -r the job is submitted by the RB directly to the computing element identified by *<res_id>*

  -n an e-mail message containing basic information regarding the job (status and identification) is sent to the specified *<e-mail address>* when the job enters one of the following status:

  DONE or ABORTED

  READY

  RUNNING

  -c the configuration file *<config file>* is pointed by the UI instead of the standard configuration file

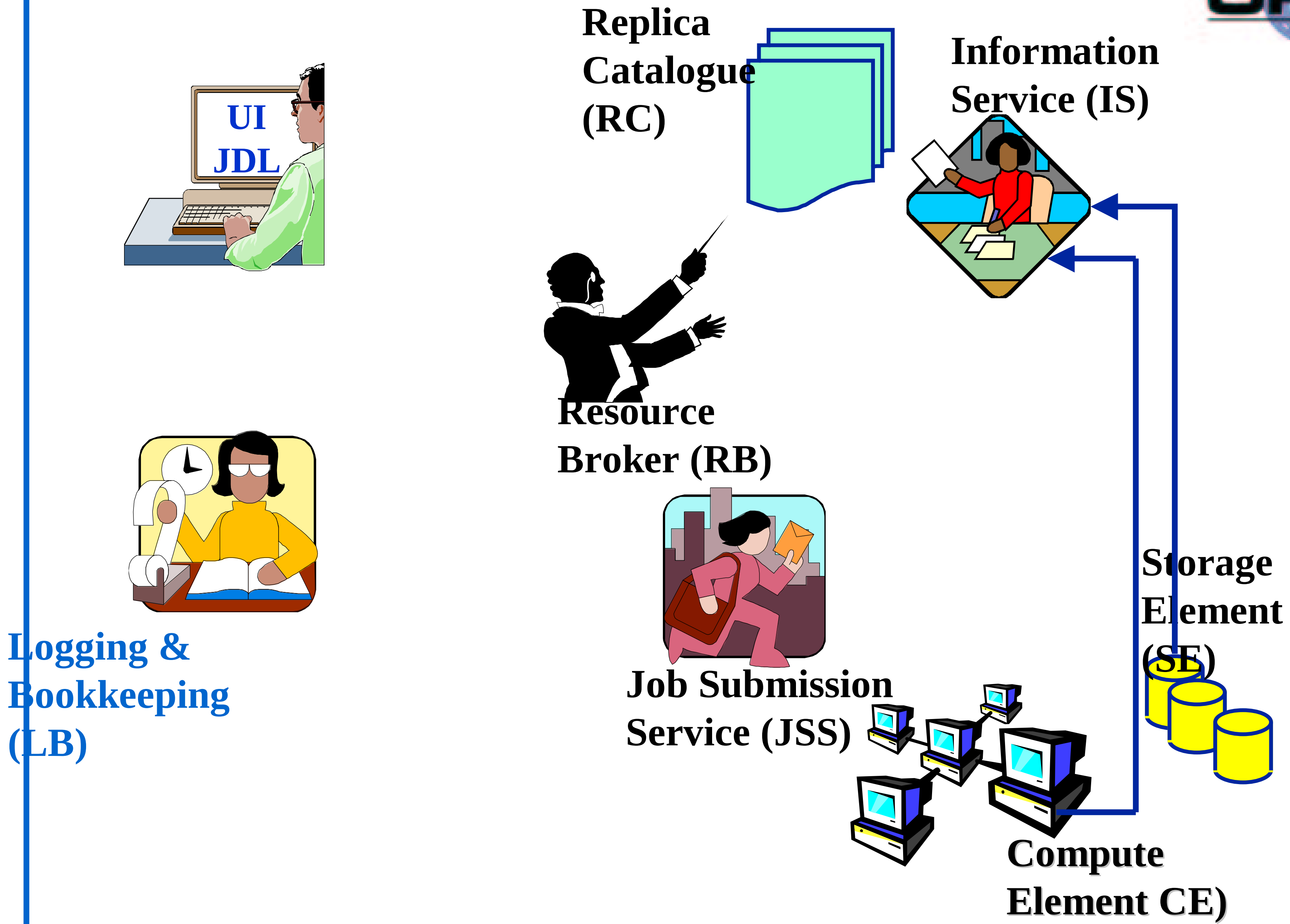
  -o the generated dg_jobId is written in the *<output file>*

  Useful for other commands, e.g.:

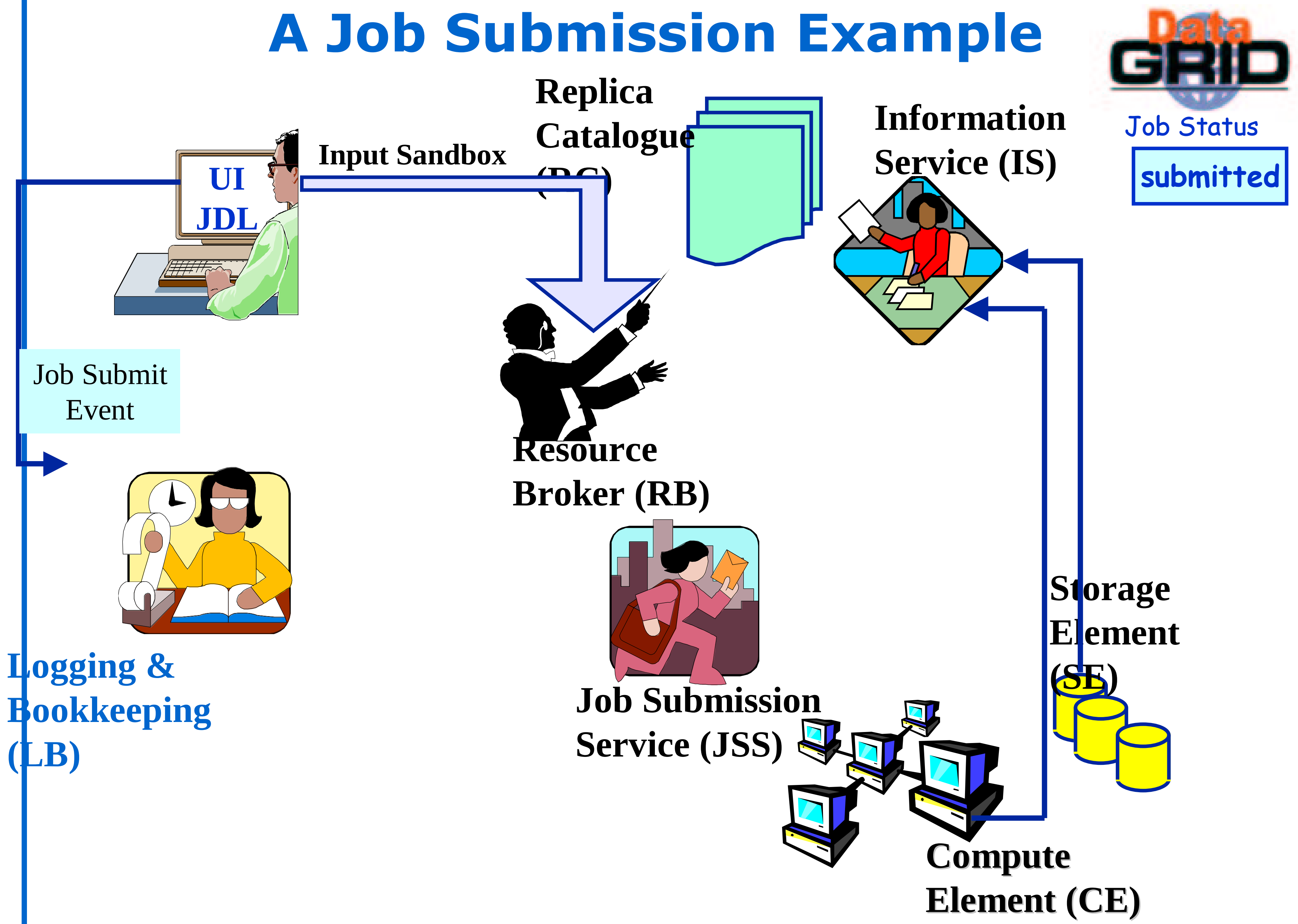
  dg-job-status –i *<input file>* (or dg_jobId)

  -i the status information about dg_jobId contained in the *<input file>* are displayed

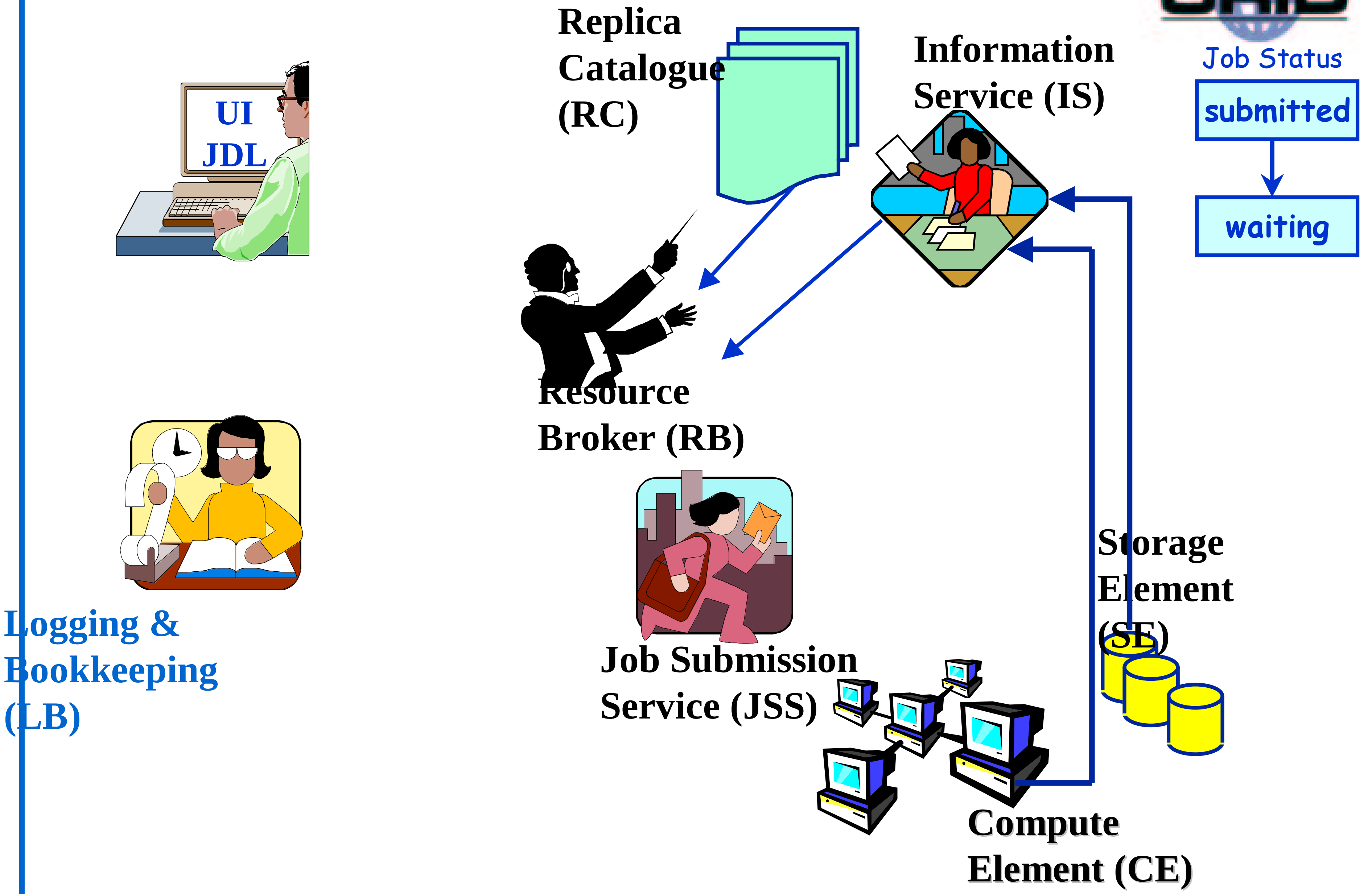
Job Submission Scenario



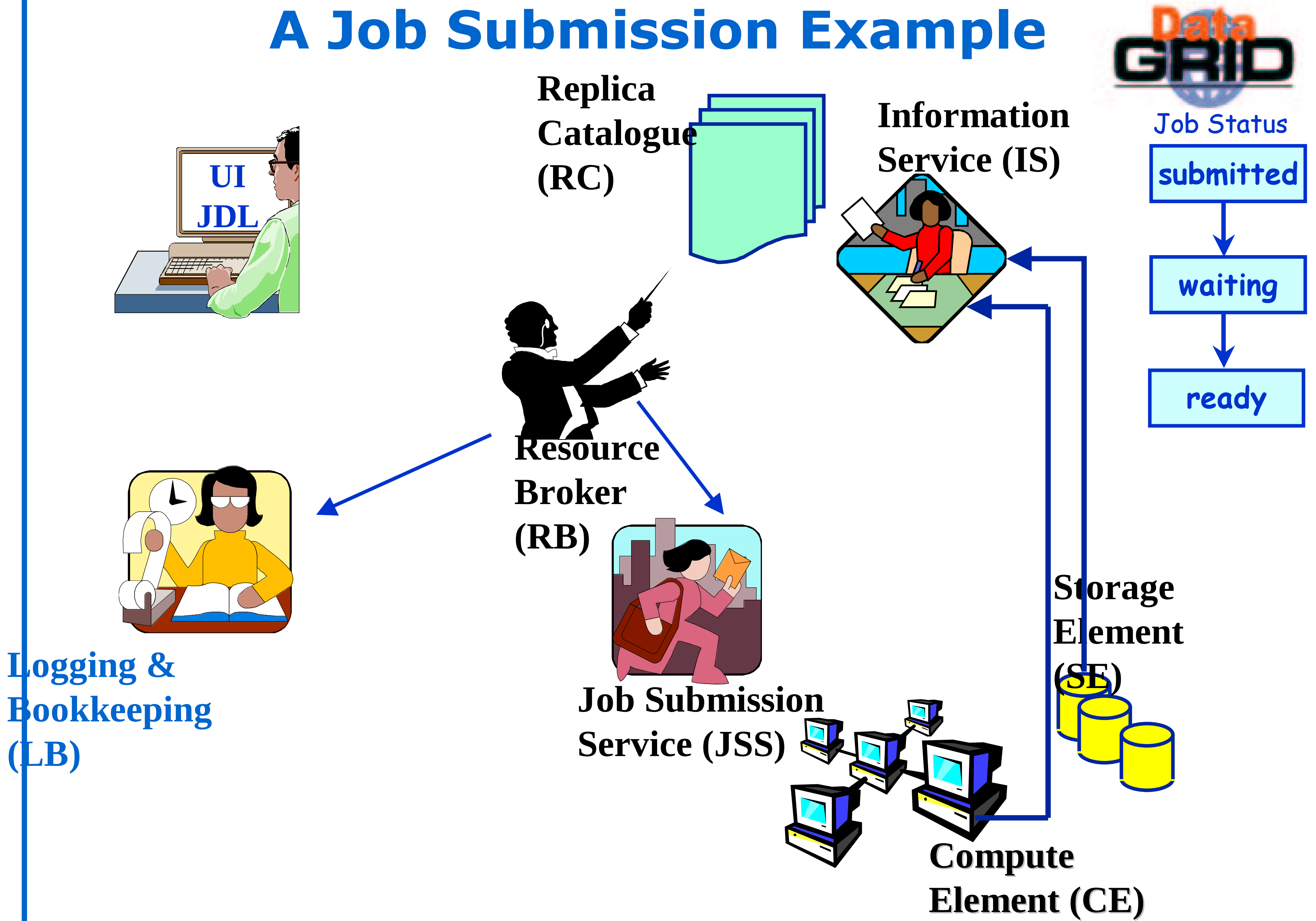
A Job Submission Example



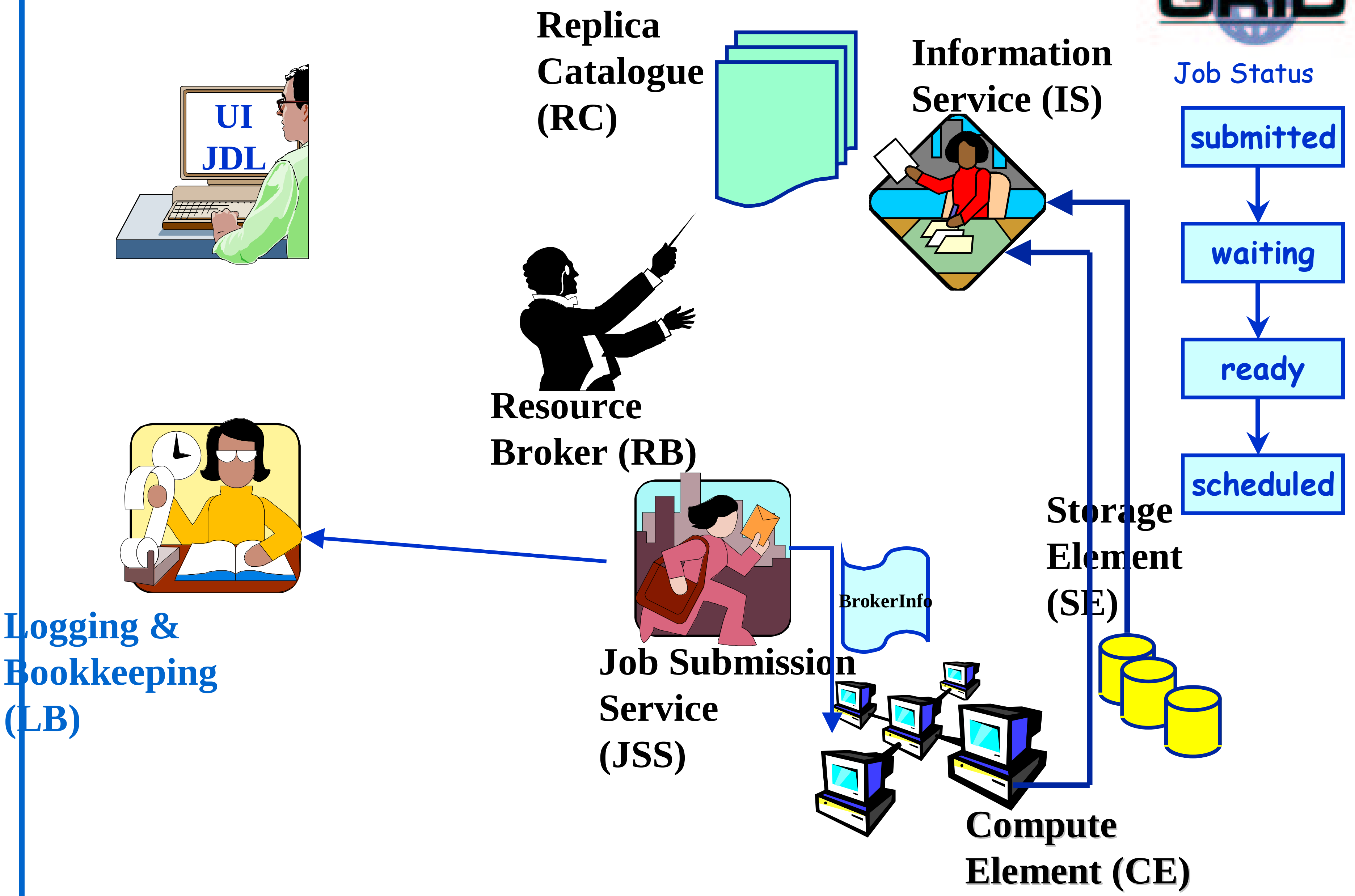
A Job Submission Example



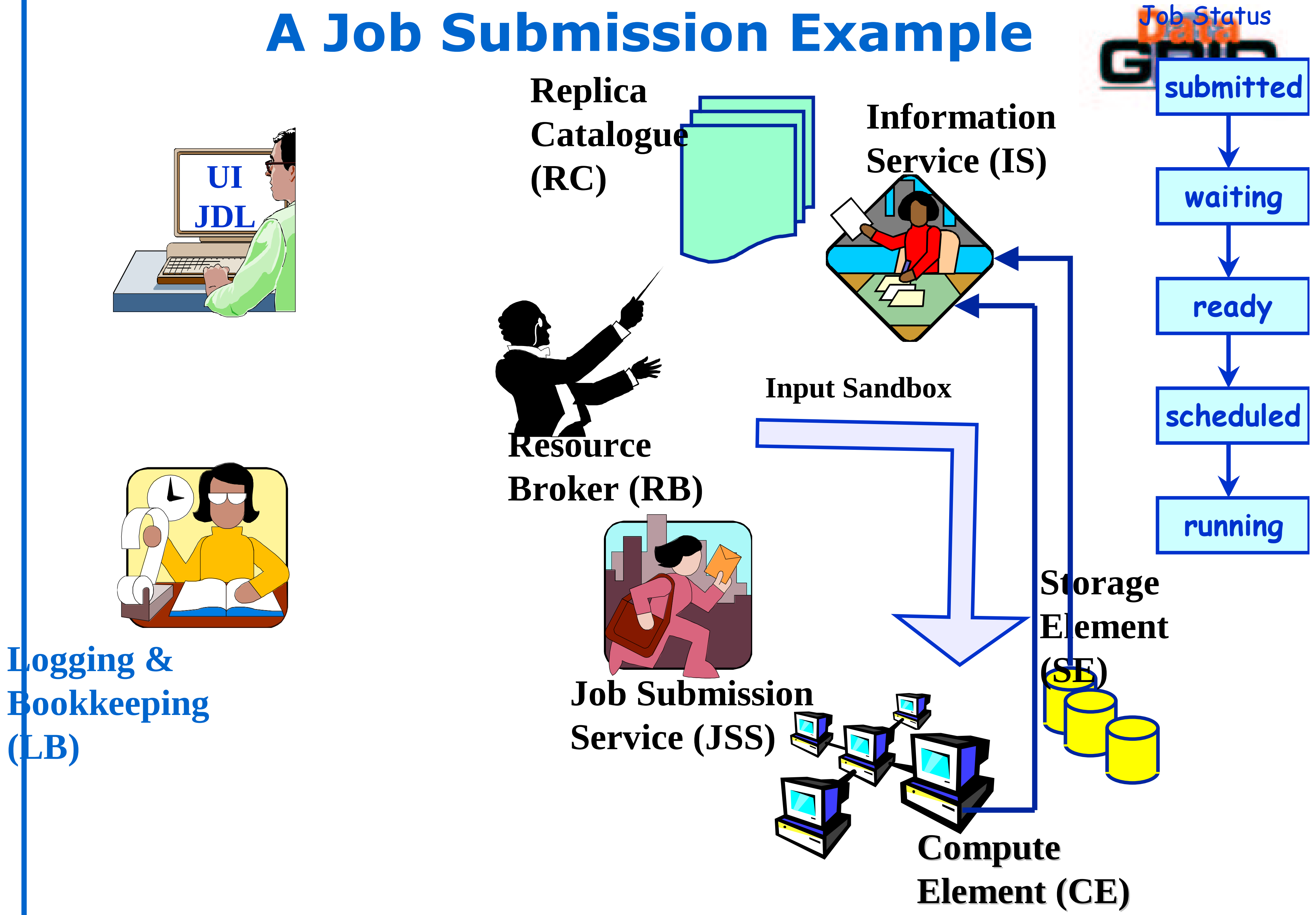
A Job Submission Example



A Job Submission Example



A Job Submission Example



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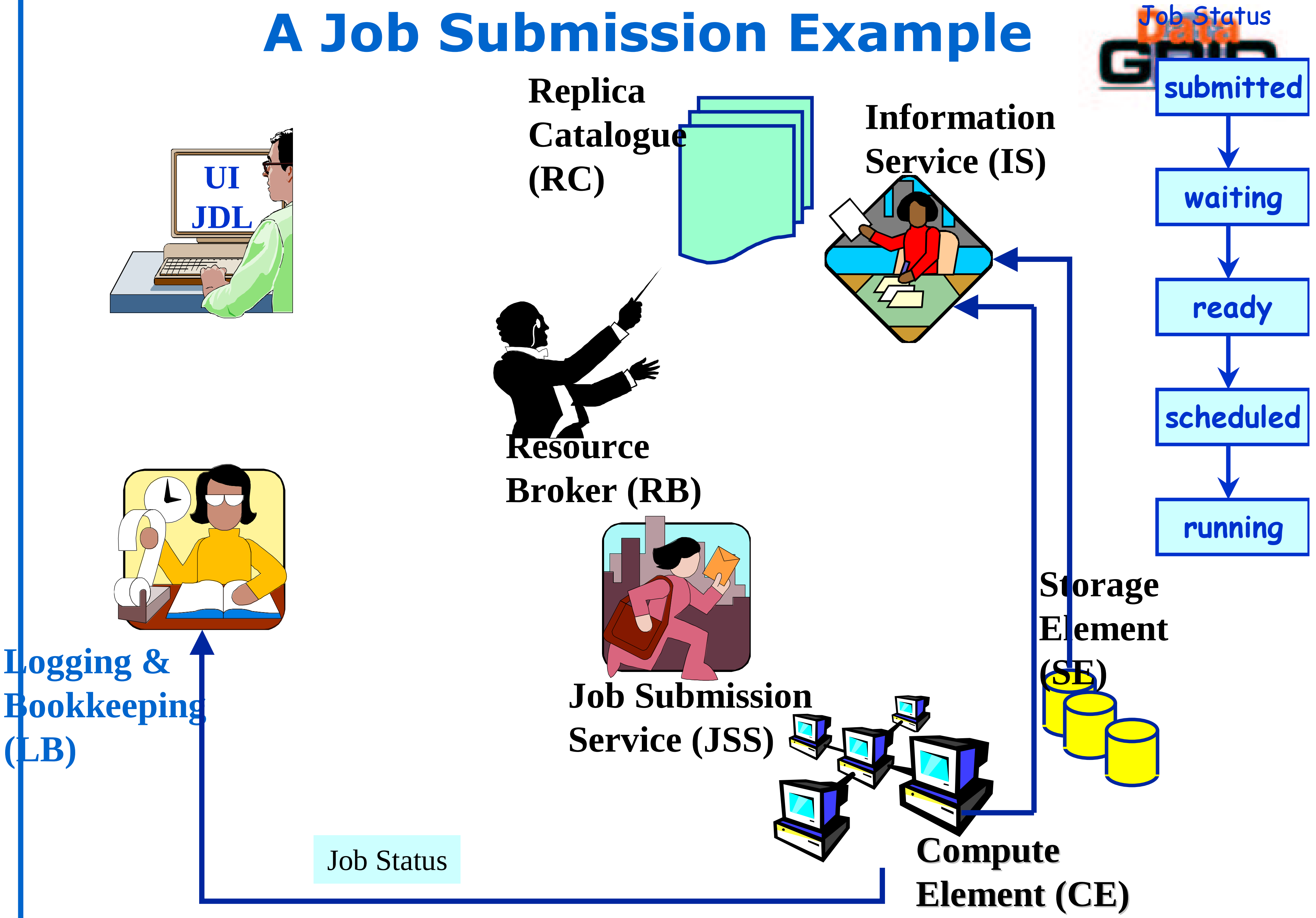

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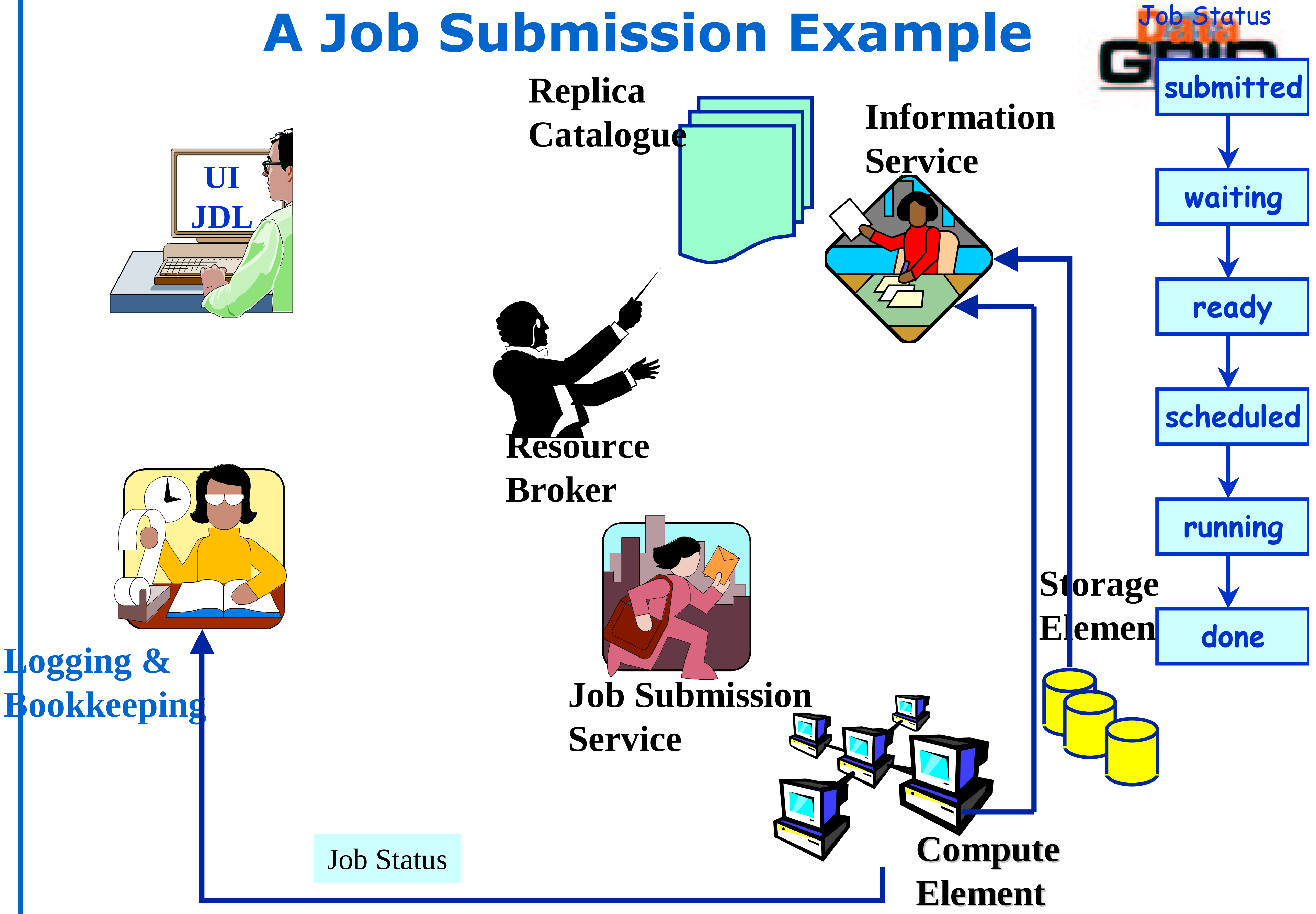

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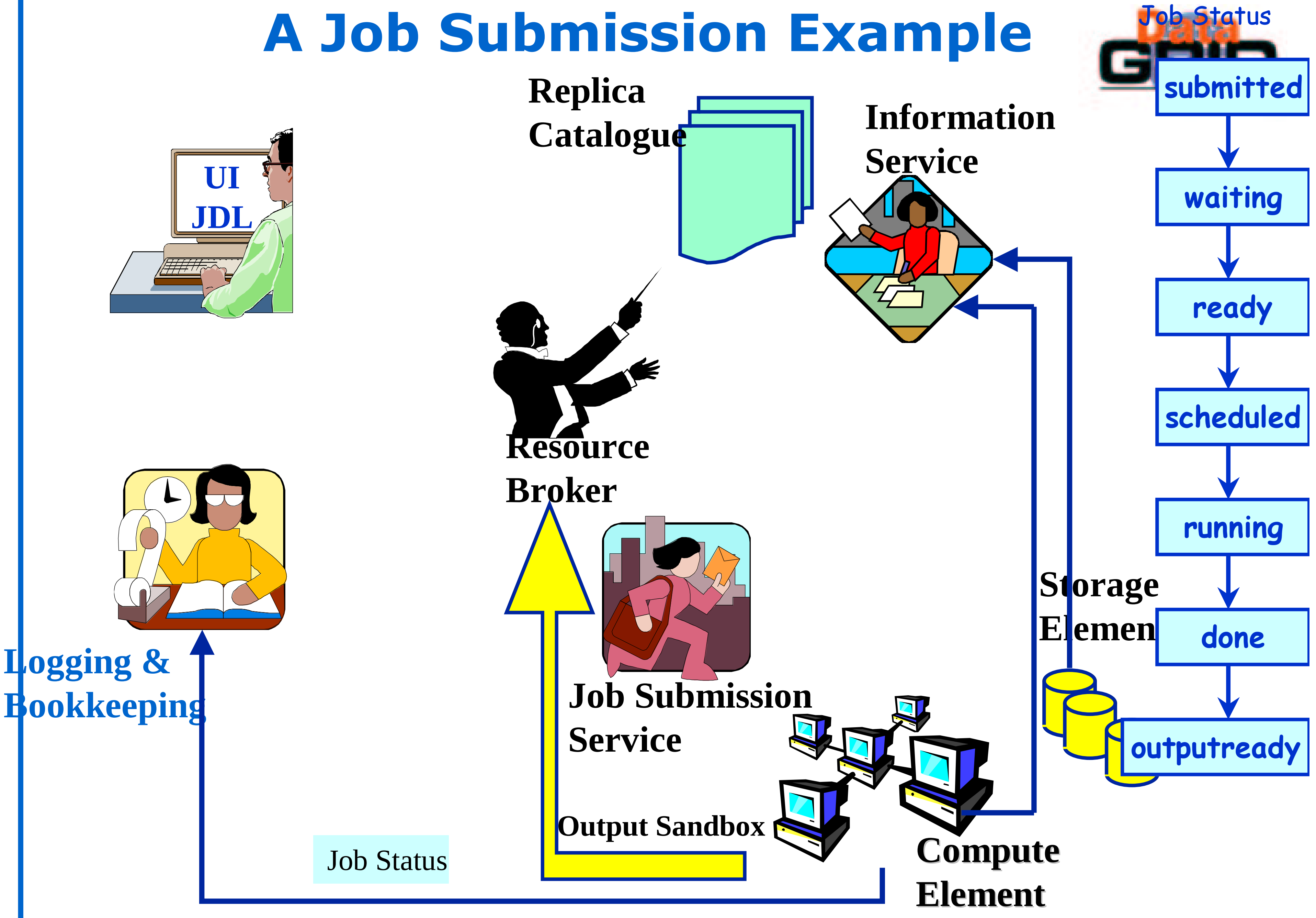

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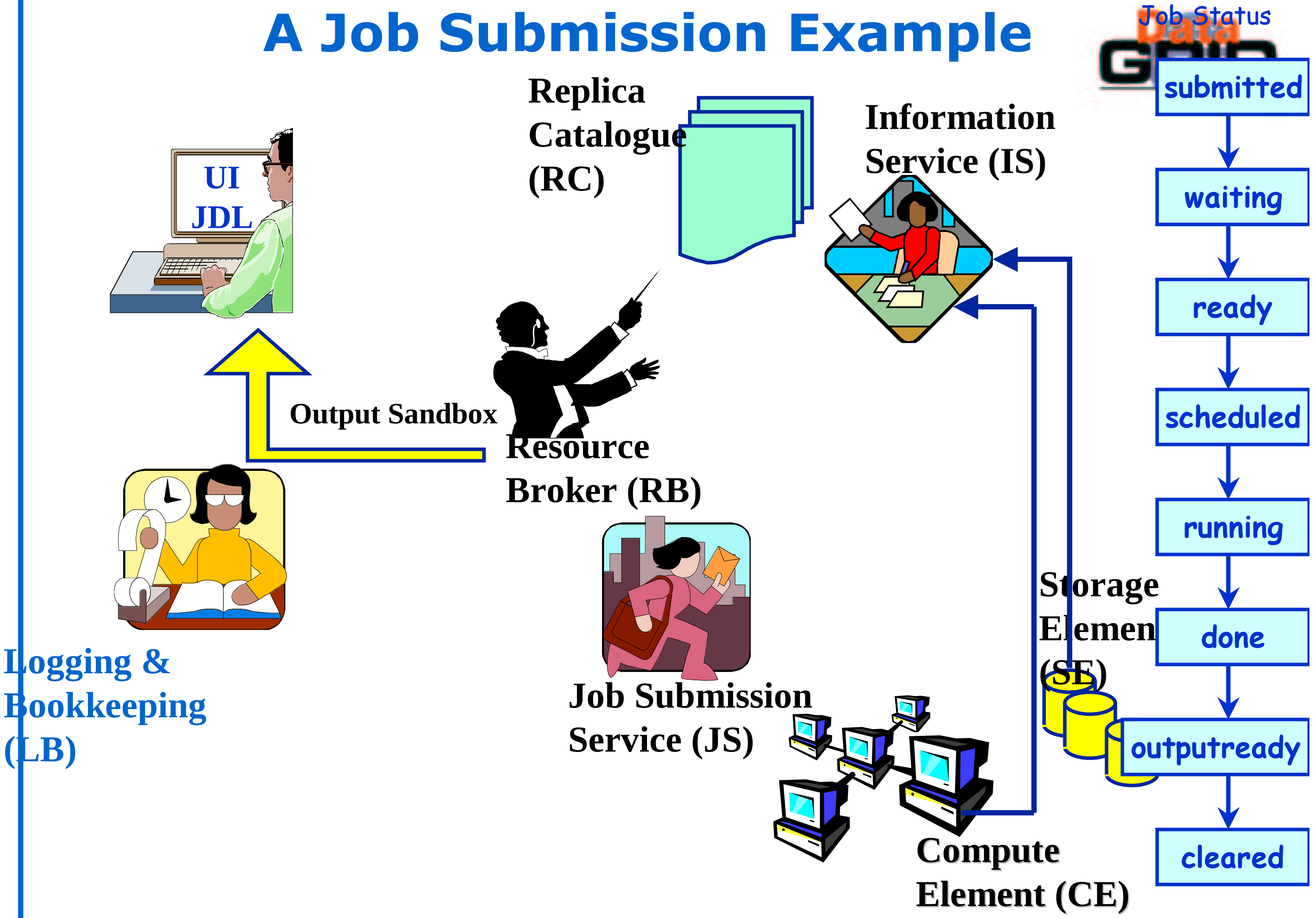
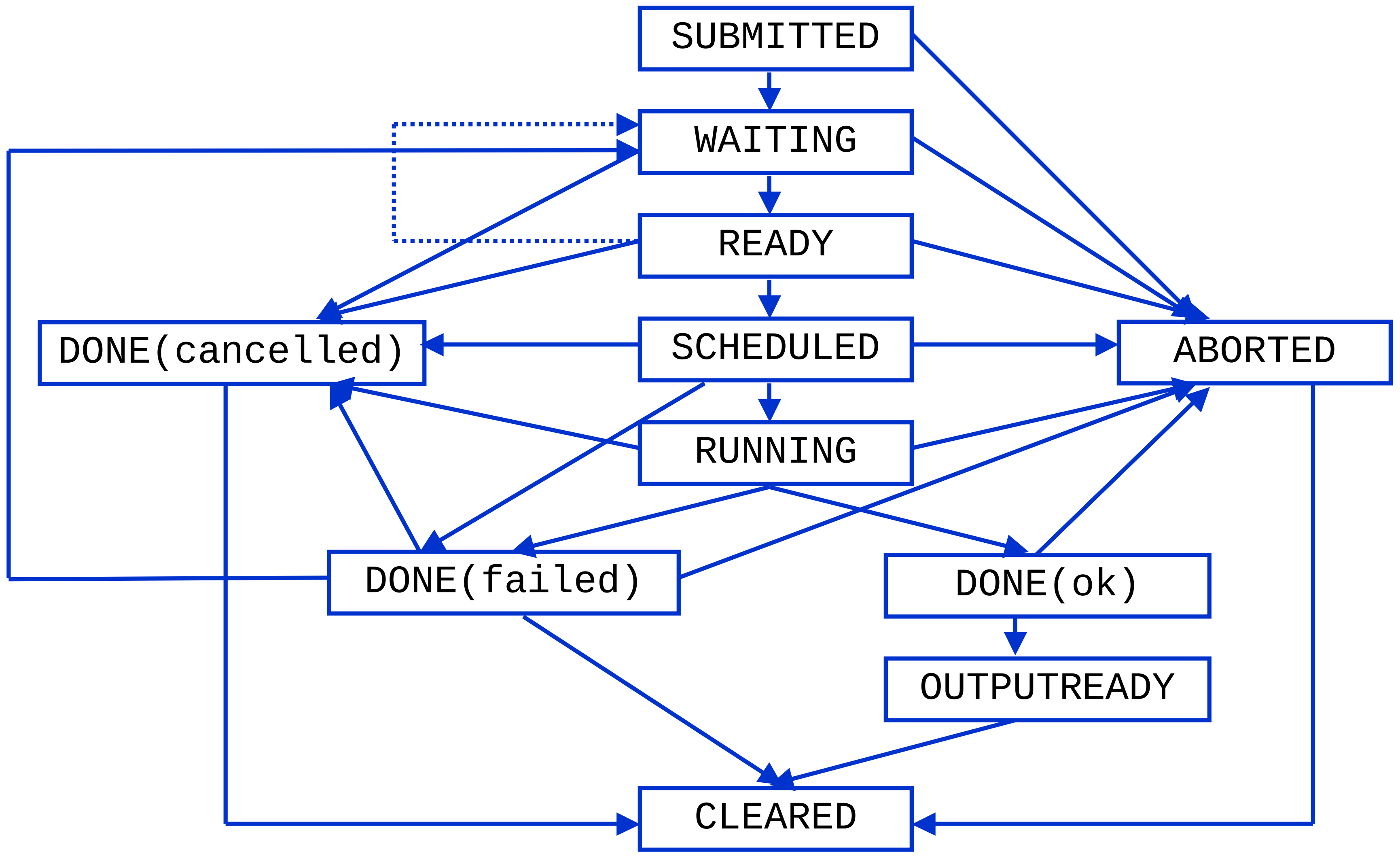


Possible Job States



Job resubmission

- If something goes wrong, the RB tries to reschedule and resubmit the job (possibly to a different resource)
- Maximum number of resubmissions (considering all the resources matching the requirements): min(RetryCount, RB_submission_retries)
  - RetryCount: JDL attribute
  - RB_submission_retries: attribute in the RB configuration file
- E.g., to disable job resubmission for a particular job: RetryCount=0; in the JDL file

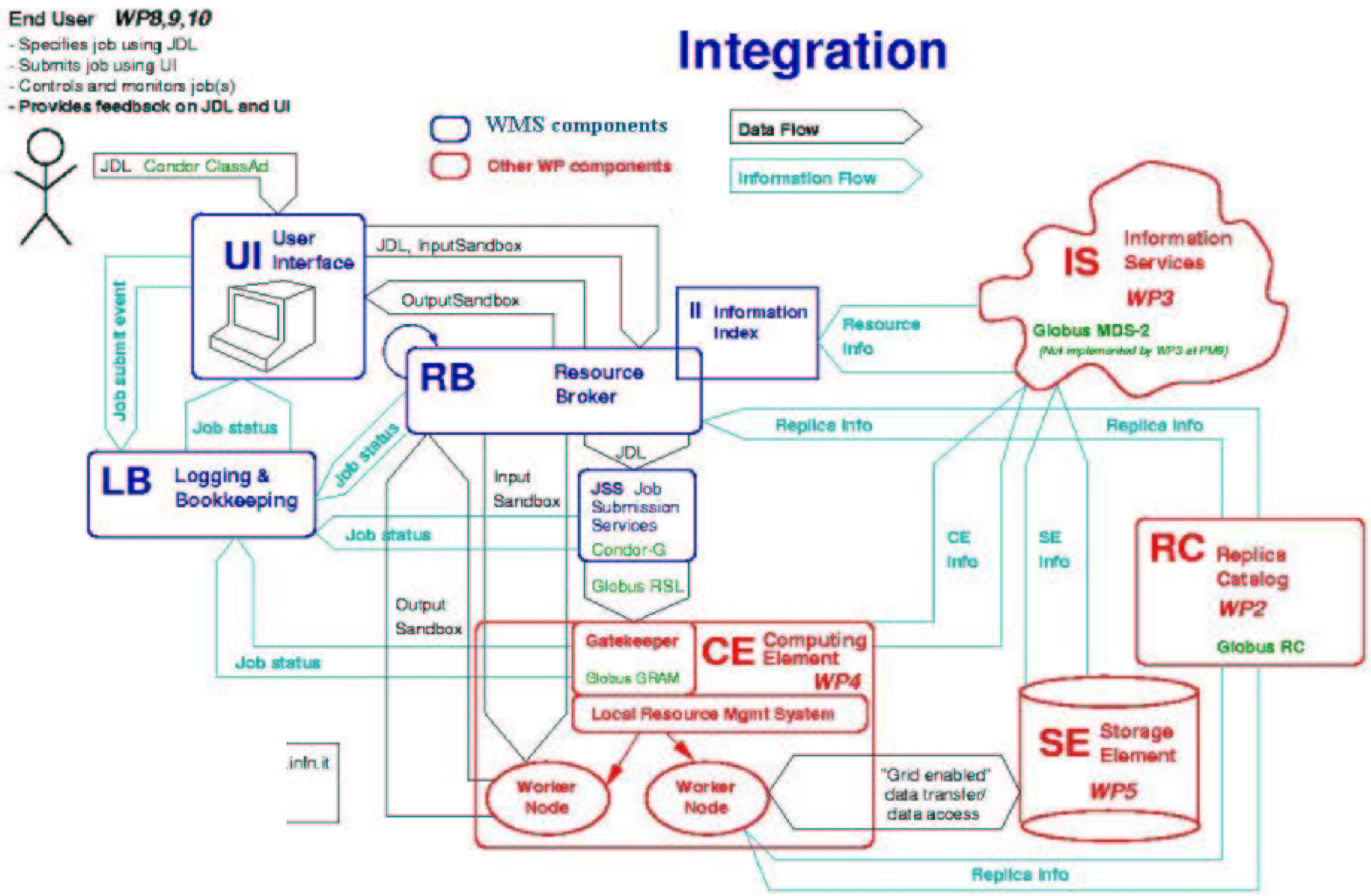
Other WMS UI Commands

- **`dg-job-list-match`**
  - Lists resources matching a job description
  - Performs the matchmaking without submitting the job
- **`dg-job-cancel`**
  - Cancels a given job
- **`dg-job-status`**
  - Displays the status of the job
- **`dg-job-get-output`**
  - Returns the job-output (the OutputSandbox files) to the user
- **`dg-job-get-logging-info`**
  - Displays logging information about submitted jobs (all the events "pushed" by the various components of the WMS)
  - Very useful for debug purposes
- **`dg-job-id-info`**
  - A utility for the user to display job info in a formatted style

UI configuration file

- Can be set if user is not happy with default one
- Most relevant attributes:
  - RB(s)
    - When submitting a job, the first specified RB is tried, if the operation fails the second one is considered, etc.
  - LBserver(s)
    - The LB to be used for a job is chosen by the RB
    - So when a dg-job-status <dg-jobid> is issued, the LB to contact is specified in the dg-jobid
    - This list specifies the LB(s) that must be contacted when issuing a dg-job-status –all / dg-job-get-logging-info –all (to have information for all the jobs belonging to that user)
  - Default JDL Requirements
    - other.active
  - Default JDL Rank
    - - other.EstimatedTraversalTime

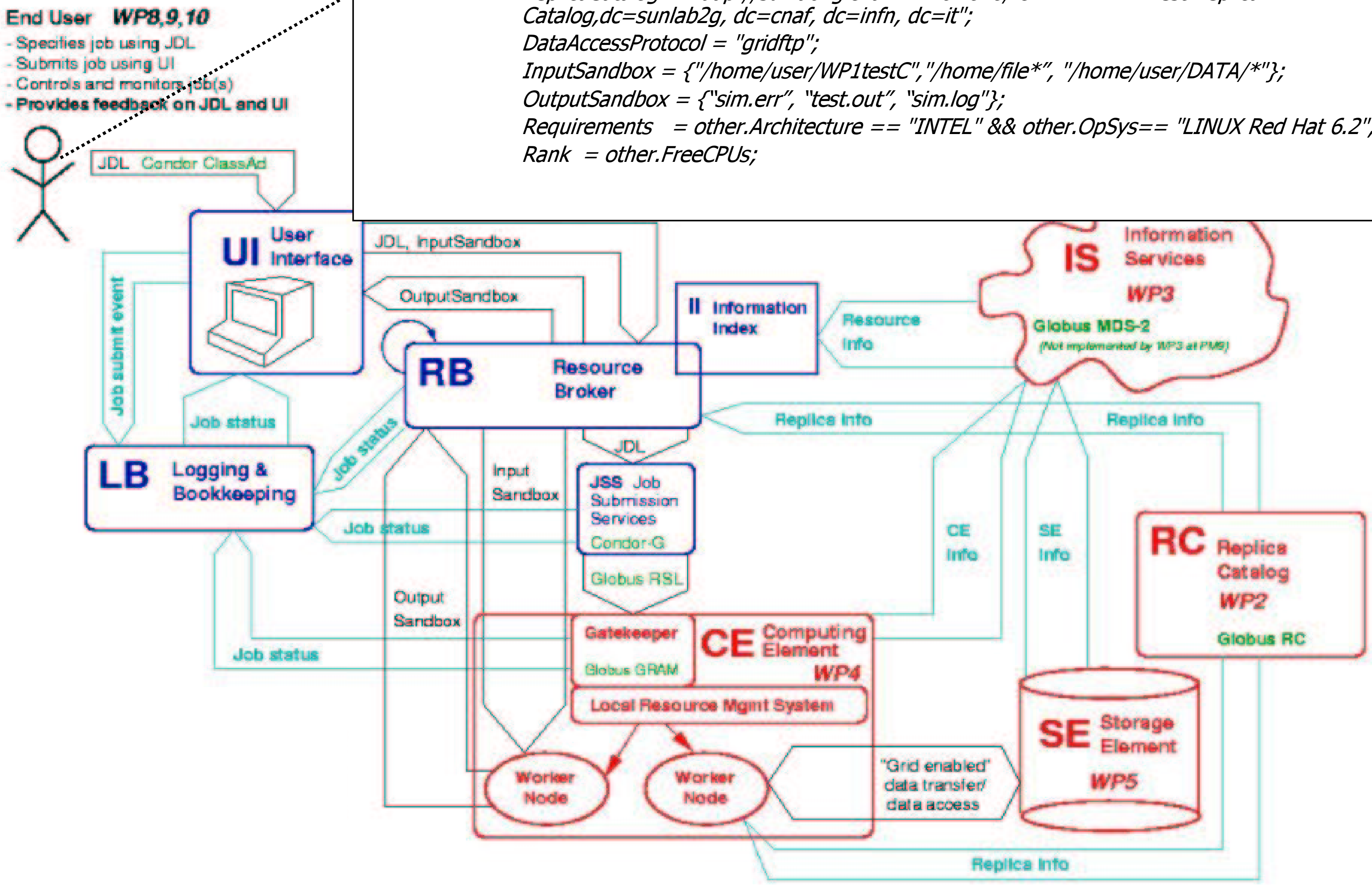
Integration



dg-job-submit myjob.jdl

Myjob.jdl

```
Executable     = "$(CMS)/exe/sum.exe";
InputData      = "LF:testbed0-00019";
ReplicaCatalog = "ldap://sunlab2g.cnaf.infn.it:2010/rc=WP2 INFN Test Replica
Catalog,dc=sunlab2g, dc=cnaf, dc=infn, dc=it";
DataAccessProtocol = "gridftp";
InputSandbox = {"/home/user/WP1testC","/home/file*", "/home/user/DATA/*"};
OutputSandbox = {"sim.err", "test.out", "sim.log"};
Requirements   = other.Architecture == "INTEL" && other.OpSys== "LINUX Red Hat 6.2";
Rank  = other.FreeCPUs;
```



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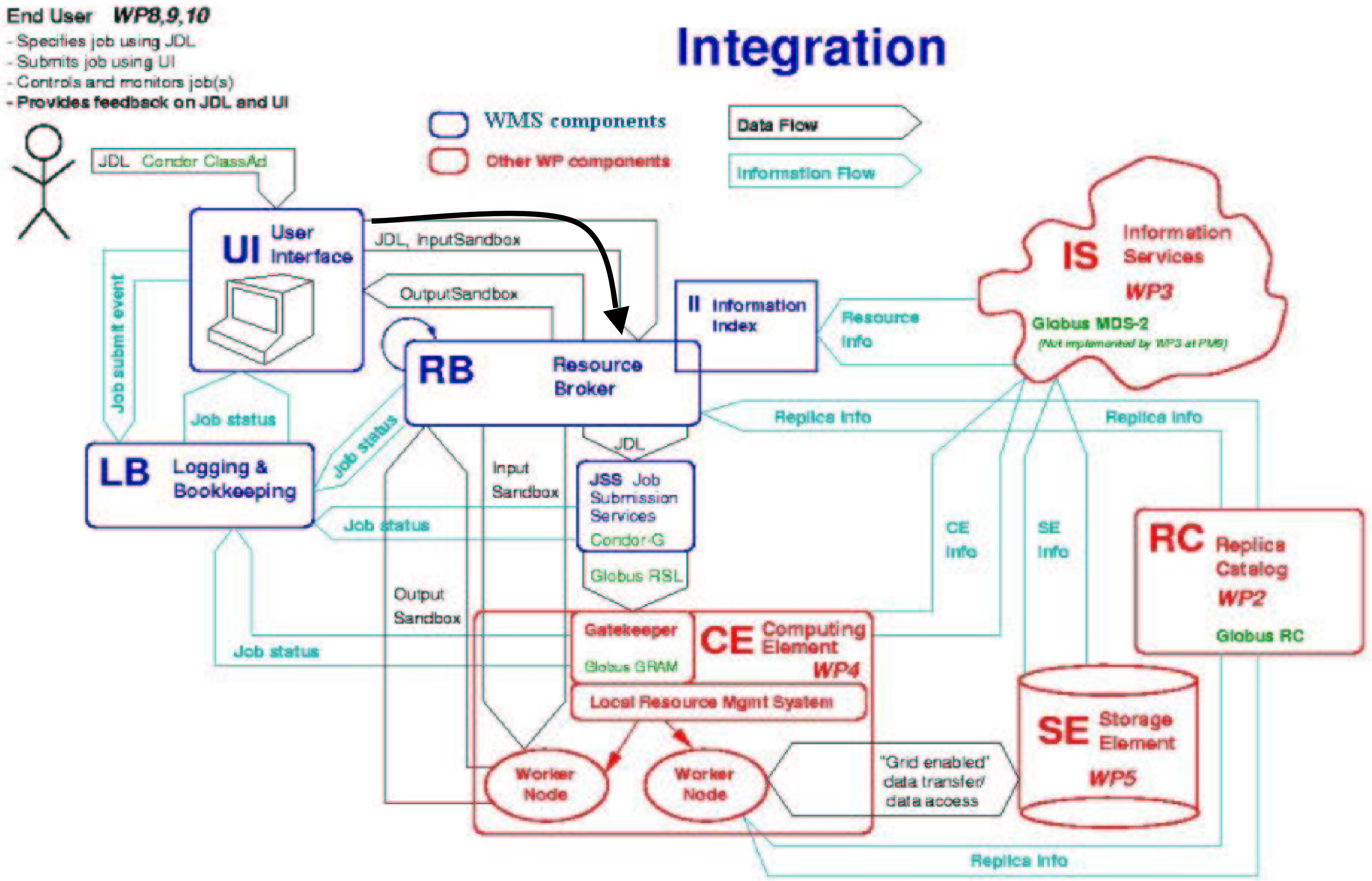

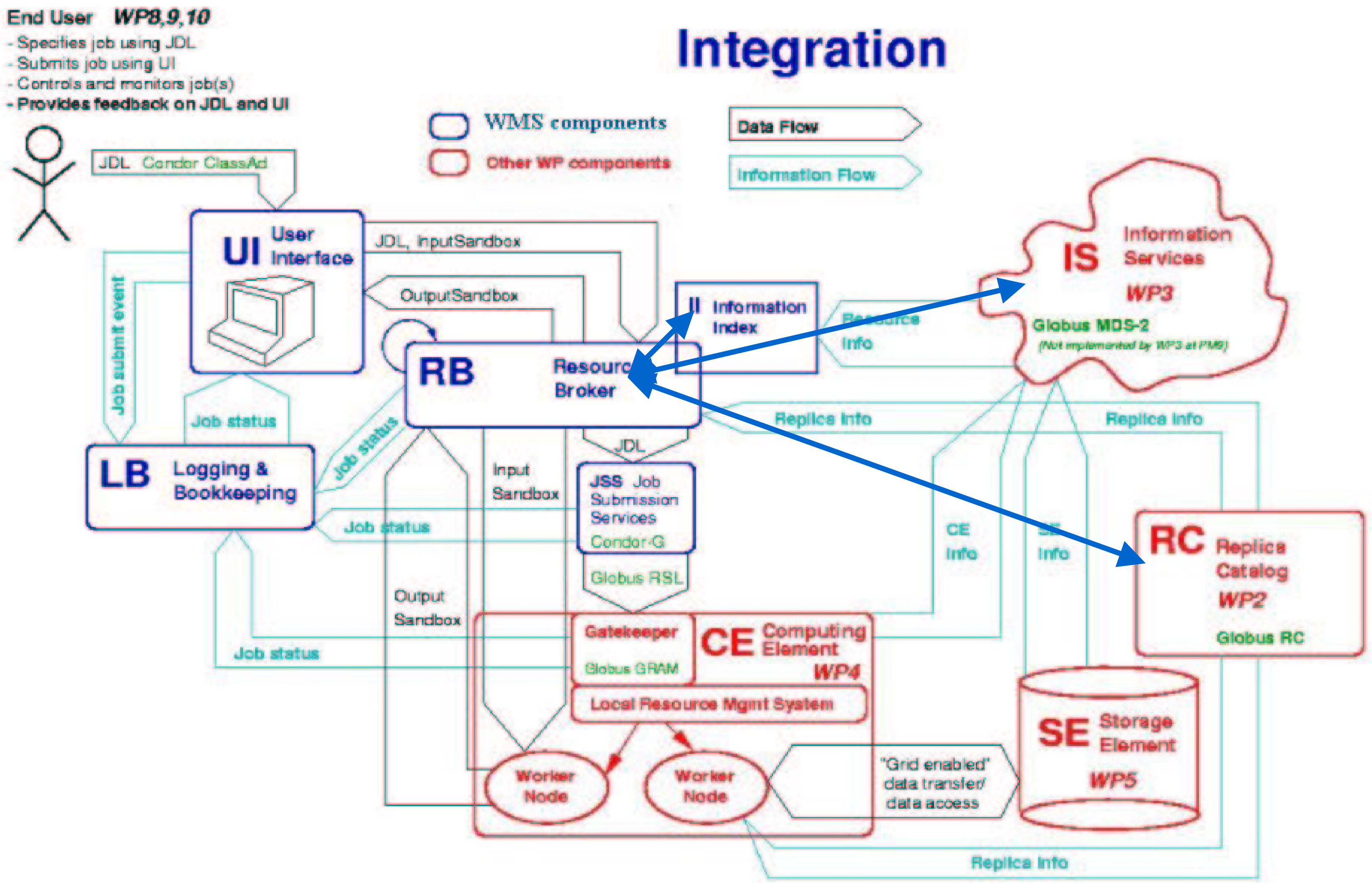

End User WP8,9,10
- Specifies job using JDL
- Submits job using UI
- Controls and monitors job(s)
- Provides feedback on JDL and UI
Integration
WMS components
Other WP components
Data Flow
Information Flow
JDL Condor ClassAd
UI User Interface
JDL, InputSandbox
OutputSandbox
Job submit event
Job status
RB Resource Broker
II Information Index
Resource Info
IS Information Services
WP3
Globus MDS-2
(Not implemented by WP3 at PM9)
Replica Info
JDL
LB Logging & Bookkeeping
Job status
Input Sandbox
JSS Job Submission Services
Condor-G
Globus RSL
CE Info
SE Info
RC Replica Catalog
WP2
Globus RC
Output Sandbox
Gatekeeper
Globus GRAM
CE Computing Element
WP4
Local Resource Mgmt System
Worker Node
Worker Node
"Grid enabled" data transfer/ data access
SE Storage Element
WP5

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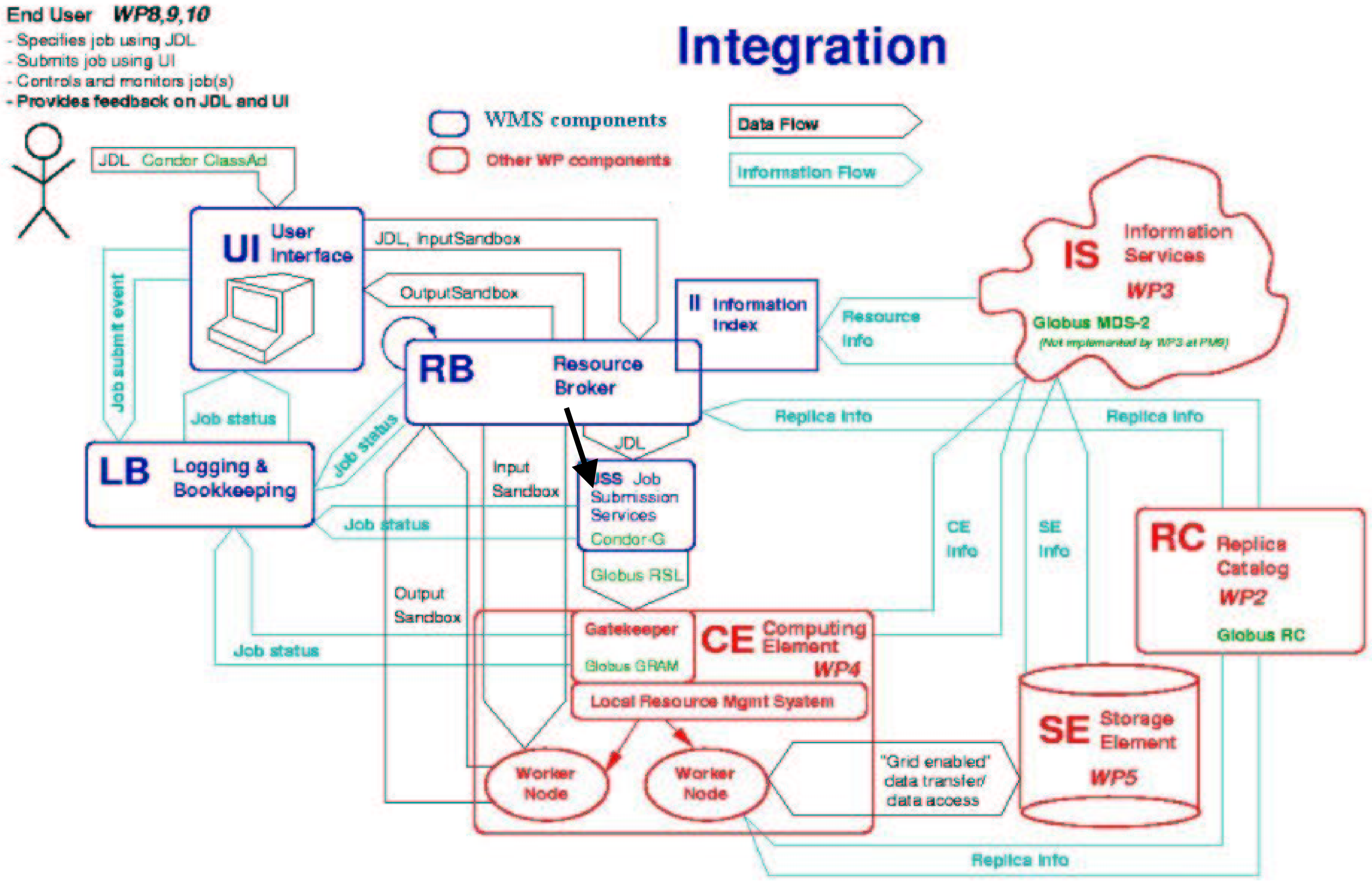

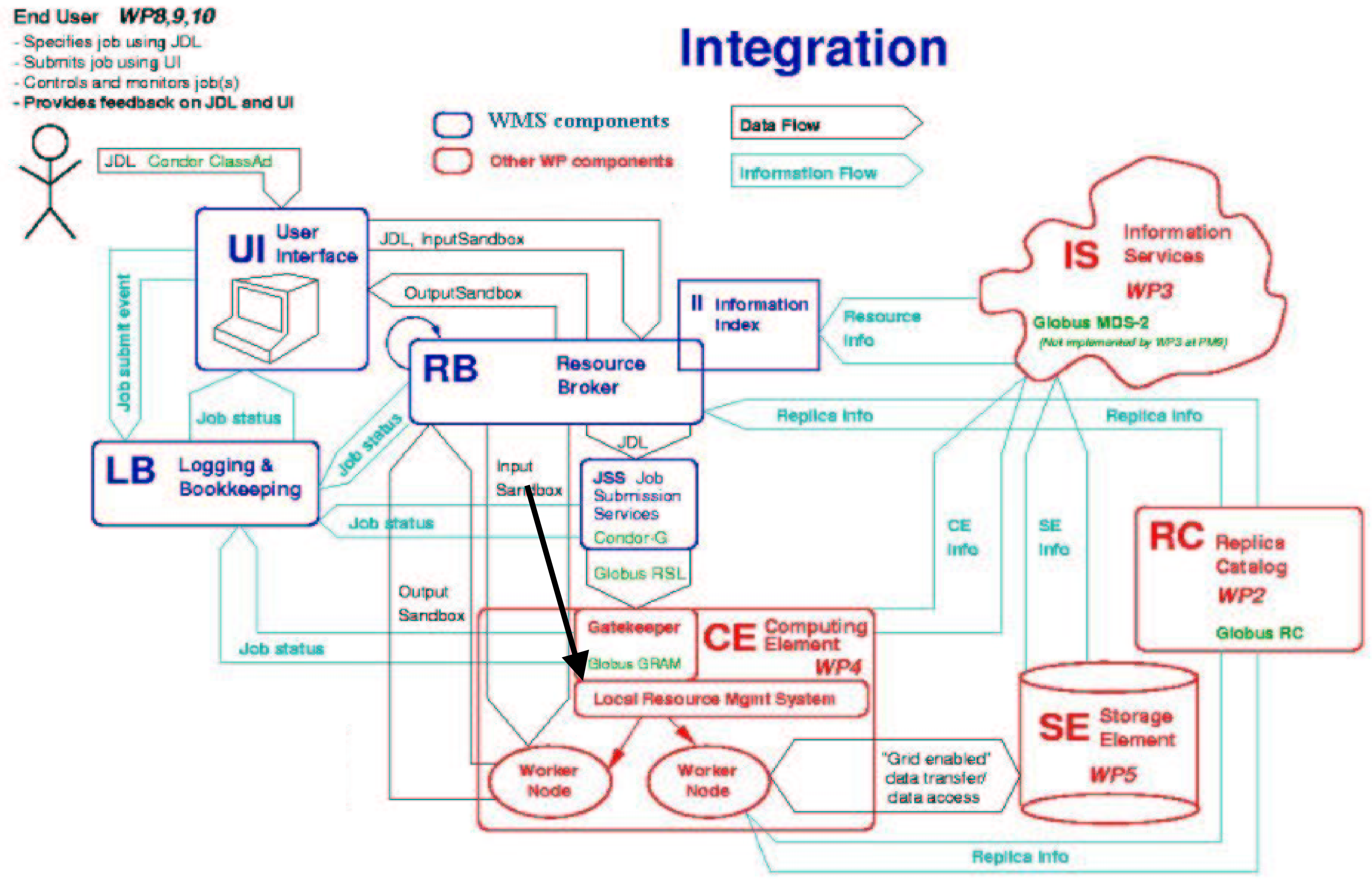
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SE Storage Element
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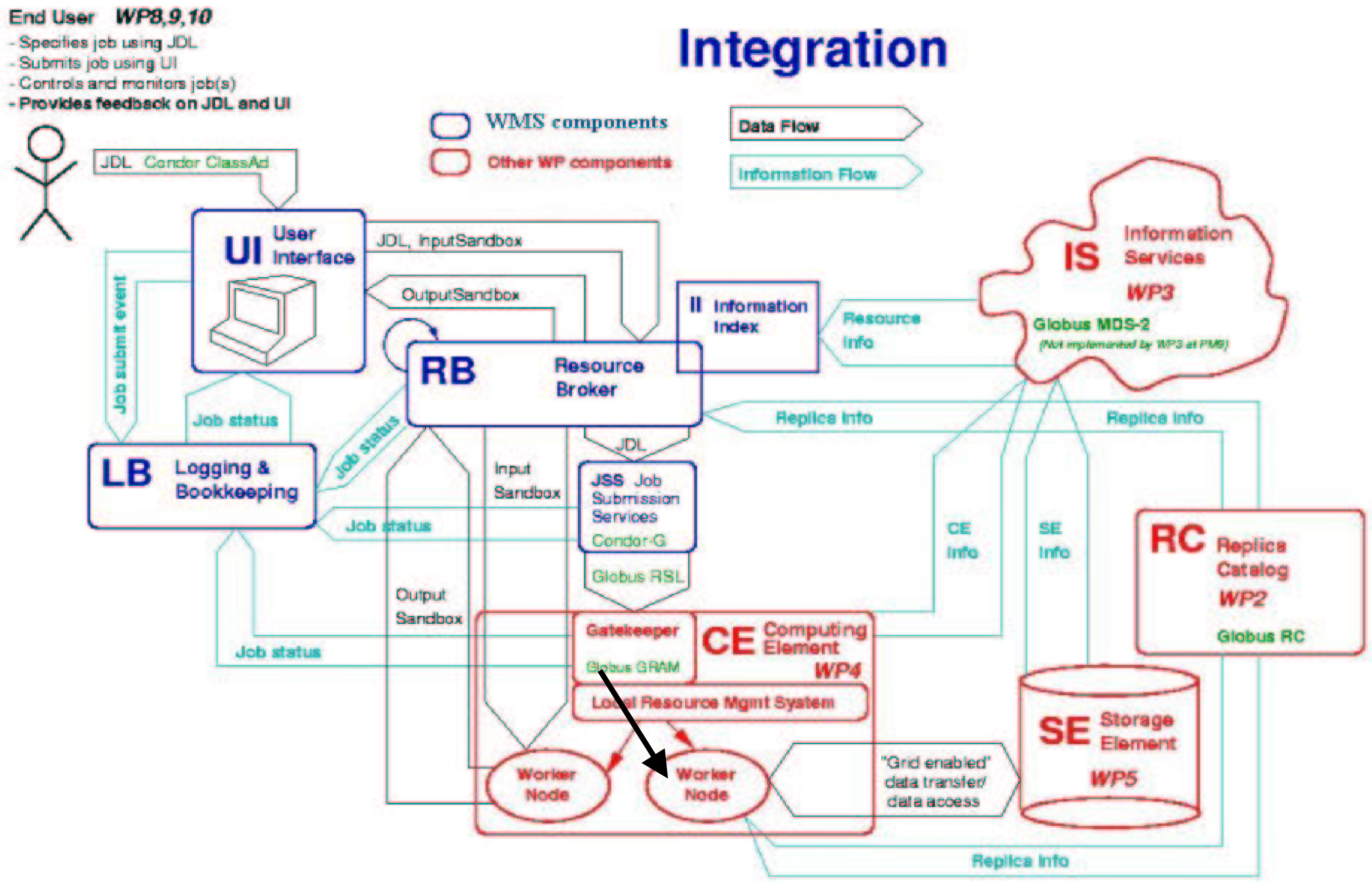
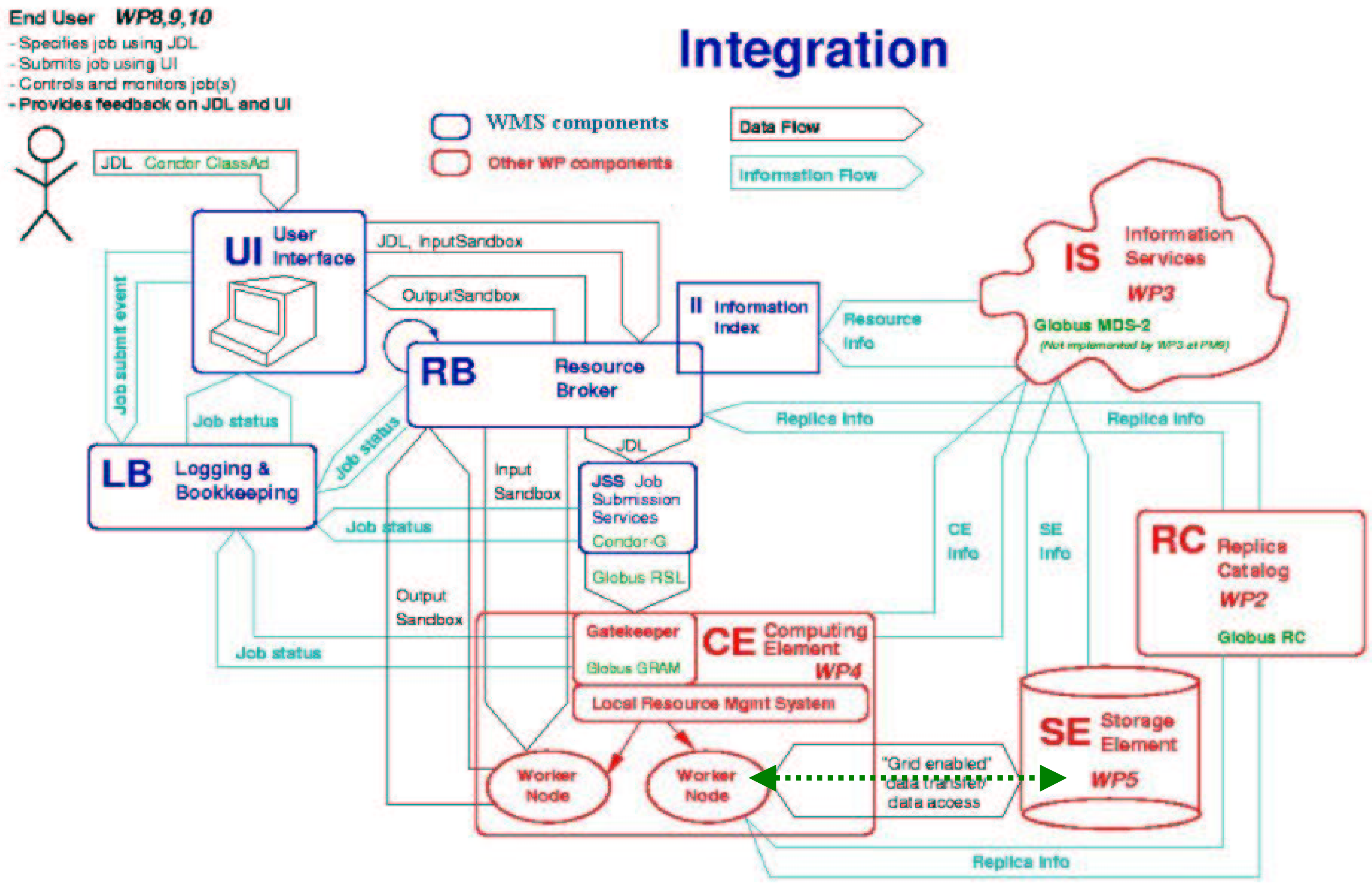


Integration



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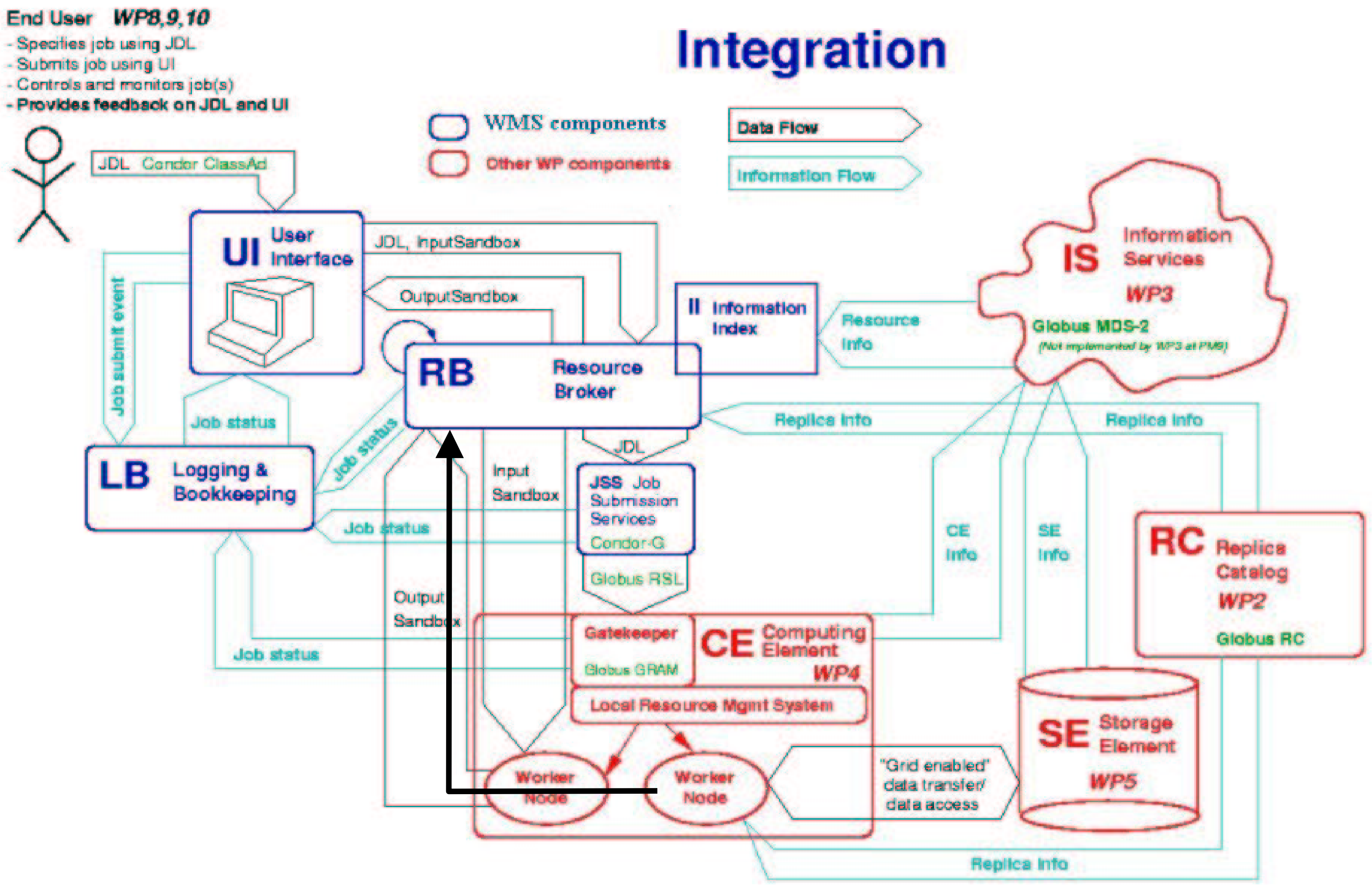

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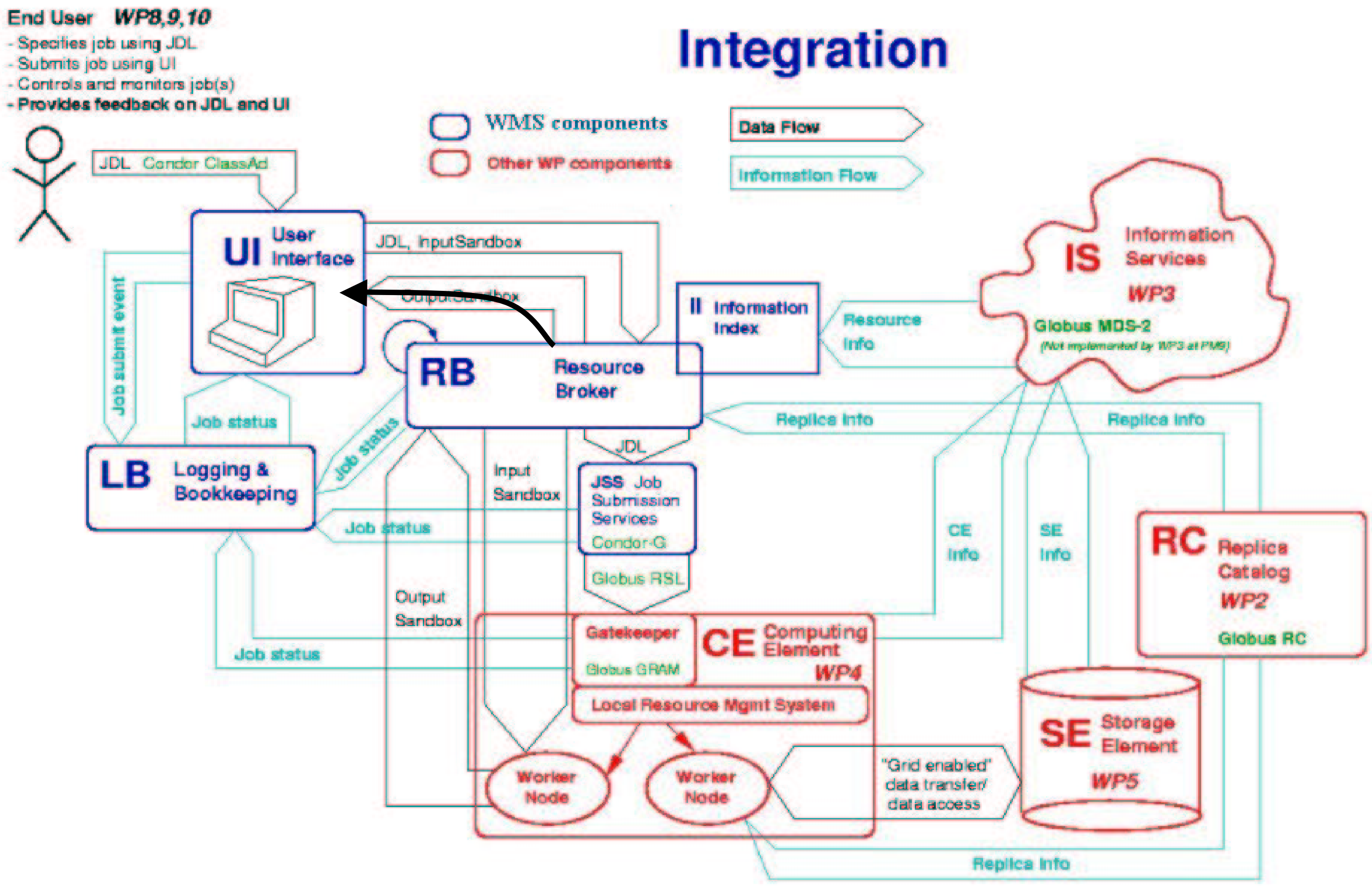

WMS Match Making 1/4

- The RB is the core component of WMS.
- It has to find the best suitable computing resource (CE) where the job will be executed
- It interacts with Data Management service and Information Service
  - They supply RB with all the information required for the resolution of the matches
- The CE chosen by RB has to match the job requirements (e.g. runtime environment, data access requirements, and so on)
- If 2 or more CEs satisfy all the requirements, the one with the best Rank is chosen

WMS Match Making 2/4

- The RB has to deal with three possible scenarios.

  1. Scenario : Direct Job Submission
     - Job is scheduled on a given CE (specified in the dg-job-submit command via –r option)
     - RB doesn’t perform any matchmaking algorithm

WMS Match Making 3/4

2. Scenario : Job Submission without data-access Requirements
   - Neither CE nor input data are specified.
   - RB starts the matchmaking algorithm, which consists of two phases:
     - Requirements check (RB contacts the IS to check which CEs satisfy all the requirements)
     - If more than one CE satisfies the job requirements, the CE with the best rank is chosen by the RB

WMS Match Making 4/4

3. Scenario : Job Submission with also data-access Requirements
   - CE is not specified in the JDL
   - RB interacts with Data Management service to find out the most suitable CE taking into account also the SEs where both input data sets are physically stored and output data sets should be staged on completion of job execution
   - RB strategy consists of submitting jobs close to data
   - The main two phases of the match making algorithm remain unchanged:
     - Requirements check
     - Rank computation
   - What changes with respect to the second scenario?

     Now, the RB executes the two phases for each class of CEs that satisfy the data-access requirements (i.e. which are close to data)

Example of Job Submission Sequence

- User logs in on the UI
- User issues a *grid-proxy-init* and enters his certificate's password, getting a valid Globus proxy
- User sets up his or her JDL file
- Example of Hello World JDL file :

```
Executable = "/bin/echo";
Arguments = "Hello World";
StdOutput = "Messagge.txt";
StdError = "stderr.log";
OutputSandbox = {"Message.txt","stderr.log"};
```

Example of Job Submission Sequence

- User issues a: *dg-job-submit HelloWorld.jdl*

  and gets back from the system a unique Job Identifier (JobId)

- User issues a: d*g-job-status JobId*

  to get logging information about the current status of his Job

- When the "OutputReady" status is reached, the user can issue a *dg-job-get-output JobId*

  and the system returns the name of the temporary directory where the job output can be found on the UI machine.

Job Submission Example

```
[reale@testbed002 EliJDL]$ dg-job-submit HelloWorld.jdl


Connecting to host lxshare0381.cern.ch, port 7771

Logging to host lxshare0381.cern.ch, port 15830

*****************************************************************************

                    JOB SUBMIT OUTCOME

 The job has been successfully submitted to the Resource Broker.

 Use dg-job-status command to check job current status. Your job identifier (dg_jobId) is:

 -https://lxshare0381.cern.ch:7846/137.138.181.214/12183940774010?lxshare0381.cern.ch:7771


*****************************************************************************
```

JobId

Job Submission Example Cont'd

```
[reale@testbed002 EliJDL]$ dg-job-status \
https://lxshare0381.cern.ch:7846/137.138.181.214/12183940774010?lxshare0381.cern.ch:7771

 Retrieving Information from LB server https://lxshare0381.cern.ch:7846

Please wait: this operation could take some seconds.

BOOKKEEPING INFORMATION:

Printing status info for the Job :
 https://lxshare0381.cern.ch:7846/137.138.181.214/12183940774010?lxshare0381.cern.ch:7771

 dg_JobId              =
 https://lxshare0381.cern.ch:7846/137.138.181.214/12183940774010?lxshare0381.cern.ch:7771

Status                 =    OutputReady

Last Update Time (UTC)  =    Wed Aug 21 12:19:39 2002

Job Destination        =    testbed008.cnaf.infn.it:2119/jobmanager-pbs-short

Status Reason          =    terminated

Job Owner              =    /C=IT/O=INFN/OU=Personal Certificate/L=CNAF/CN=Mario
 Reale/Email=Mario.Reale@cnaf.infn.it

Status Enter Time (UTC) =    Wed Aug 21 12:19:39 2002
```

Job Submission Example Cont'd

```
[reale@testbed002 EliJDL]$ dg-job-get-output --dir result
   https://lxshare0381.cern.ch:7846/137.138.181.214/12183940774010?lxshare0381.cern.ch:7771
*************************************************************************
 JOB GET OUTPUT OUTCOME
 Output sandbox files for the job:
 - https://lxshare0381.cern.ch:7846/137.138.181.214/12183940774010?lxshare0381.cern.ch:7771
 have been successfully retrieved and stored in the directory:
 /shift/lxshare072d/data01/UIhome/reale/EliJDL/result/12183940774010
*************************************************************************
[reale@testbed002 EliJDL]$ more result/12183940774010/Message.txt
Hello World
[reale@testbed002 EliJDL]$ more result/12183940774010/stderr.log
```

Common Error Messages 1/2

- The UI commands accept some arguments in input. If the user makes a mistake via command line, the following messages can appear:
  - Argument * is not allowed (the argument is not known)
  - Argument * must be specified at the end of the command (both the jobId and JDL file name must be put at the end of the command line)
  - Argument * is missing for the "—output" option (the user forgot to add the parameter, required by the argument)
  - Argument "-all" cannot be specified with argument "—input" (some arguments are OR-exclusive)
  - CEId format is: <full hostname>;<port number>/jobmanager-<service>. The provided CEID: "http://lx01.absolute.com:10854/jobmanager" has a wrong format. (the user has mis-spelled the CE identifier after –resource)
- During the calling of the RB API, the following can happen:
  - Resource Broker "grid013g.cnaf.infn.it:7771" not available (can't open a connection with the RB specified in the UI configuration file)
  - Unable to get LB address from RB "grid013g.cnaf.infn.it" (the function get_lb_contact returned an error)

Common Error Messages 2/2

- While the UI commands are checking the JDL file, the following errors may occur:
  - Mandatory Attribute default error in the configuration file "/opt/edg/etc/UI_ConfigENV.cfg" (there aren't any default values)
  - Mandatory Attribute missing in JDL file "Executable" (Executable is one of the mandatory attributes)
  - Multiple "InputSandbox" attribute found in JDL file (InputSandbox attribute is repeated twice)
  - Wrong function call for list attribute *. Function usage is: "Member/IsMember(List, Value)" (e.g. in the requirements attribute the function Member/IsMember is used with a wrong syntax)
- Proxy (this refers to the security grid proxy and not to a proxy machine)
  - If the user specifies a duration for the proxy that he wants to provide, using the option –h of dg-job-submit, a possible message is
    - Proxy certificate will expire in less then X hours. Creating a new X-hours-duration certificate (this to make sure that at least the required proxy validity is granted)

WMS Proxy Renewal

- Why?
  - To avoid job failure because it outlived the validity of the initial proxy
- WMS support automatic proxy renewal mechanism as long as the user credentials are handled by a proxy server.

1. Short term proxies can then be used to start jobs using

   grid-proxy-init –hours <hours> command

2. Register this proxy with the MyProxy server using

   myproxy-init –s <server> [-t <cred> -c <proxy>]

   server is the server address (e.g. lxshare0375.cern.ch)

   cred is the number of hours the proxy should be valid on the server

   proxy is the number of hours renewed proxies should be valid

3. MyProxyServer specified in the JDL file
4. The Proxy is automatically renewed by WMS without user intervention for all the job life

Further Information

- The EDG User's Guide

  http://marianne.in2p3.fr

- EDG WP1 Web site

  http://www.infn.it/workload-grid

  In particular WMS User & Admin Guide and JDL docs

- ClassAd

  https://www.cs.wisc.edu/condor/classad