The EU DataGrid Workload Management System: towards the second major release

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Talk Outline

- DataGrid and Datagrid WP1
- The DataGrid Workload Management System
- The new revised WP1 WMS architecture
  - What's has been revised and new functionalities
- Future work & conclusions

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DataGrid and DataGrid WP1

- European DataGrid Project
  - Goal: Grid software projects meet real-life scientific applications (High Energy Physics, Earth Observation, Biology) and their deadlines, with mutual benefit
  - Middleware development and integration of existing middleware
  - Bring the issues of data identification, location, transfer and access into the picture
  - Large scale testbed
- WP1 (Grid Workload Management)
  - Mandate: "*To define and implement a suitable architecture for distributed scheduling and resource management on a GRID environment*"
  - This includes the following areas of activity:
    - Design and development of a useful (as seen from the DataGrid applications perspective) grid scheduler, or Resource Broker
    - Design and development of a suitable job description and monitoring infrastructure
    - Design and implementation of a suitable job accounting structure

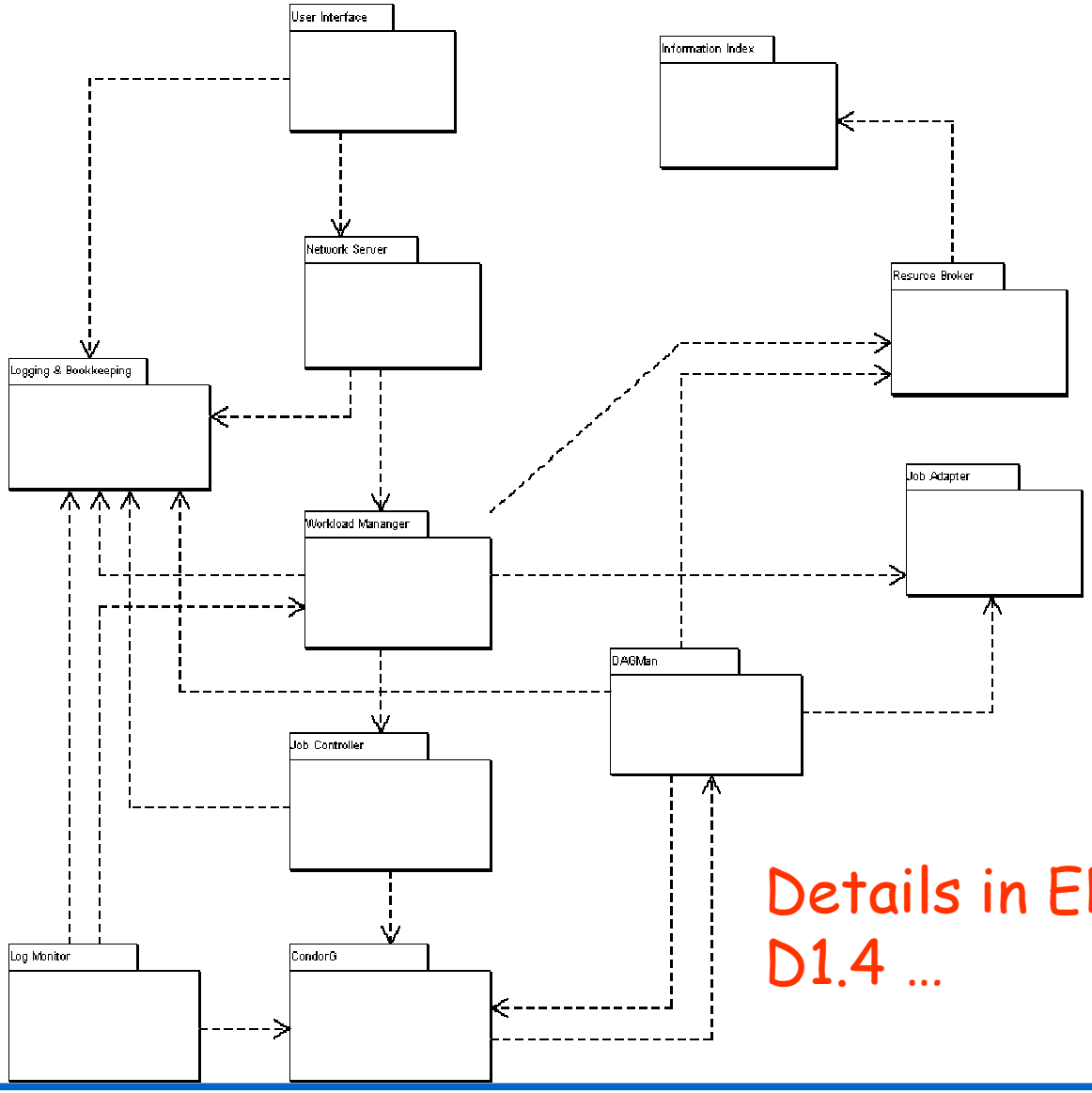
WP1 Workload Management System

- Working Workload Management System prototype implemented by WP1 in the first phase of the EDG project (presented at CHEP2001)
  - Ability to define (via a Job Description Language, JDL) a job, submit it to the DataGrid testbed from any user machine, and control it
  - WP1's Resource Broker chooses an appropriate computing resource for the job, based on the constraints specified in the JDL
    - Where the submitting user has proper authorization
    - That matches the characteristics specified in the job JDL (Architecture, computing power, application environment, etc.)
    - Where the specified input data (and possibly the chosen output Storage Element) are determined to be "close enough" by the appropriate resource administrators
- Application users have now been experiencing for about one year and a half with this first release of the workload management system
  - Stress tests and semi-production activities (e.g. CMS stress tests, Atlas efforts)
  - Significant achievements exploited by the experiments but also various problems were spotted
    - Impacting in particular the reliability and scalability of the system

Review of WP1 architecture

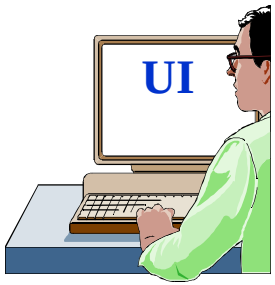
- WP1 WMS architecture reviewed
  - To apply the "lessons" learned and addressing the shortcomings emerged with the first release of the software
    - Reduce of persistent job info repositories
    - Avoid long-lived processes
    - Delegate some functionalities to pluggable modules
    - Make more reliable (e.g.via file system) communication among components
    - … (see also other EDG WP1 talk given by Francesco Prelz)
  - To increase the reliability of the system
  - To support new functionalities
  - To favor interoperability with other Grid frameworks, by allowing exploiting WP1 modules (e.g. RB) also "outside" the WP1 WMS
  - New WMS (v. 2.0) presented at the 2nd EDG review and scheduled for integration at April 2003

WP1 reviewed architecture



Details in EDG deliverable D1.4 …

Job submission example



RB node

Network Server

Workload Manager

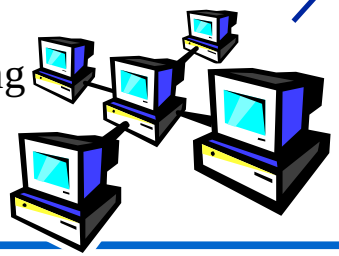
Job Contr. - CondorG

Replica Catalog

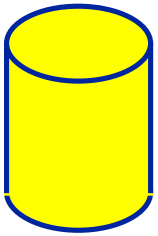
Inform. Service

CE characts & status

SE characts & status



Computing Element



Storage Element

Job subm

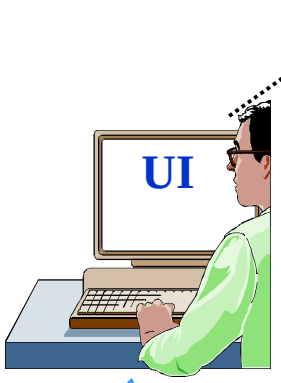
edg-job-submit myjob.jdl

Myjob.jdl

```
JobType = "Normal";
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. GlueHostOperatingSystemName == "linux" &&
other. GlueHostOperatingSystemRelease == "Red Hat 6.2" &&
other.GlueCEPolicyMaxWallClockTime > 10000;
Rank  = other.GlueCEStateFreeCPUs;
```

Job Status

submitted



UI: allows users to access the functionalities of the WMS

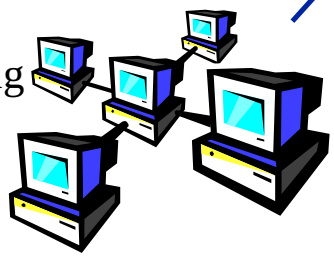
Job Contr. - CondorG

Job Description Language (JDL) to specify job characteristics and requirements

CE characts & status

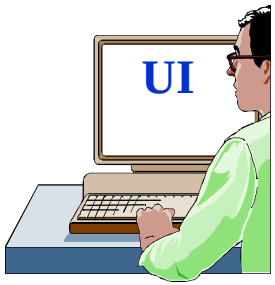
SE characts & status

Computing Element



Storage Element

Job submission



Job

Input Sandbox files

RB storage

RB n

Network Server

Workload Manager

Job Contr. - CondorG

NS: network daemon responsible for accepting incoming requests

Replica Catalog

Inform. Service

CE characts & status

SE characts & status

Computing Element

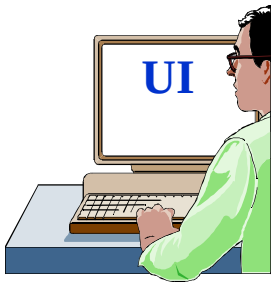
Storage Element

Job Status

submitted

waiting

Job submission



RB node

Network Server

Job

Workload Manager

RB storage

Job Contr. - CondorG

WM: responsible to take the appropriate actions to satisfy the request

Replica Catalog

Inform. Service

CE characts & status

SE characts & status

Computing Element

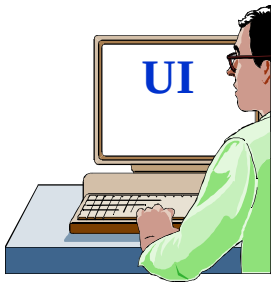
Storage Element

Job Status

submitted

waiting

Job submission



RB node

Network Server

Match-maker

Replica Catalog

Workload Manager

RB storage

Where must this job be executed ?

Inform. Service

Job Contr. - CondorG

Job Status

submitted

waiting

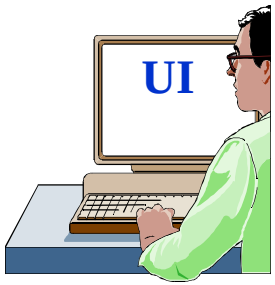
CE characts & status

SE characts & status

Computing Element

Storage Element

Job submission



RB node

Matchmaker: responsible to find the "best" CE where to submit a job

Match-Maker/ Broker

Workload Manager

RB storage

Job Contr. - CondorG

Replica Catalog

Inform. Service

CE characts & status

SE characts & status

Computing Element

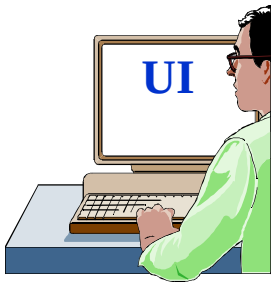
Storage Element

Job Status

submitted

waiting

Job submission



RB node

Network Server

Workload Manager

Job Contr. - CondorG

RB storage

Match-Maker/ Broker

Where are (which SEs) the needed data ?

Replica Catalog

What is the status of the Grid ?

Inform. Service

CE characts & status

SE characts & status

Computing Element

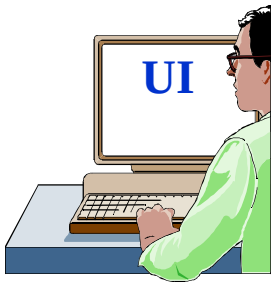
Storage Element

Job Status

submitted

waiting

Job submission



RB node

Network Server

Match-maker

Workload Manager

CE choice

RB storage

Job Contr. - CondorG

Replica Catalog

Inform. Service

CE characts & status

SE characts & status

Computing Element

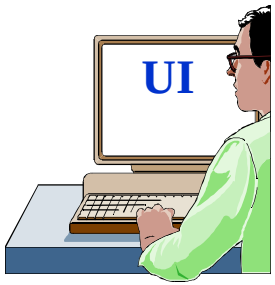
Storage Element

Job Status

submitted

waiting

Job submission



RB node

Network Server

Workload Manager

Job Contr. - CondorG

Job Adapter

RB storage

Replica Catalog

Inform. Service

Job Status

submitted

waiting

JA: responsible for the final “touches” to the job before performing submission (e.g. creation of wrapper script, etc.)

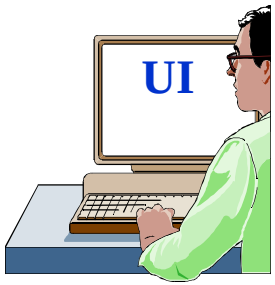
haracts
us

SE characts & status

Computing Element

Storage Element

Job submission



RB node

Network Server

RB storage

Workload Manager

Job

Job Contr. - CondorG

JC: responsible for the actual job management operations (done via CondorG)

Replica Catalog

Inform. Service

CE characts & status

SE characts & status

Computing Element

Storage Element

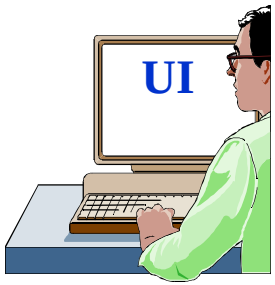
Job Status

submitted

waiting

ready

Job submission



RB node

Network Server

Workload Manager

RB storage

Job Contr. - CondorG

Replica Catalog

Inform. Service

Input Sandbox files

Job

CE characts & status

SE characts & status

Computing Element

Storage Element

Job Status

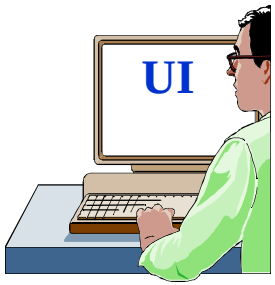
submitted

waiting

ready

scheduled

Job submission



RB node

Network Server

RB storage

Workload Manager

Job Contr. - CondorG

Input Sandbox

Replica Catalog

Inform. Service

Job Status

submitted

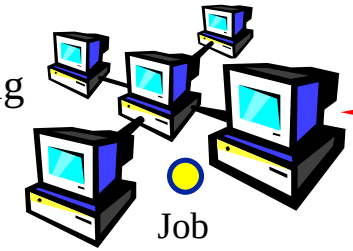
waiting

ready

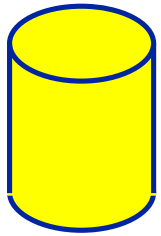
scheduled

running

Computing Element

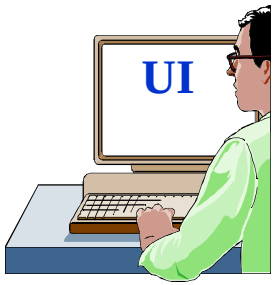


"Grid enabled" data transfers/ accesses



Storage Element

Job submission



RB node

Network Server

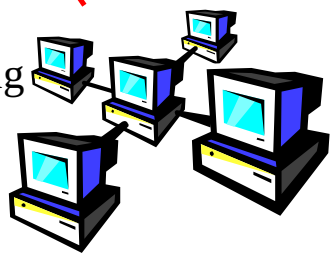
Workload Manager

Job Contr. - CondorG

RB storage

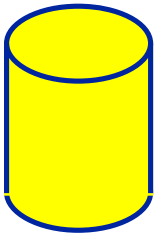
Output Sandbox files

Computing Element



Replica Catalog

Inform. Service



Storage Element

Job Status

submitted

waiting

ready

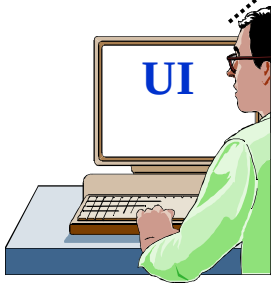
scheduled

running

done

Job submission

edg-job-get-output <dg-job-id>



RB node

Network Server

Workload Manager

RB storage

Job Contr. - CondorG

Output Sandbox

Replica Catalog

Inform. Service

Job Status

submitted

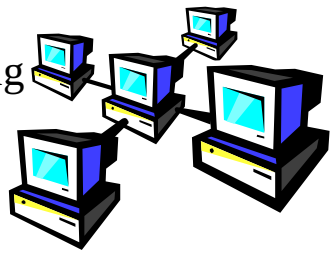
waiting

ready

scheduled

running

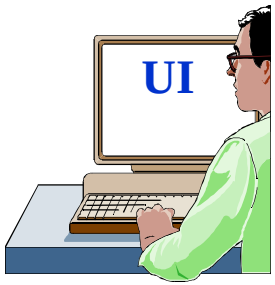
done



Computing Element

Storage Element

Job submission



Output Sandbox files

RB node

RB storage

Network Server

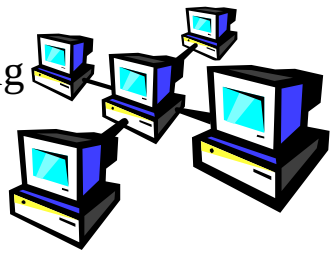
Workload Manager

Job Contr. - CondorG

Replica Catalog

Inform. Service

Computing Element



Storage Element

Job Status

submitted

waiting

ready

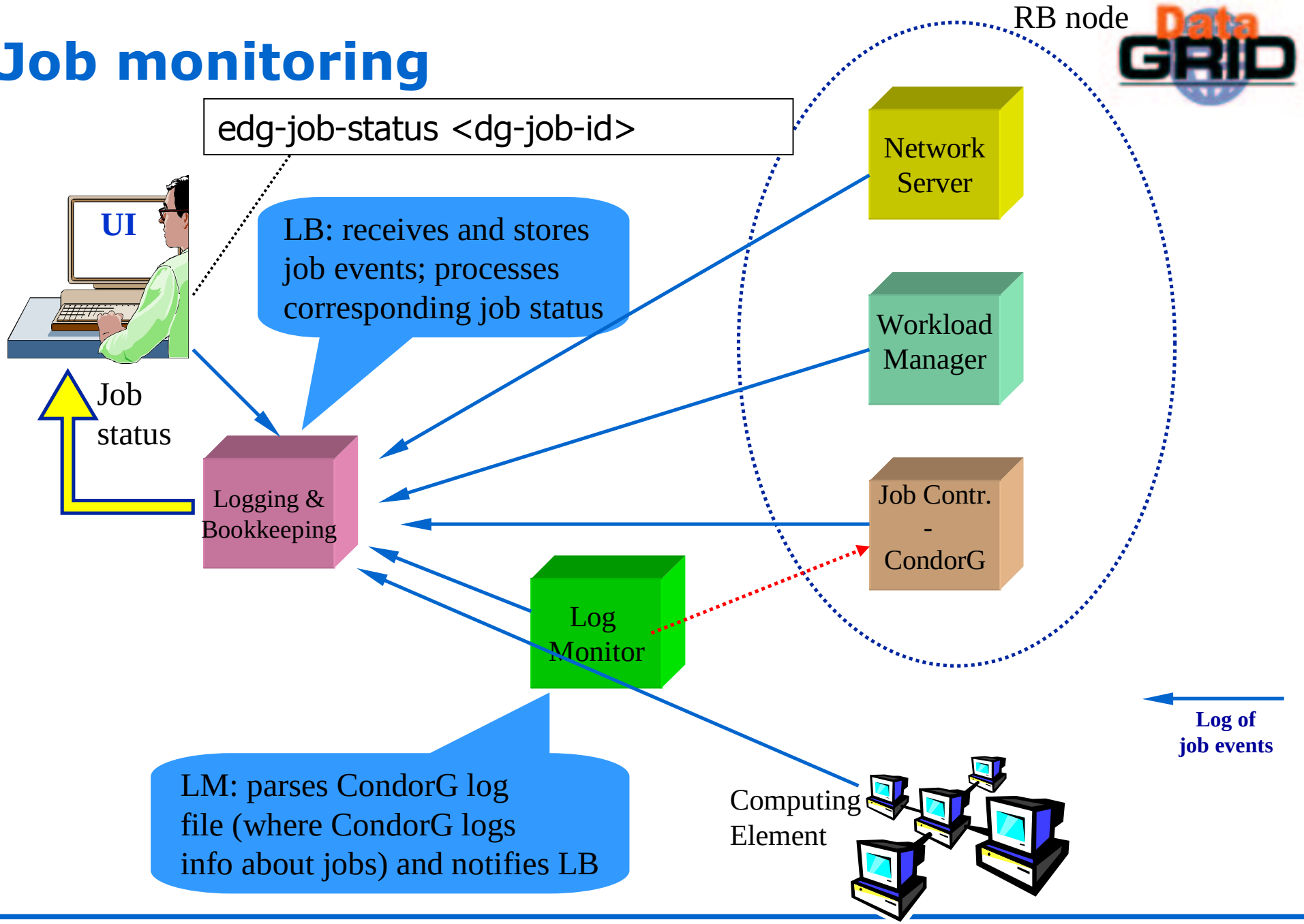
scheduled

running

done

cleared

Job monitoring



New functionalities introduced

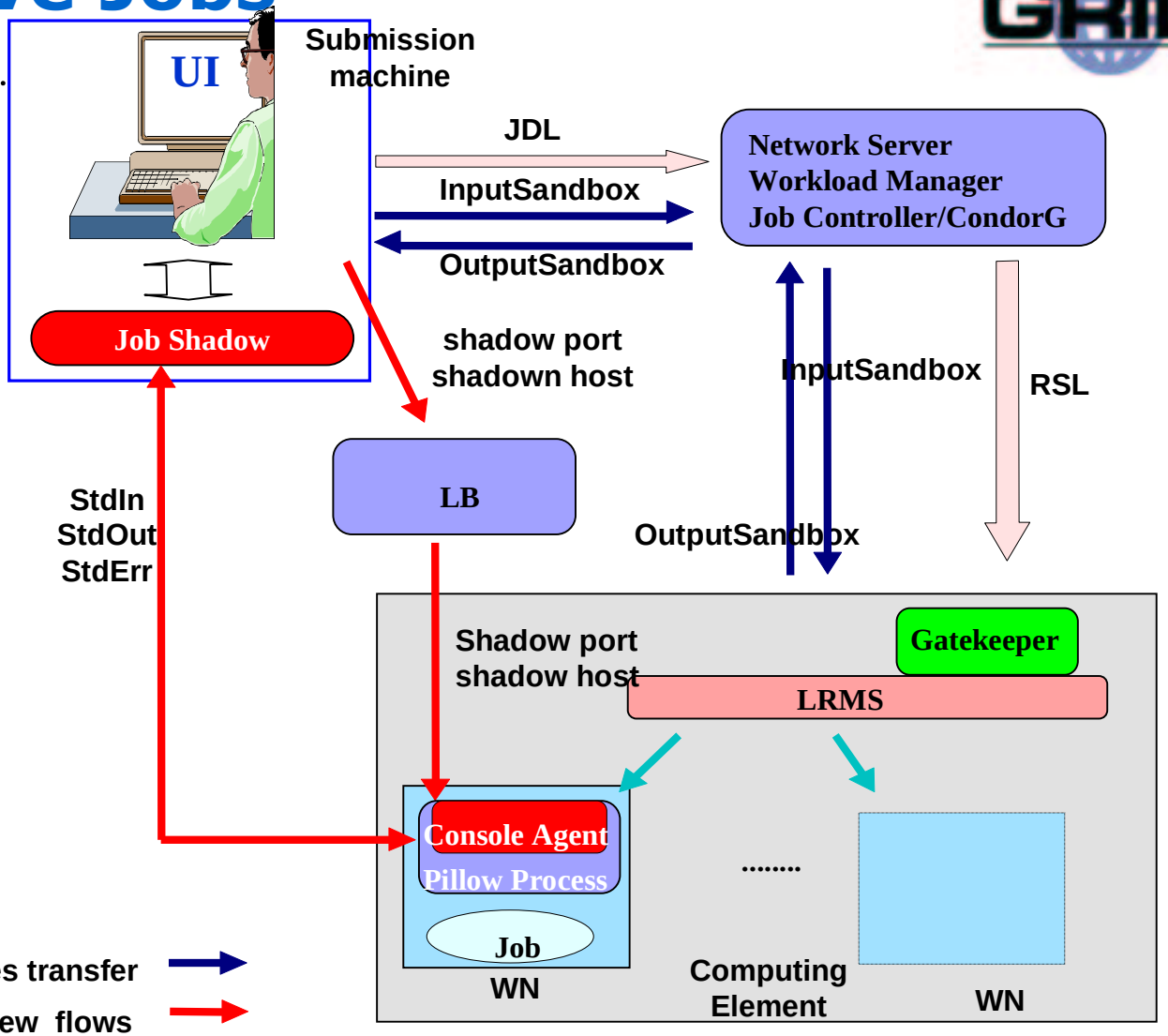
- User APIs
  - Including a Java GUI
- "Trivial" job checkpointing service
  - User can save from time to time the state of the job (defined by the application)
  - A job can be restarted from an intermediate (i.e. "previously" saved) job state
- Glue schema compliance
- Gangmatching
  - Allow to take into account both CE and SE information in the matchmaking
    - For example to require a job to run on a CE close to a SE with "enough space"
- Integration of EDG WP2 Query Optimisation Service
  - Help for RB to find the best CE based on data location
- Support for parallel MPI jobs
- Support for interactive jobs
  - Jobs running on some CE worker node where a channel to the submitting (UI) node is available for the standard streams (by integrating the Condor Bypass software)

Interactive Jobs

edg-job-submit jobint.jdl

jobint.jdl

```
[JobType = "interactive";
ListenerPort = 2654;
Executable      = "int-prg.exe";
StdOutput = Outfile;
InputSandbox = "/home/user/int-prg.exe",
OutputSandbox = "Outfile",
Requirements =
other. GlueHostOperatingSystemName ==
"linux" &&
Other.GlueHostOperatingSystemRelease ==
"RH 6.2";]
```



Future functionalities

- Dependencies of jobs
  - Integration of Condor DAGMan
  - "Lazy" scheduling: job (node) bound to a resource (by RB) just before that job can be submitted (i.e. when it is free of dependencies)
- Support for job partitioning
  - Use of job checkpointing and DAGMan mechanisms
    - Original job partitioned in sub-jobs which can be executed in parallel
    - At the end each sub-job must save a final state, then retrieved by a job aggregator, responsible to collect the results of the sub-jobs and produce the overall output
- Grid Accounting
  - Based upon a computational economy model
    - Users pay in order to execute their jobs on the resources and the owner of the resources earn credits by executing the user jobs
  - To have a nearly stable equilibrium able to satisfy the needs of both resource `producers' and `consumers'
  - To credit of job resource usage to the resource owner(s) after execution
- Advance reservation and co-allocation
  - Globus GARA based approach
- Development already started (most of this software already in a good shape) but integration foreseen after release 2.0

Conclusions

- In the first phase of the EDG project, WP1 implemented a working Workload Management System prototype
- Applications have been experiencing with this WMS for one year and a half
- Revised WMS architecture (WMS v. 2.0 planned for integration in Apr 2003)
  - To address emerged shortcomings, e.g.
    - Reduce of persistent job info repositories
    - Avoid long-lived processes
    - Delegate some functionalities to pluggable modules
    - Make more reliable communication among components
  - To support new functionalities
    - APIs, Interactive jobs, Job checkpointing, Gangmatching, …
  - Hooks to support other functionalities planned to be integrated later
    - DAGman, Job partitioning, Grid accounting, Resource reservation and co-allocation
- Other info
  - http://www.infn.it/workload-grid (Home page for EDG WP1)
  - http://www.eu-datagrid.org (Home page for EDG project)

Thanks to the EU and our national funding agencies for their support of this work