The EDG Workload Management System: release 2

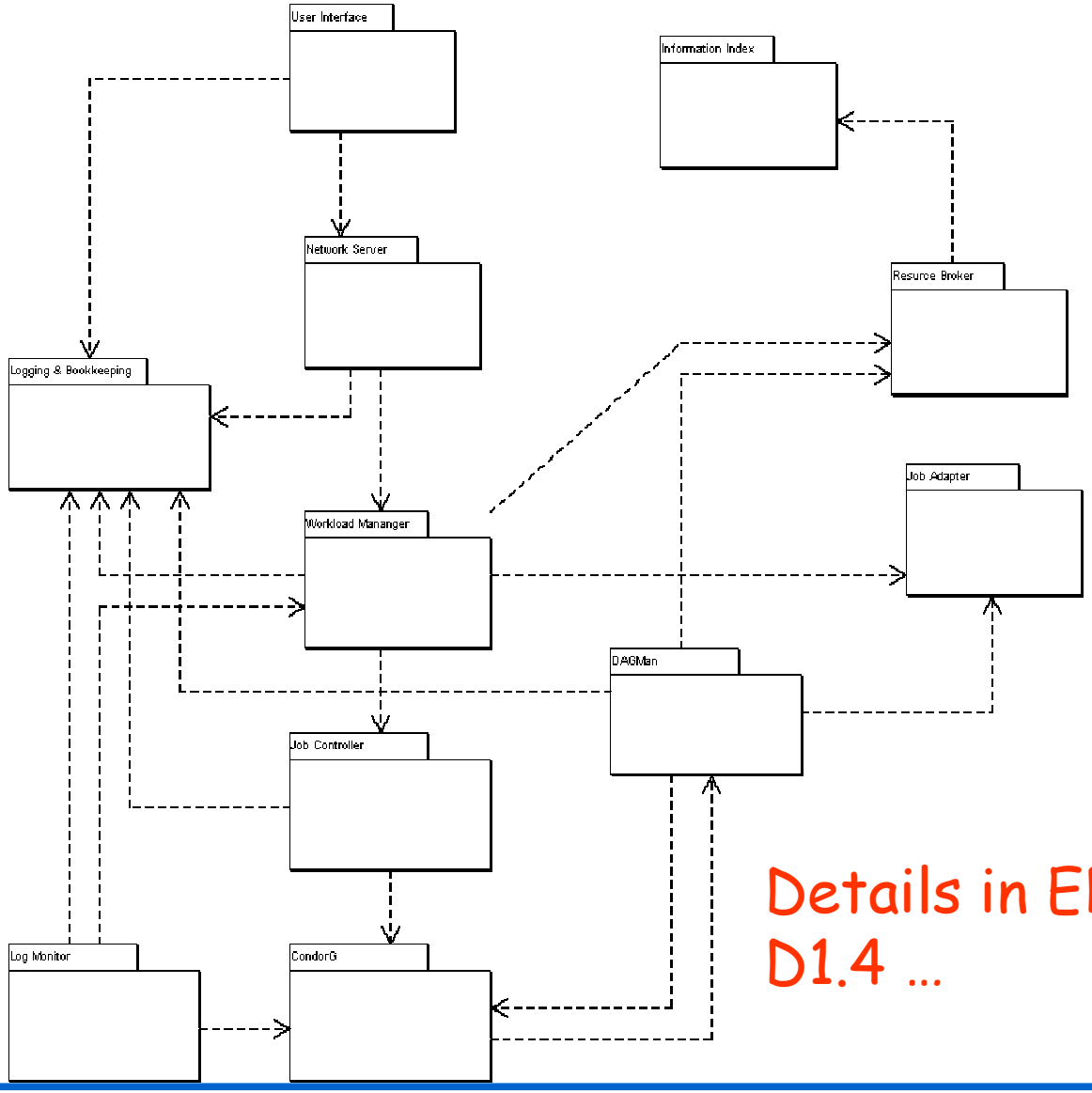
Massimo Sgaravatto
INFN Padova - DataGrid WP1

massimo.sgaravatto@pd.infn.it

Review of WP1 WMS architecture

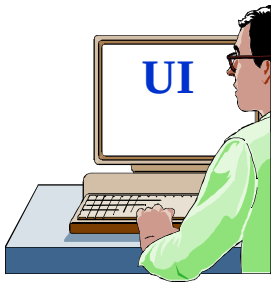
- WP1 WMS architecture reviewed
  - To apply the "lessons" learned and addressing the shortcomings emerged with the first release of the software, in particular
    - To increase the reliability problems
    - To address the scalability problems
  - To support new functionalities
  - To favor interoperability with other Grid frameworks, by allowing exploiting WP1 modules (e.g. RB) also "outside" the EDG WMS

WP1 WMS reviewed architecture



Details in EDG deliverable D1.4 …

Job submission example



RB node

Network Server

Workload Manager

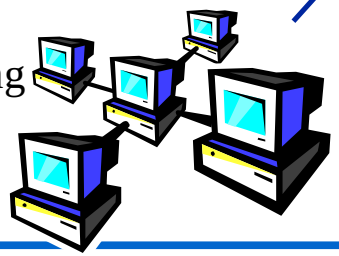
Job Contr. - CondorG

RLS

Inform. Service

CE characts & status

SE characts & status



Computing Element

Storage Element

Job subm

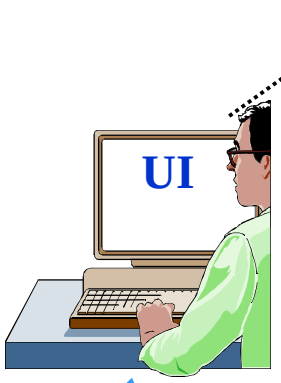
edg-job-submit myjob.jdl

Myjob.jdl

```
JobType = "Normal";
Executable     = "$(CMS)/exe/sum.exe";
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

Workload Manager

Job Contr. - CondorG

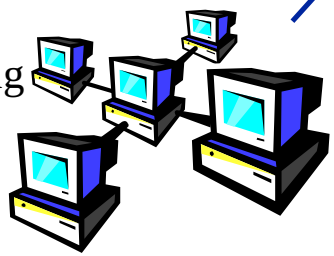
Inform. Service

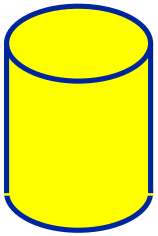
Job Description Language (JDL) to specify job characteristics and requirements

CE characts & status

SE characts & status

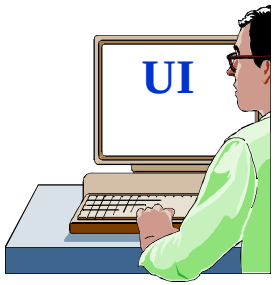
Computing Element





Storage Element

Job submission



Job

Input Sandbox files

RB storage

RB node

Network Server

Workload Manager

Job Contr. - CondorG

NS: network daemon responsible for accepting incoming requests

RLS

Inform. Service

CE characts & status

SE characts & status

Computing Element

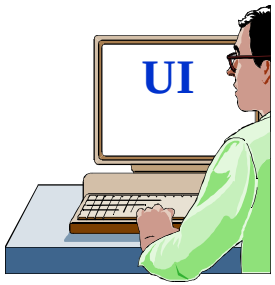
Storage Element

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

RLS

Inform. Service

CE characts & status

SE characts & status

Computing Element

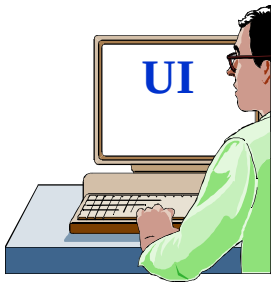
Storage Element

Job Status

submitted

waiting

Job submission



RB node

Network Server

Match-Maker/ Broker

RLS

Workload Manager

RB storage

Where must this job be executed ?

Inform. Service

Job Contr. - CondorG

CE characts & status

SE characts & status

Computing Element

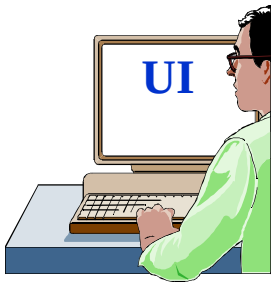
Storage Element

Job Status

submitted

waiting

Job submission



RB node

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

Match-Maker/ Broker

RLS

Job Status

submitted

waiting

RB storage

Workload Manager

Inform. Service

Job Contr. - CondorG

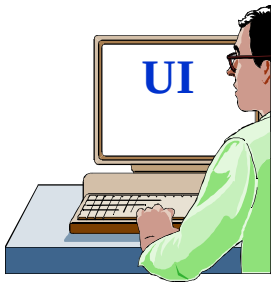
CE characts & status

SE characts & status

Computing Element

Storage Element

Job submission



RB node

Network Server

Workload Manager

Job Contr. - CondorG

RB storage

Match-Maker/ Broker

Where are (which SEs) the needed data ?

RLS

Inform. Service

What is the status of the Grid ?

CE characts & status

SE characts & status

Computing Element

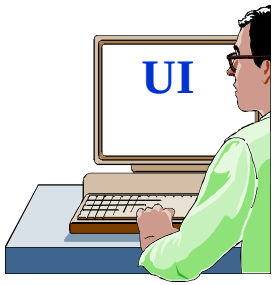
Storage Element

Job Status

submitted

waiting

Job submission



RB node

Network Server

Match-Maker/ Broker

Workload Manager

CE choice

RB storage

Job Contr. - CondorG

RLS

Inform. Service

Job Status

submitted

waiting

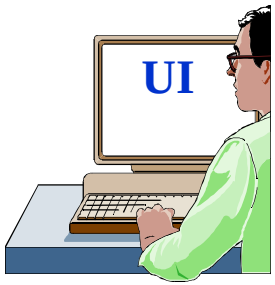
CE characts & status

SE characts & status

Computing Element

Storage Element

Job submission



RB node

Network Server

Workload Manager

Job Contr. - CondorG

Job Adapter

RB storage

RLS

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.)

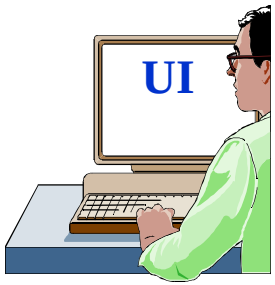
haracts
us

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)

RLS

Inform. Service

CE characts & status

SE characts & status

Computing Element

Storage Element

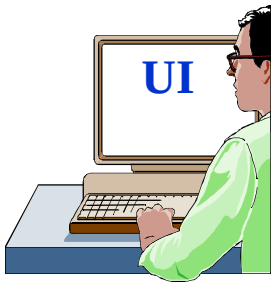
Job Status

submitted

waiting

ready

Job submission



RB node

Network Server

Workload Manager

RB storage

Job Contr. - CondorG

Input Sandbox files

Job

Computing Element

RLS

Inform. Service

CE characts & status

SE characts & status

Storage Element

Job Status

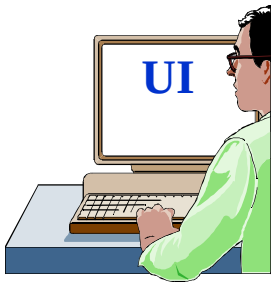
submitted

waiting

ready

scheduled

Job submission



RB node

Network Server

Workload Manager

RB storage

Job Contr. - CondorG

Input Sandbox

RLS

Inform. Service

Job Status

submitted

waiting

ready

scheduled

running

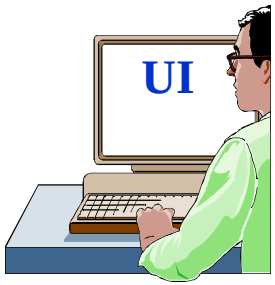
Computing Element

Job

"Grid enabled" data transfers/ accesses

Storage Element

Job submission



RB node

Network Server

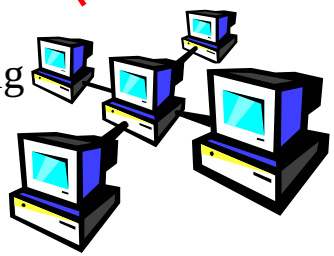
Workload Manager

Job Contr. - CondorG

RB storage

Output Sandbox files

Computing Element



RLS

Inform. Service

Storage Element

Job Status

submitted

waiting

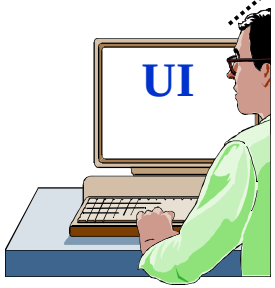
ready

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

RLS

Inform. Service

Job Status

submitted

waiting

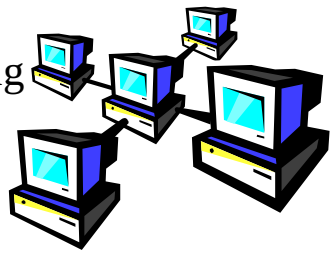
ready

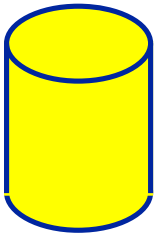
scheduled

running

done

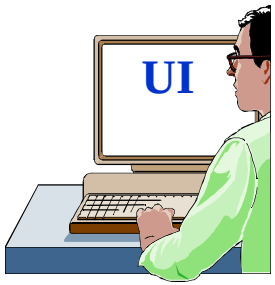
Computing Element





Storage Element

Job submission



Output Sandbox files

RB node

RB storage

Network Server

Workload Manager

Job Contr. - CondorG

RLS

Inform. Service

Job Status

submitted

waiting

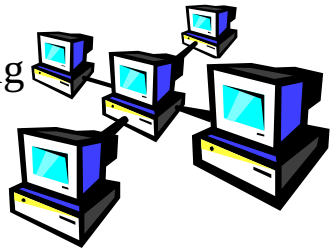
ready

scheduled

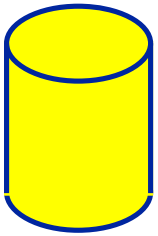
running

done

cleared

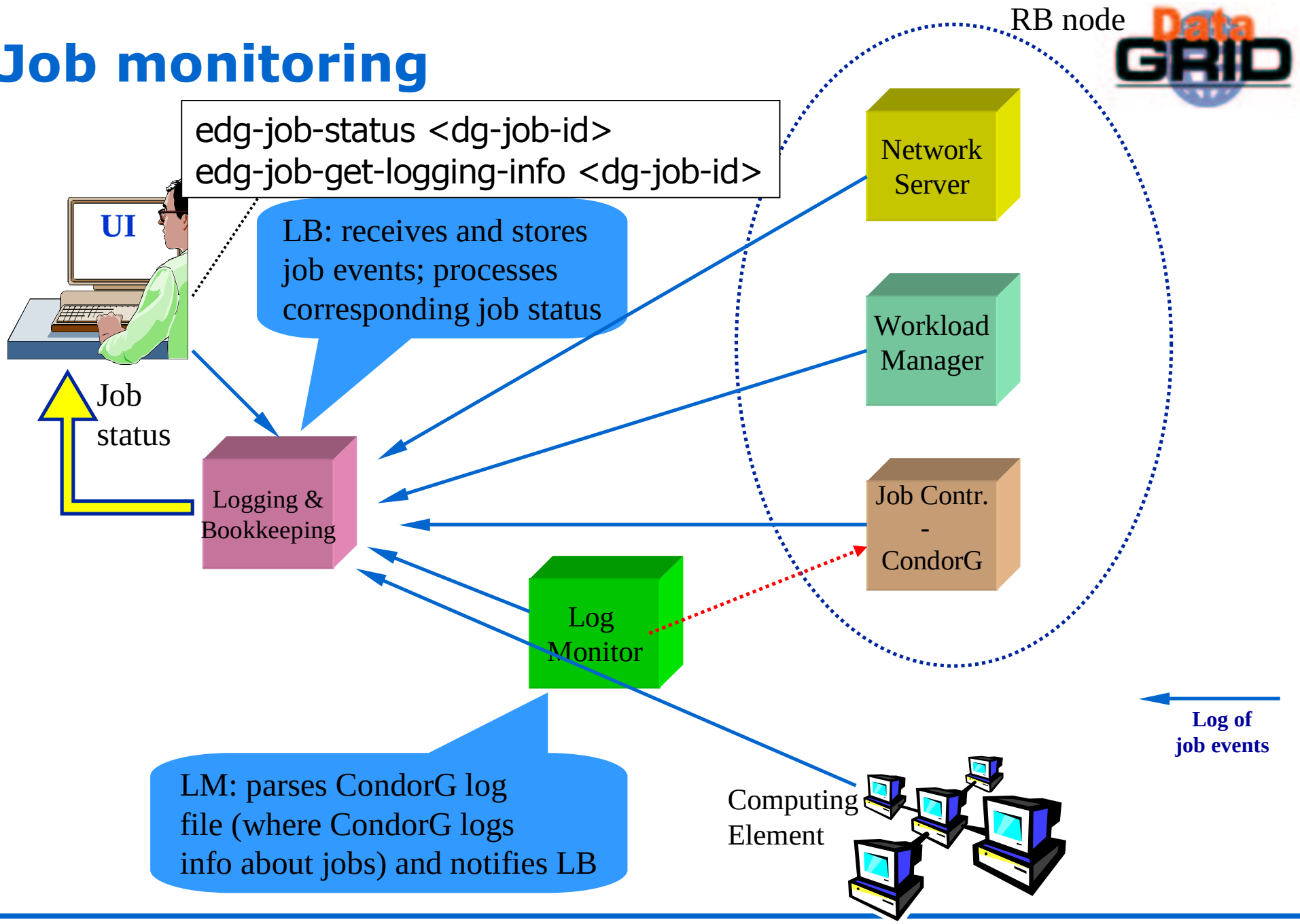


Computing Element



Storage Element

Job monitoring



Addressing reliability and scalability

- No more a monolithic long-lived process
  - Some functionalities (e.g. matchmaking) delegated to pluggable modules
  - Less exposed to memory leaks (coming not only from EDG software)
- No more multiple job info repositories
  - No more job status inconsistencies which caused problems
  - Also improvement from a user perspective (e.g job status not OutputReady, but it was possible to retrieve output sandbox)
- Reliable communications among components
  - Done via the file system (filequeues)
  - For example jobs are not lost if the target entity is temporary down: when it restarts it gets and "process" the jobs

Addressing reliability and scalability

- No more STL string problems on SMP machines
  - Which caused problems to the RB and required the cleaning of internal databases and loss of all active jobs
  - WP1 sw built with gcc 3.2
- Integration of newer (v. 6.5.1) CondorG (deployed via VDT)
  - Better job submission system
  - No more 'max 512 concurrent jobs' limit
  - Actually still some issues to address (already in touch with Condor developers)

Other improvements wrt release 1.x

- Security of sandbox files
  - Not possible anymore to access sandbox files of other users
  - Done via a patched gridftp server and via a proper grid-mapfile in the "RB node"
- Addressed disk space mgmt problem on the "RB node"
  - Could get completely filled with sandbox files
  - Problem addressed:
    - WMS admin can specify a maximum size for the input sandbox (if greater: job refused)
    - WMS can also specify a percentage of disk: if free disk less than this value, new jobs refused
    - Also possible to rely on disk quota (WMS admin can set disk quota for the various users)
    - Also possible to rely on "dynamic" disk quota (WMS admin can not set disk quota for the various users: when a job is submitted, its quota is automatically increased of a certain amount of space, which is released when job completes)
  - Also possible to run from time to time (e.g. via a cron job) a purger, which cleans "old" sandbox directories (configurable policies)

Other improvements wrt release 1.x

- Improvements in LB
  - No more one LB server per "RB", but possible to have more LB servers
    - Could be useful in case of LB overloaded
  - Extended querying capabilities
    - E.g. Give me all jobs marked as 'XYZ' (user tag) and running on CE1 or C'E2
    - Necessary to create custom indices
      - LB server refuses to process a query which would not utilize any index to prevent overloading the underlying database engine
  - R-GMA interfaces
    - LB server capable of feeding the R-GMA infrastructure with notifications on job state changes
- Proxy renewal
  - Fixed (very silly) problem of release 1 (renewed proxy was too short)
  - Reliable proxy renewal service (doesn't forget about registered proxies in case of service restart)

Other improvements wrt release 1.x

- Other typical rel. 1 problems fixed
  - CE chosen in a random way among the CEs which meet all the requirements and have the same best rank
  - No more JSSparser stuck → status of jobs don't updated
    - The problem was in PSQL, not used anymore
- Other fixes and improvements
- Much better stability sought in our internal tests
- But difficult for us to perform stress tests in our small WP1 testbed
  - Prepared to address problems we will find when performing the real integrated stress tests on the real big testbed

Other improvements/changes

- Integration with WP2 software
  - Interaction with WP2 RLS (instead of the "old" RC to have the logical → physical file name mappings)
  - Possible to rely on the WP2 getAccessCost as JDL rank
    - I.e. getAccessCost finds the best CE among the ones meeting all the requirements (taking into account data location)
- Integration with R-GMA (wrt Information Services) completely transparent for WP1 sw (via GIN, GOUT mechanisms)
- New Glue schema
  - → JDL expressions must rely on this new IS schema

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
  - Presented at the EDG review
- 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"
- Output data upload and registration
  - Possible to trigger (via proper JDL attribute) automatic data upload and registration at job completion

New functionalities introduced

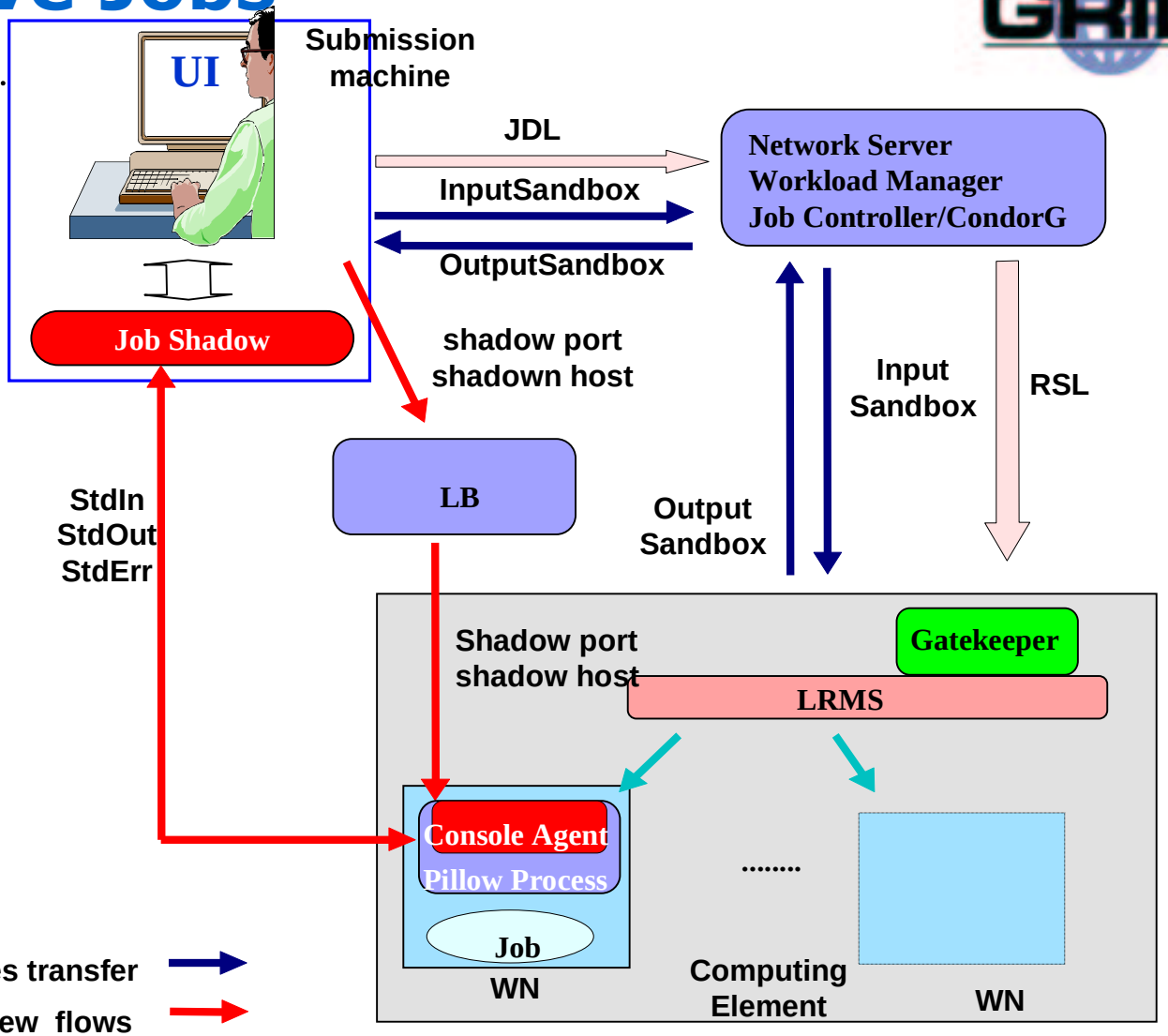
- Support for parallel MPI jobs
  - Parallel jobs within single CEs
- Grid accounting services
  - Just for economic accounting for Grid User and Resources
    - The users pay for resource usage while the resources earn virtual credits executing user jobs
  - No integration with “brokering” module
- 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

- Hooks in place for other 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
  - Integration of Grid Accounting with "matchmaking" module
    - 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'
  - Advance reservation and co-allocation
    - Globus GARA based approach
- Development of these new functionalities already started (most of this software already in a good shape)

Conclusions

- Revised WMS architecture
  - 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, Resource reservation and co-allocation, …