Introduction

DIRAC Project

Outline

- Disclaimer
- Specific issues of large Grid Communities
- DIRAC solution
  - Workload Management
  - Data Management
  - Other systems
  - Extending DIRAC
  - User interfaces
- Tutorial plan

Disclaimer

- This is not an introduction to Computing Grids

- DIRAC developers has lots of experience with HEP applications but less with other domains
  - Do not hesitate to ask questions

- We are not professional tutors
  - Do not hesitate to repeat questions

HEP applications

- HEP experiments collect unprecedented volumes of data to be processed on large amount of geographically distributed computing resources
  - 10s of PBytes of data per year
  - 10s of thousands CPUs in 100s of centers
  - 100s of users from 100s of institutions

However, other application domains are quickly approaching these scales

Large VO issues

- Large user communities (Virtual Organizations) have specific problems
  - Dealing with heterogeneous resources
    - Various computing clusters, grids, etc
  - Dealing with the intracommunity workload management
    - User group quotas and priorities
    - Priorities of different activities
  - Dealing with a variety of applications
    - Massive data productions
    - Individual user applications, etc

General problems

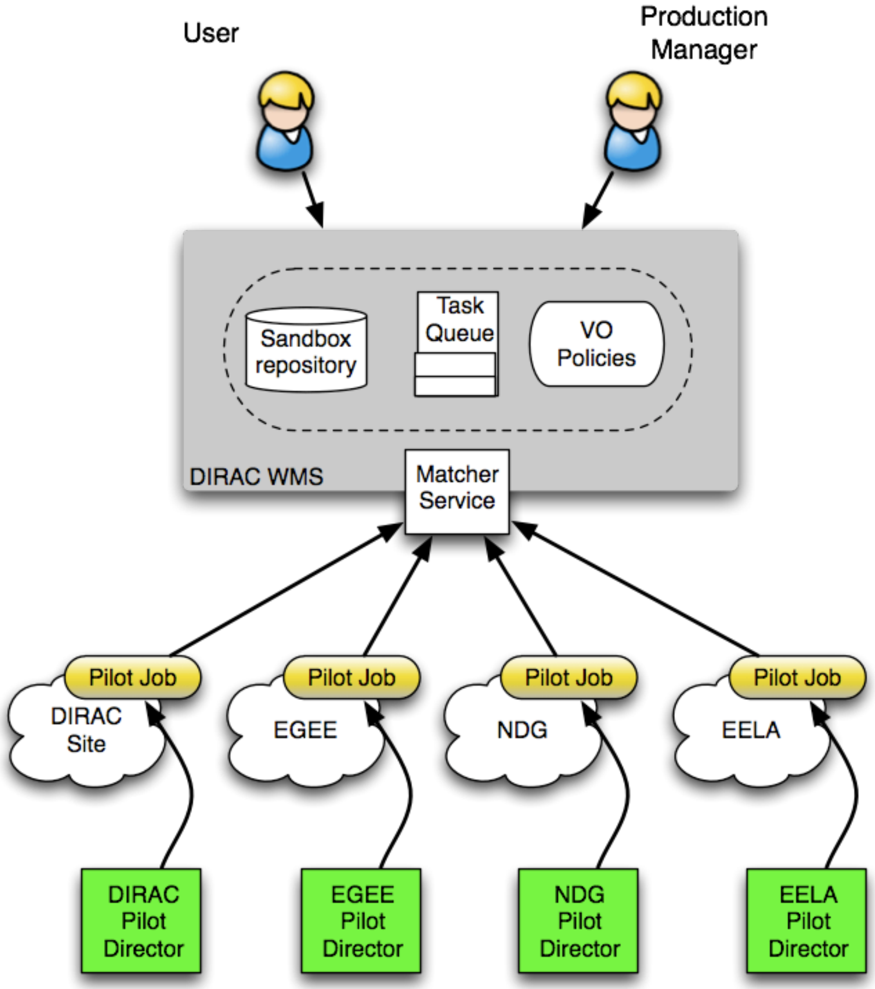
- Overcome deficiencies of the standard grid middleware
  - Inefficiencies, failures
    - Production managers can afford that, users can not
  - Lacking specific functionality
- Alleviate the excessive burden from sites – resource providers – in supporting multiple VOs
  - Avoid complex VO specific configuration on sites
  - Avoid VO specific services on sites

DIRAC Grid Solution

- DIRAC is providing a complete grid middleware stack
  - Developed originally for the LHCb experiment with the goal:
    - Integrate all the heterogeneous computing resources available to LHCb
    - Minimize human intervention at LHCb sites
  - Evolved to a generic grid solution to solve user community needs
    - Fault tolerance
    - Quicker turnaround of user jobs
    - Enabling Community policies
    - …

DIRAC WMS

- Jobs are submitted to the DIRAC Central Task Queue with credentials of their owner
- Pilot Jobs are submitted by specific Directors to a Grid WMS with credentials of a user with a special Pilot role
- The Pilot Job fetches the user job and the job owner's proxy
- The User Job is executed with its owner's proxy used to access SE, catalogs, etc



User Job efficiency

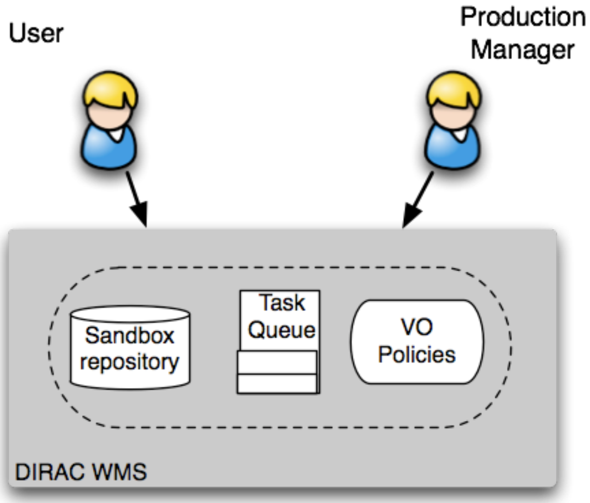
- Improved visible efficiency due to pilot agents
  - ~96% efficiency for DIRAC jobs vs 70-90% efficiency for the WLCG jobs
- If some resources are failing, it is just seen as a reduced pool of resources for the users

It is normal that computing resources are failing but
It is not normal that users are suffering from that

WMS: applying VO policies

- In DIRAC both User and Production jobs are treated by the same WMS
  - Same Task Queue

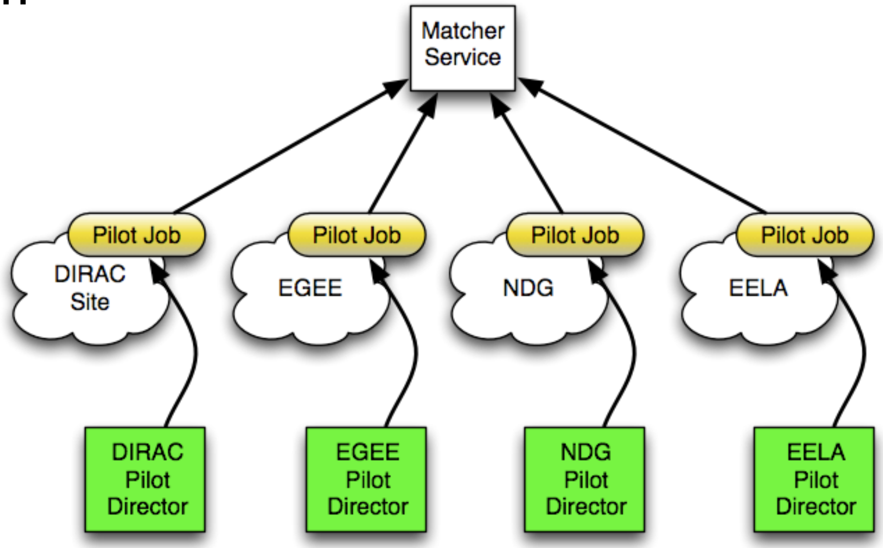
- This allows to apply efficiently policies for the whole VO
  - Assigning Job Priorities for different groups and activities
  - Static group priorities are used currently
  - More powerful scheduler can be plugged in
    - demonstrated with MAUI scheduler



- The VO policies application in the central Task Queue dictates the use of Multiuser Pilot Agents
  - No apriori knowledge which job has the highest priority at the moment of matching
  - DIRAC fully supports this mode of operation
    - Multiuser Pilots Jobs submitted with a special "pilot" VOMS role
    - Using glexec on the WNs to track the identity of the payload owner

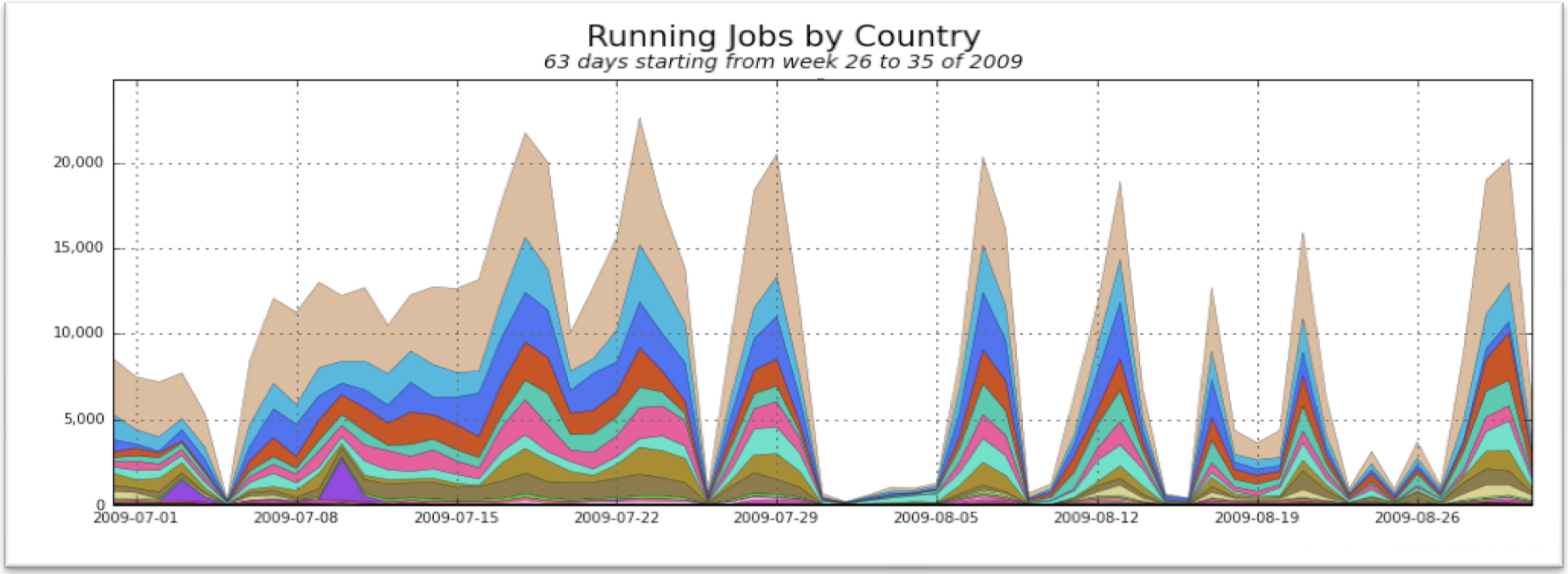
WMS: using heterogeneous resources

- Including resources in different grids and standalone clusters is simple with Pilot Jobs
  - Needs a specialized Pilot Director per resource type
  - Users just see new sites appearing in the job monitoring



- Resources include:
  - Grids: EGEE, GISELA, NDG
    - OSG is coming
  - Batch clusters, e.g. Torque
    - No special site installation is needed
  - Commercial computing clouds
    - Amazon EC2

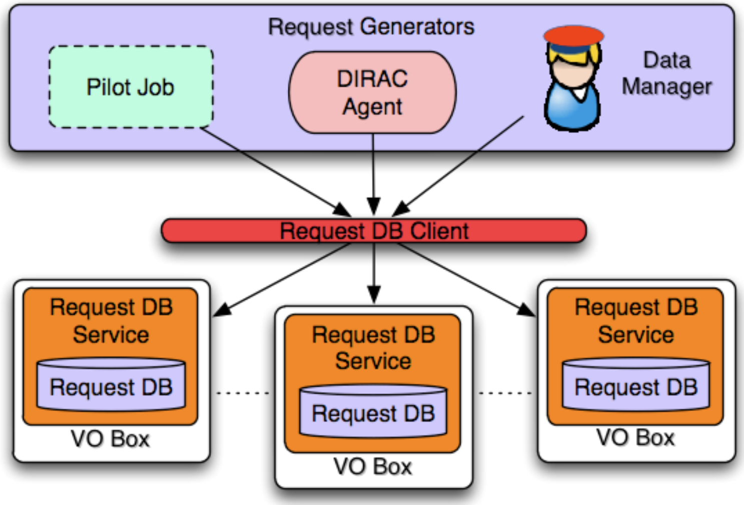
WMS performance



- DIRAC performance measured in real LHCb production runs
  - Up to 25K concurrent jobs in ~120 distinct sites
  - Several mid-range central servesr hosting DIRAC services
  - Further optimizations to increase the capacity are possible
    - Hardware, database optimizations, service load balancing, etc

Request Management system

- A Request Management System (RMS) to accept and execute asynchronously any kind of operation that can fail
  - Data upload and registration
  - Job status and parameter reports



- Request are collected by RMS instances on VO-boxes at 7 Tier-1 sites
  - Extra redundancy in VO-box availability

- Requests are forwarded to the central Request Database
  - For keeping track of the pending requests
  - For efficient bulk request execution

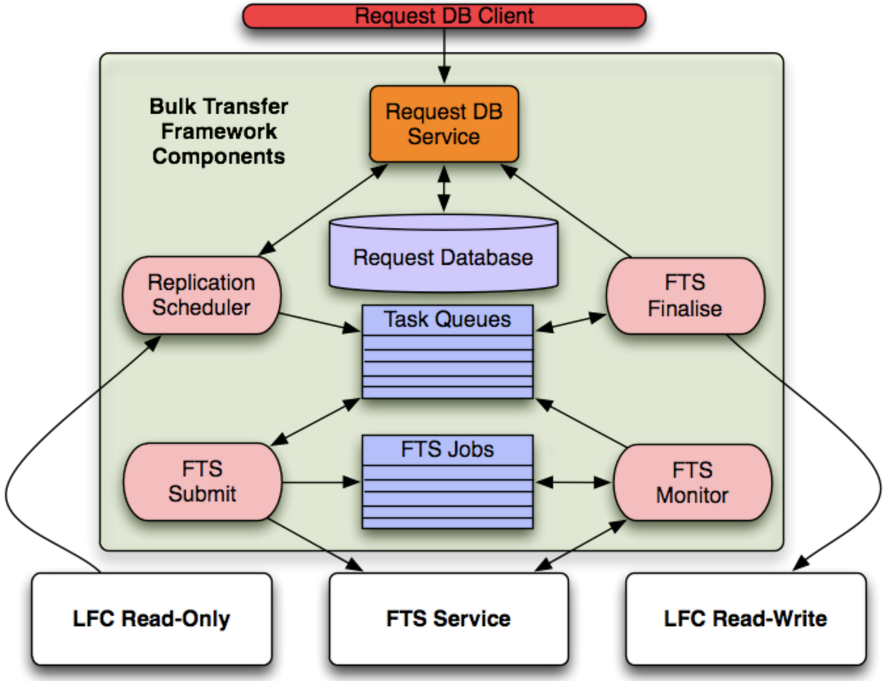
Data Management tools

- Storage Element services
  - SRM Storage Elements
  - DIRAC Storage Elements
  - Transparent access for the user
    - Replication, access from the jobs

- File Catalogs
  - LFC
  - DIRAC File Catalog
    - Compact, high performance
    - Includes user defined metadata
  - Uniform access
    - both catalogs can be used simultaneously

Data Management System

- All the Data Distribution operations
  - Pit to CERN transfers
  - T0-T1 transfers
  - T1-T1 transfers
- Based on the Request and Production Management Systems
  - Automatic transfer scheduling
  - Full monitoring of ongoing operations
- Using FTS for bulk data transfers
  - Full failure recovery



- Comprehensive checks of data integrity in SEs and File Catalogs

DIRAC development environment

- Python is the main development language
  - Fast prototyping/development cycle
  - Platform independence
  -
- MySQL database for the main services
  - ORACLE database backend for the LHCb Metadata Catalog
- Modular architecture allowing an easy customization for the needs of a particular community
  - Simple framework for building custom services and agents

DIRAC Framework

- Services oriented architecture
  - DIRAC systems consist of services, light distributed agents and client tools
- All the communications between the distributed components are secure
  - DISET custom client/service protocol
    - Control and data communications
  - X509, GSI security standards
  - Fine grained authorization rules
    - Per individual user FQAN
    - Per service interface method
    - Per job

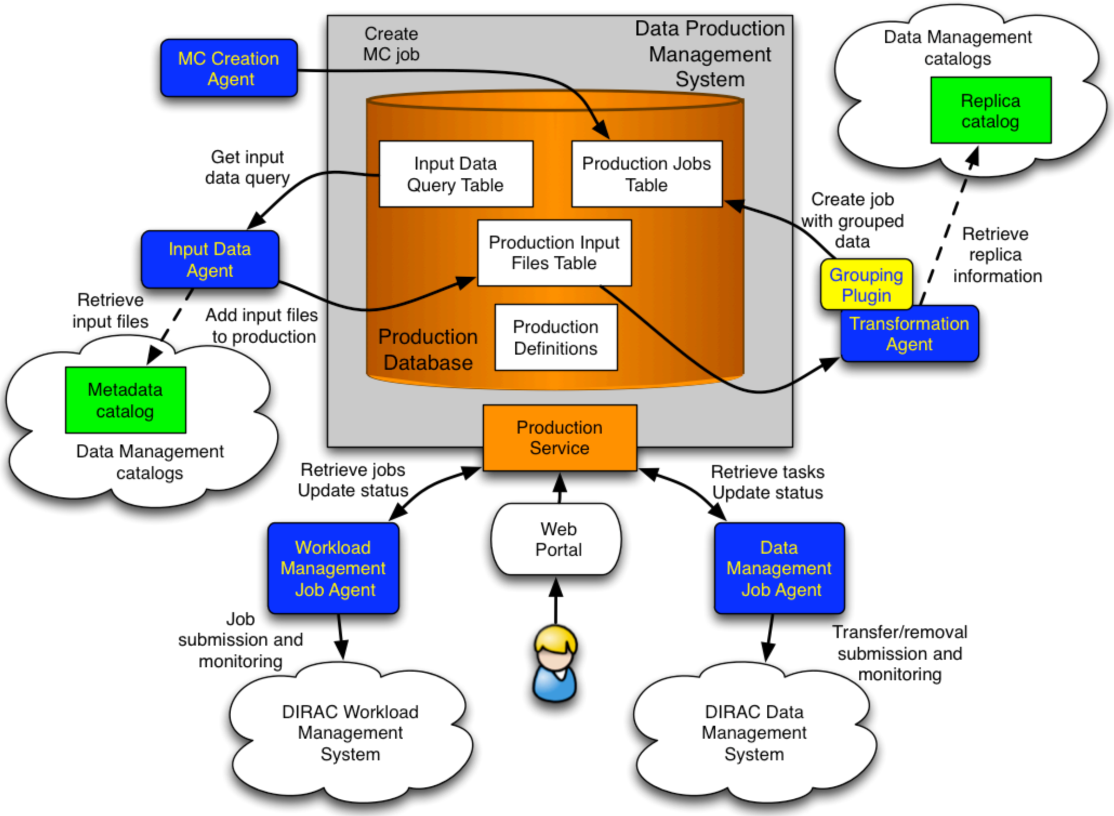
DIRAC extensions

- High level LHCb systems are built in the same DIRAC framework
  - Collaborating services and agents
  - Web based monitoring and controls
  - Detailed authorization rules

- Other community extensions
  - Belle – Amazon VM scheduler
  - ILC – File and Metadata Catalog
  - …

LHCb Production Management System

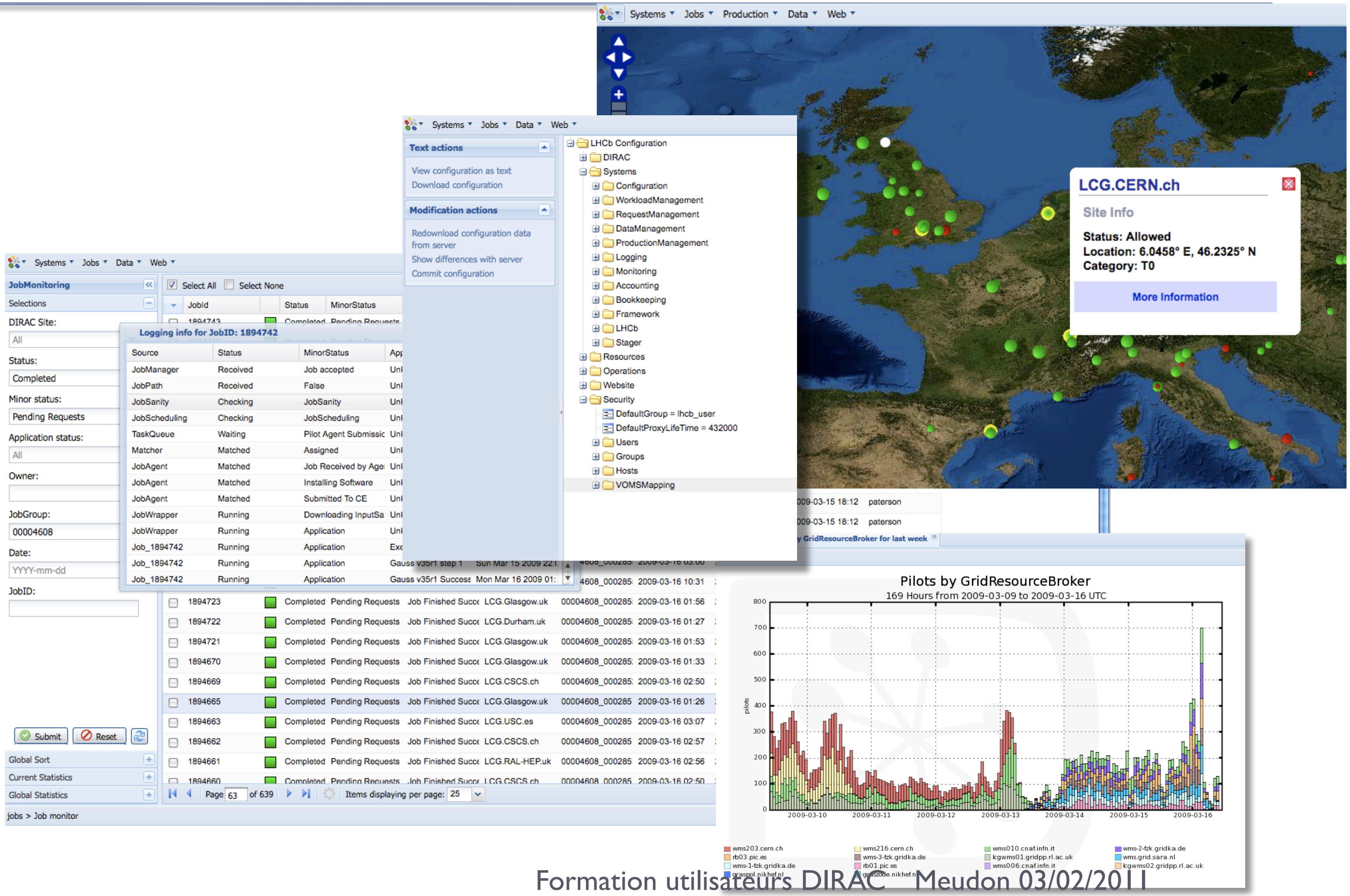
- Example extension
  - LHCb specific parts implemented as plugins
- Production Management built on top of the DIRAC WMS and DMS
  - Data requests formulated by users are processed and monitored using Web based tools
  - Automatic data reconstruction jobs creation and submission according to predefined scenarios
  - Interfaced to the LHCb Bookkeeping Database


MC Creation Agent
Create MC job
Data Production Management System
Data Management catalogs
Replica catalog
Get input data query
Input Data Query Table
Production Jobs Table
Create job with grouped data
Retrieve replica information
Input Data Agent
Production Input Files Table
Grouping Plugin
Retrieve input files
Add input files to production
Production Database
Production Definitions
Transformation Agent
Metadata catalog
Data Management catalogs
Production Service
Retrieve jobs Update status
Retrieve tasks Update status
Workload Management Job Agent
Web Portal
Data Management Job Agent
Job submission and monitoring
Transfer/removal submission and monitoring
DIRAC Workload Management System
DIRAC Data Management System

DIRAC: User perspective

- Easy client installation for various platforms (Linux, MacOS)
  - Includes security components
- Familiar usage patterns
  - JDL notation for job description
    - Simplified with respect to the « standard » JDL
  - Command line tools
    - à la gLite UI commands
    - e.g. dirac-wms-job-submit
- Extensive Python API for all the tasks
  - Job creation and manipulation, results retrieval
    - Possibility to use complex workflow templates
  - Data operations, catalog inspection
  - Used by GANGA user front-end
- DIRAC Web Portal

Web Portal: example interfaces



DIRAC Site: All

Status: Completed

Minor status: Pending Requests

Application status: All

Owner:

JobGroup: 00004608

Date: YYYY-mm-dd

JobID:

☑ Select All ☐ Select None

Logging info for JobID: 1894742

Source	Status	MinorStatus	App	
JobManager	Received	Job accepted	Unl	
JobPath	Received	False	Unl	
JobSanity	Checking	JobSanity	Unl	
JobScheduling	Checking	JobScheduling	Unl	
TaskQueue	Waiting	Pilot Agent Submissic	Unl	
Matcher	Matched	Assigned	Unl	
JobAgent	Matched	Job Received by Age	Unl	
JobAgent	Matched	Installing Software	Unl	
JobAgent	Matched	Submitted To CE	Unl	
JobWrapper	Running	Downloading InputSa	Unl	
JobWrapper	Running	Application	Unl	
Job_1894742	Running	Application	Exe	
Job_1894742	Running	Application	Gauss v35r1 step 1	Sun Mar 15 2009 22:(
Job_1894742	Running	Application	Gauss v35r1 Success	Mon Mar 16 2009 01:

	JobId		Status	MinorStatus				
☐	1894743	🟩	Completed	Pending Requests				
							4608_000285	2009-03-16 03:00
							4608_000285	2009-03-16 10:31
☐	1894723	🟩	Completed	Pending Requests	Job Finished Succe	LCG.Glasgow.uk	00004608_000285	2009-03-16 01:56
☐	1894722	🟩	Completed	Pending Requests	Job Finished Succe	LCG.Durham.uk	00004608_000285	2009-03-16 01:27
☐	1894721	🟩	Completed	Pending Requests	Job Finished Succe	LCG.Glasgow.uk	00004608_000285	2009-03-16 01:53
☐	1894670	🟩	Completed	Pending Requests	Job Finished Succe	LCG.Glasgow.uk	00004608_000285	2009-03-16 01:33
☐	1894669	🟩	Completed	Pending Requests	Job Finished Succe	LCG.CSCS.ch	00004608_000285	2009-03-16 02:50
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☐	1894661	🟩	Completed	Pending Requests	Job Finished Succe	LCG.RAL-HEP.uk	00004608_000285	2009-03-16 02:56
☐	1894660	🟩	Completed	Pending Requests	Job Finished Succe	LCG.CSCS.ch	00004608_000285	2009-03-16 02:50

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LHCb Configuration
- DIRAC
- Systems
  - Configuration
  - WorkloadManagement
  - RequestManagement
  - DataManagement
  - ProductionManagement
  - Logging
  - Monitoring
  - Accounting
  - Bookkeeping
  - Framework
  - LHCb
  - Stager
- Resources
- Operations
- Website
- Security
  - DefaultGroup = lhcb_user
  - DefaultProxyLifeTime = 432000
  - Users
  - Groups
  - Hosts
  - VOMSMapping

009-03-15 18:12 paterson

009-03-15 18:12 paterson

y GridResourceBroker for last week

LCG.CERN.ch

Site Info

Status: Allowed
Location: 6.0458° E, 46.2325° N
Category: T0

Pilots by GridResourceBroker
169 Hours from 2009-03-09 to 2009-03-16 UTC

Summary

- DIRAC has most of the features of a "standard" Grid middleware stack

- Occasional users will not see much difference in functionality compared to other middlewares
  - E.g. gLite middleware, Ganga frontend
  - Better efficiency and turnaround for intensive work

- Power users will see extra support:
  - Massive job execution
  - Data operations

- Community administrators get tools to apply community policies
  - User and group priorities, quotas

- Site administrators can easily include their resources
  - Easy addition of new resources without bulky installation
  - Easy user management with only one "VO user"

- The DIRAC project is in full development
  - More new exciting features to come – stay tuned !
  - Your contributions are welcome
  - Quick bug fixes and feature request implementation

DIRAC Tutorial plan

- Getting Started
  - Getting ready the DIRAC software
  - Getting ready user credentials
- Job execution mechanics
  - Basic job operations explained
- Job manipulation tools
  - Submission, monitoring, getting results
- Data management tools
  - Upload, download, replication, access in the jobs
  - Metadata management
- Web Portal tools
  - Other info available on the Web Portal

DIRAC Tutorial setup

- DIRAC installation at dirac.in2p3.fr
  - Running in a virtual machine at CC
  - Started as installation for the VO "formation"
  - Intended to be a permanent service for the users of the NGI EGEE/France
    - Now only VO "formation" fully supported
    - Multiple VO support is coming

- Resources
  - gLite Sites and SEs available to the VO "formation"
  - One DIRAC SE (DIRAC-USER)

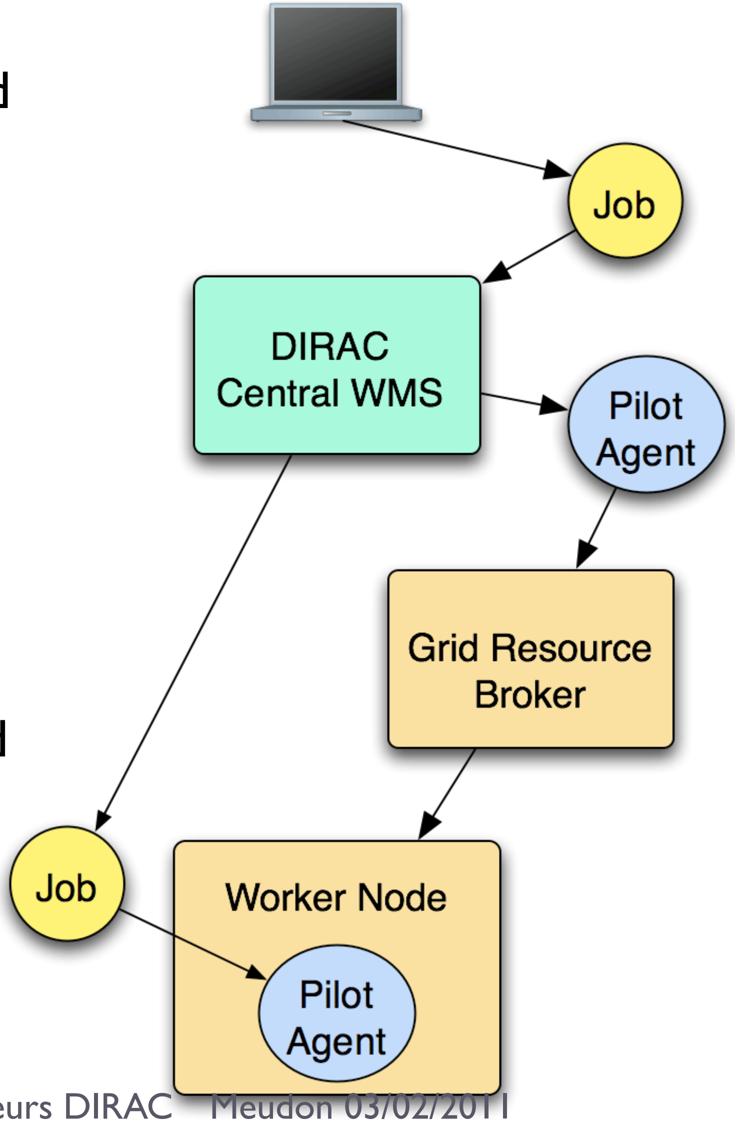
Backup slides

DIRAC is not …

- DIRAC is not a yet another Grid Web Portal
- DIRAC is not a yet another Meta Scheduler
- DIRAC is not a yet another job submission frontend
- DIRAC is not a yet another Application Server
- DIRAC is all of the above but also much more

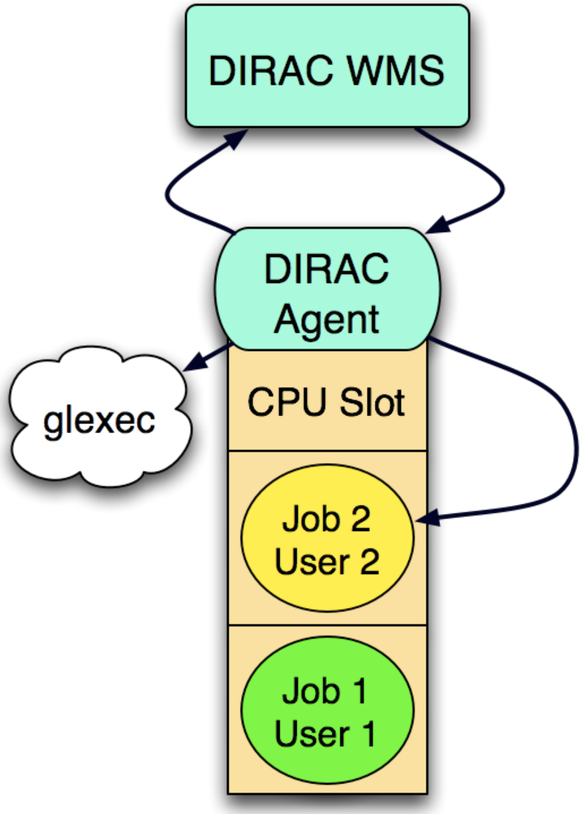
Pilot Jobs in a nutshell

- Pilot agents are deployed on the Worker Nodes as regular jobs using the standard grid scheduling mechanism
  - Form a distributed Workload Management system
  - Reserve the resource for immediate use
- Once started on the WN, the pilot agent performs some checks of the environment
  - Measures the CPU benchmark, disk and memory space
  - Installs the application software
- If the WN is OK the user job is ***pulled*** from the central DIRAC Task Queue and executed
  - Terminate gracefully if no work is available



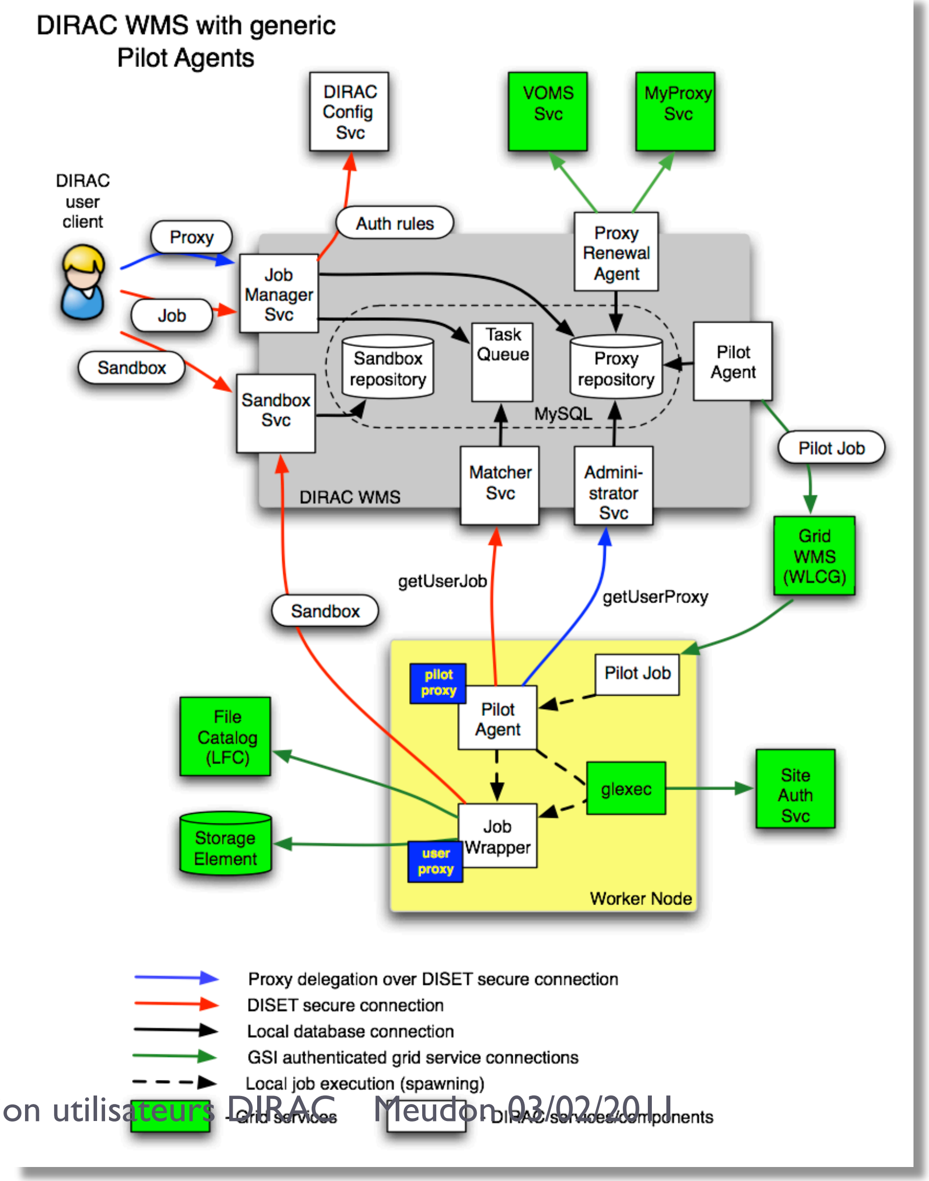
Workload optimization

- Pilot Agents work in an optimized 'Filling Mode'
  - Multiple jobs can run in the same CPU slot
  - Significant performance gains for short, high priority tasks
  - Also reduces load on LCG since fewer pilots are submitted
  - Needs reliable tools to estimate remaining time in the queue
- Considering also agents in a "preemption" mode
  - Low priority task can be preempted by a high priority tasks
    - Low priority, e.g. MC, jobs behave as resource reservation for analysis jobs



Security issues of the model

- The VO WMS must be as secure as the basic grid middleware
  - User job submissions using grid security standards: GSI
  - Secure proxy storage in the WMS repository
- The VO WMS takes over the user proxy renewal
  - Limited user proxy
  - Limited number of proxy retrievals per pilot
- Sites still retain the full right to control which individuals are accessing their resources
  - SCAS/glexec facility to authorize user workload execution on the worker node

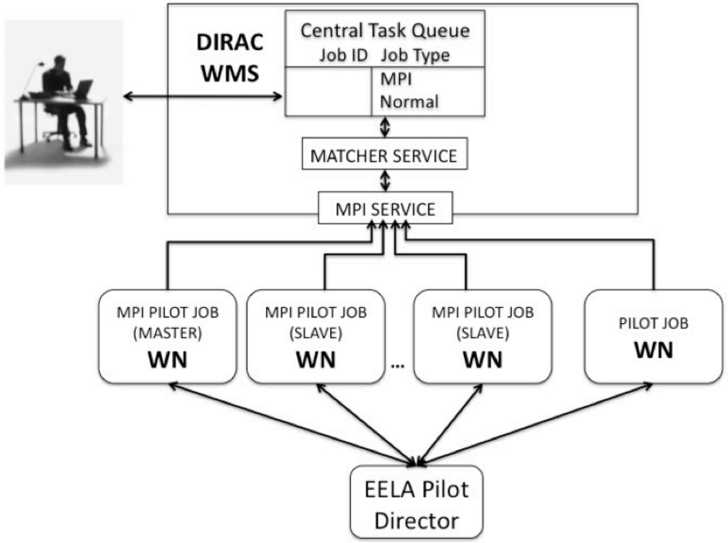


Advantages for site resources providers

- No need for a variety of local batch queues per VO
  - One long queue per VO would be sufficient
  - 24-48 hours queue is a reasonable compromise
    - Site maintenance requirements
  - Reduced number of grid jobs
- No need for specific VO configuration and accounting on sites
  - Priorities for various VO groups, activities
  - User level accounting is optional
- In the whole it can lower the site entry threshold
  - Especially useful for newcomer sites

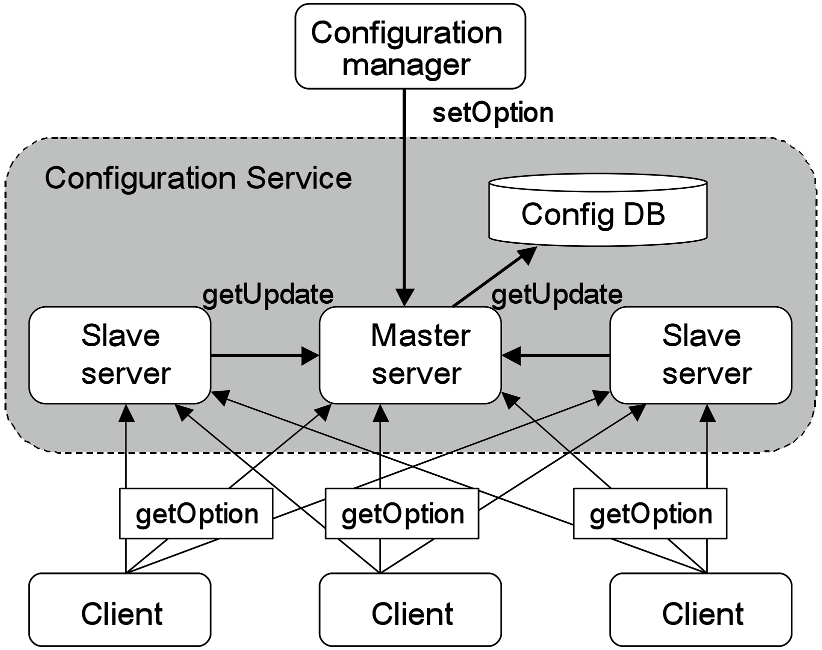
Support for MPI Jobs

- MPI Service developed for applications in the EELA Grid
  - Astrophysics, BioMed, Seismology applications
  - No special MPI support on sites
    - MPI software installed by Pilot Jobs
  - MPI ring usage optimization
    - Ring reuse for multiple jobs
      - □ Lower load on the gLite WMS
    - Variable ring sizes for different jobs



Configuration Service

- This is the back bone of the whole system
  - Provides service discovery and setup parameters for all the DIRAC components
- Multiply redundant for high availability
- Contains only static information
  - Unlike R-GMA or BDII


Configuration manager
setOption
Configuration Service
Config DB
getUpdate
getUpdate
Slave server
Master server
Slave server
getOption
getOption
getOption
Client
Client
Client