



- aggregates and masks the heterogeneity of computing and storage systems;
- provides consistent workload and data management tools;
- provides means to coordinate the activity of the community;
- improves the reliability of available resources by adding redundancy and failover mechanisms.

The DIRAC architecture consists of numerous cooperating Distributed Services and Light Agents all built using the same DISET framework. This allows to create secure and efficient systems tailored for the needs of a particular user community. The recently introduced new component type - *Executors* – increases considerably the reactivity of the system by triggering Executor operations with messages sent by a common Dispatcher service. The proprietary client/service DISET protocol was augmented by the message passing capability needed by the Executors framework.

The diagram illustrates the DIRAC architecture. At the top, a yellow box contains the text "DIRAC Services, Agents, Executors". Below this, a central grey double-headed arrow labeled "DISET" connects two light blue boxes: "CLI / GUI" on the left and "Web site" on the right. At the bottom, a light green box labeled "Base services" contains three green boxes: "Monitoring System", "Configuration System", and "Logging System".

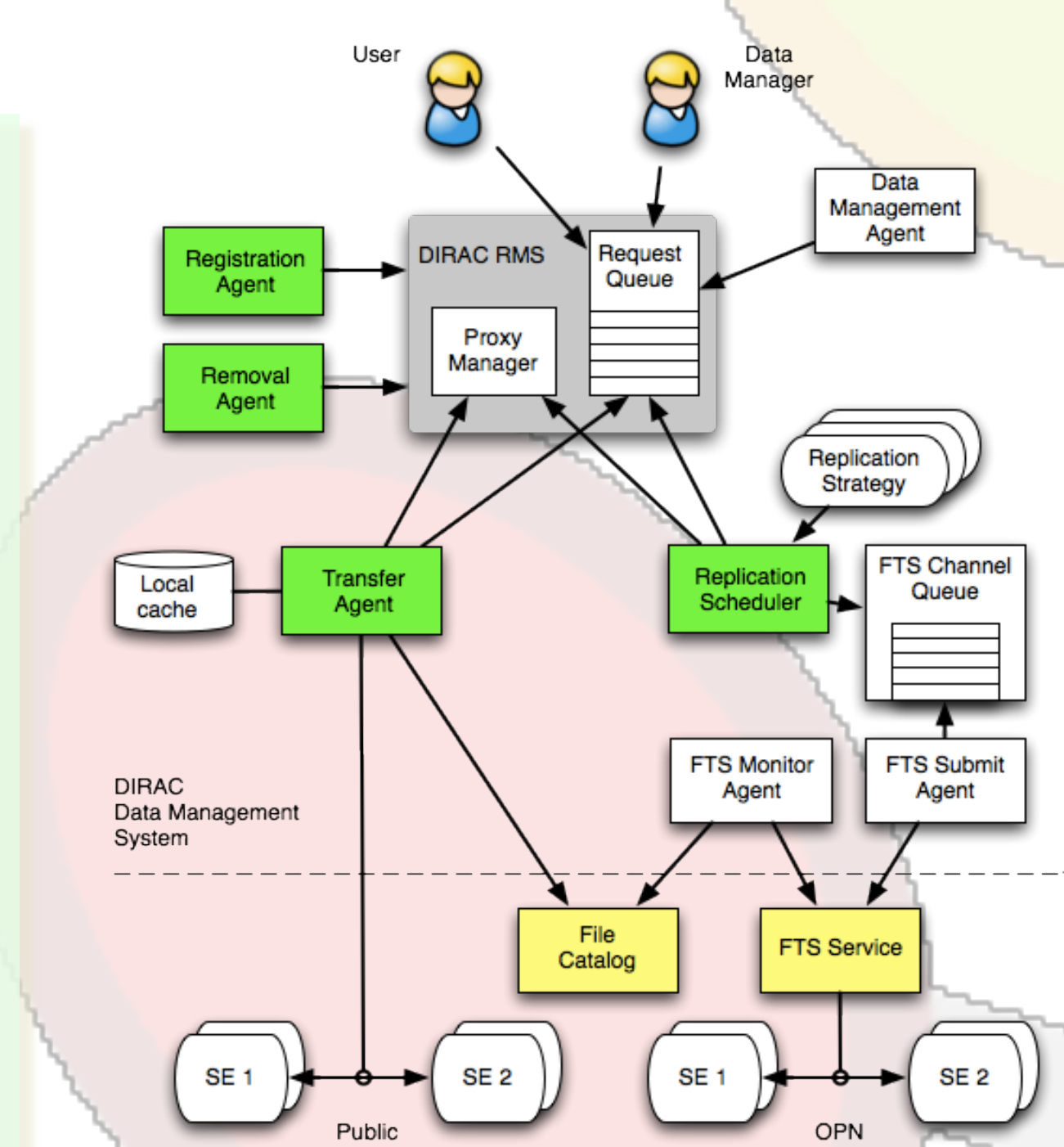


The pilot paradigm was successfully applied also to handle MPI jobs by dynamic creation of virtual clusters (MPI rings) reusable for multiple jobs. No special MPI support is required from sites which increases the amount of resources for parallel jobs.

The diagram illustrates the DIRAC WMS architecture. At the top, the DIRAC WMS box contains a Task Queue, a Proxy Manager, and a Pilot Director. The Task Queue sends tasks to the Pilot Director. The Proxy Manager sends proxies to the Pilot Director. The Pilot Director sends a Pilot + Proxy bundle to the Gateway at the Site. The Gateway, labeled with the user <dirac>, connects to the Batch System, which then executes the tasks on the Site's resources.

DIRAC gives access to various types of Storages and File Catalogs. The recently developed DIRAC File Catalog combines the Replica and Metadata capabilities, it is designed to be especially efficient for bulk queries.

DIRAC allows also automated data distribution using configurable policies. Data Transfers are reliable at all stages of the processing due to multiple failover and retry mechanisms. Multiple data consistency checks ensure integrity and help recovering from data losses.



DIRAC provides access to various types of Computing and Storage resources. The Storage solutions include SRM based SEs, DIRAC native SEs, File servers accessed by HTTP, BBFTP and other protocols. Along with standard grid Computing Elements, Clusters with various batch systems, DIRAC includes also support for Clouds providing an intelligent Virtual Machine Scheduler.

The newly introduced framework for Resource Status monitoring allows to automate maintenance of the resource information for all the DIRAC subsystems.

See [144] by M.Ubeda, F.Stagni

DIRAC is providing multiple interfaces – command line tools, specialized shells, Python API. However, the main emphasis is made on a versatile Web Interface. Nearly all the user operations are possible with the DIRAC Web Portal including certificate proxy uploads, File Catalog browsing, data transfers as well as all the job management operations.

Specialized application portals are now gaining more and more interest and can indeed considerably help non-expert users to get access to the grid resources. DIRAC is providing now a RESTful interface suitable for application portals. Integration with some popular portals is demonstrated.

The screenshot shows the LHCb-Production web interface. The 'Production' tab is selected, and a dropdown menu is open, showing options: 'Production monitor', 'Requests manager', and 'Step manager'. The main table displays job details for 'atsareg@lh'. A 'Launchpad' dialog box is open, showing job parameters: JobName: DIRAC_atareg_520418, Executable: /bin/ls, Arguments: -ls, and OutputSandbox: std.out, std.err. The dialog also includes a 'Browse...' button for the input sandbox.

DIRAC is now used by multiple High Energy Physics experiments and projects in other domains – ILC, CLIC, Belle II, BES III, CTA, VIP/biomed, etc. The LHCb Collaboration remains the main DIRAC user for all its Distributed Computing tasks.

LHCb jobs

21 Weeks from Week 52 of 2010 to Week 21 of 2011

pps

2011-01-04 2011-01-01 2011-01-02 2011-01-03 2011-01-04 2011-01-05

Max: 38,109; Min: 1,914; Average: 19,022; Current: 17,411

■ LCG-DRSNA de	9.1%	■ LCG-Kalman pt	3.1%	■ LCG-Liverpool us	2.5%
■ LCG-CPERNA fr	8.2%	■ LCG-LAL-IMPAC	3.1%	■ LCG-SAMBA pt	1.5%
■ LCG-CPERNA pt	6.2%	■ LCG-LAL-2C-HEP.us	2.9%	■ LCG-Manchester uk	1.3%
■ LCG-Manchester uk	4.2%	■ LCG-Guangzhou cn	2.6%	■ LCG-CERN.ch	1.3%
■ LCG-CMAF fr	4.0%	■ LCG-Guangzhou us	2.6%	■ LCG-PHRI ru	1.2%
■ LCG-BAL uk	3.6%	■ LCG-ORNL-UNA us	2.1%	■ LCG-CPERNA pt	1.2%
■ LCG-Pisa it	3.6%	■ LCG-TCH us	1.8%	■ LCG-CERN.ch	1.2%
■ LCG-ANP-P2.T2 fr	3.5%	■ LCG-CMAF T2 fr	1.7%	■ LCG-UK-LT2-OMU.uk	1.2%
■ LCG-Pisa it	3.4%	■ LCG-TCH us	1.7%	plus 7 more	

DIRAC middleware is providing a complete grid functionality and is rather complex to install and manage, especially for small user communities with low grid expertise level. Therefore, several grid projects are providing now the DIRAC functionality as a service for their users: GISELA Latin America Grid, France-Grilles and IberGrid National Grid Initiatives. Other grid infrastructure projects are considering provisioning DIRAC services



DIRAC has a very active and growing user and developer communities. Its development environment is based on the Git code management system and constructed around the GitHub service (<https://github.com/DIRACGrid>). The user and developer forums are maintained with the *Google Groups* facility. The project web site at <http://diracgrid.org> contains references to all the relevant information about the DIRAC software and services usage.

Based on a solid and proven by many years of successful operation middleware, the DIRAC Project is still rapidly developing to follow all the innovations in the distributed computing technologies and to provide its users with rich and easy to use tools for their applications.

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<http://diracgrid.org>

