Fabric Management in EU DataGrid: An Overview

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Outline

- Fabric Management in EDG
- Deployment
- Issues and Lessons learned
EU DataGrid project

- Project started 1/2001 and ended 3/2004
- 6 principal contractors
  - CERN (Switzerland)
  - CNRS (France)
  - ESA-ESRIN (Italy)
  - INFN (Italy)
  - NIKHEF (Netherlands)
  - PPARC (UK)
- 15 assistant contractors
- ~150 FTE
- http://www.eu-datagrid.org
- 12 workpackages
Work Packages in EDG

EDG WPs
- WP1: Workload Management
- WP2: Grid Data Management
- WP3: Grid Monitoring Services
- WP4: Fabric Management
- WP5: Mass Storage Management
- WP6: Integration Testbed – Production quality International Infrastructure
- WP7: Network Services
- WP8: High-Energy Physics Applications
- WP9: Earth Observation Science Applications
- WP10: Biology Science Applications
- WP11: Information Dissemination and Exploitation
- WP12: Project Management
WP4 objective and partners

“To deliver a computing fabric comprised of all the necessary tools to manage a center providing grid services on clusters of thousands of nodes.”

- User job management (Grid and local)
- Automated management of large clusters

- 6 partners: CERN, NIKHEF, ZIB, KIP, PPARC, INFN.
- ~14 FTEs over 3 years = 42 man/years (18 funded by the EU).
- The development work divided into 6 subtasks:
Functionality requirements

- Provision for running Grid and local jobs
  - Authorization according to local policies
  - Mapping Grid credential to local ones
  - Publication of fabric resources and job information
  - Sharing of resources amongst local and Grid users according to local policies

- Enterprise system administration - scalable to O(10K) nodes
  - Automated installation and maintenance of nodes
  - Resource management (batch, interactive)
  - Monitoring of events and performance
  - Fault tolerance & recovery actions
  - Fabric Configuration Management
DataGrid Architecture

- **Local Computing**
  - Local Application
  - Local Database

- **Grid Application Layer**
  - Job Management
  - Data Management
  - Metadata Management
  - Object to File Mapping

- **Collective Services**
  - Information & Monitoring
  - Replica Manager
  - Grid Scheduler

- **Underlying Grid Services**
  - SQL Database Services
  - Computing Element Services
  - Storage Element Services
  - Replica Catalog
  - Authorization Authentication and Accounting
  - Service Index

- **Fabric services**
  - Resource Management
  - Configuration Management
  - Monitoring and Fault Tolerance
  - Node Installation & Management
  - Fabric Storage Management

- **WP4 tasks**
Fabric Management

Grid Users

FABRIC

Fabric Gridification

Resource Management

Installation Configuration Management

Fabric Fault Tolerance

Fabric Monitoring
User job management

- Secure job submission and job control
- Local authorization and mapping of grid credentials
- Scheduling and execution of user (grid or local) jobs and their coordination with maintenance tasks
- Information Providers for Grid Information Services (MDS,R-GMA)
Fabric Management

- Fabric wide CDB provides central storage and management of all fabric configuration information
- Subsystems running on the nodes take care of managing software packages and configuring local services

Grid Users
- Framework for automatic fault detection and correction
- Correlation Engines regularly check the monitoring data (locally or centrally)
- If data is not between defined limits, they trigger alarms or recovery actions

Automated management of large clusters

LCFGng
Fabric Management

Grid Users

FABRIC

LCAS
LCMAPS

Local Users

RMS

LCFGng
quattor

Fault Tolerance Framework

LCAS
LCMAPS
Grid and local job management status

- **Gridification (LCAS/LCMAPS):**
  - Deployed on all EDG / LCG testbeds.
  - Adopted by other projects like EU CrossGrid
  - Will be further developed within EGEE, collaborating with GGF. Eg. XACML support, GridFTP support
  - Maintained by NIKHEF (Netherlands)

- **Resource Management System (RMS):**
  - More focus on R&D than production
  - Evolution for data aware scheduling in clusters
  - Adopt to Globus Toolkit 3, OGSA/WSRF
  - Maintained by ZIB Berlin (Germany)

- **CE Information Providers:**
  - Critical and very (too?) sensitive part of EDG architecture.
  - Specifications by GLUE WG not fine-grained enough, even after much coordination work
  - Overall load distribution concept being revised by EGEE
Automated cluster management status

♦ Quattor:
  - Production deployment at CERN
  - Other sites (LAL/IN2P3, NIKHEF, RAL) and projects (EGEE) evaluating/adopting it.
  - Ongoing community-driven effort for providing complete LCG-2 port
  - Maintained by CERN
  - (See talk 24/7/04)

♦ Lemon:
  - Production deployment at CERN
  - Interfacing with grid-wide monitoring solutions eg. GridICE
  - Maintained by CERN
  - (See talk 24/7/04)

♦ Fault Tolerance:
  - Implementation issues hindered a wide deployment
  - Re-engineered, light-weight Framework for global and local correlations and fault recovery has been developed at CERN and is now part of LEMON
LCFG experience

- Testbed installation / configuration solutions where **missing but required** at the beginning of EDG

- LCFGng ([www.lcfg.org](http://www.lcfg.org)): interim solution chosen by WP4 while quattor was being developed
  - Tool modified (and improved) to be adapted to EDG testbed needs
  - Appreciated its plug-in architecture allowing quick instrumentation of Grid middleware components

- Used at almost all EDG testbed sites
  - very valuable feedback from a large group of site administrators
  - Learned a lot from it to understand what sysadmins really want
  - ... but required much support from our side, which was **not planned** for!

- Issues with LCFGng (later addressed in quattor)
  - Weak configuration language (validation, information sharing)
  - Maintains proprietary solutions where standards exist (e.g. base installation, SysV services)
  - Scalability issues – was designed for $O(100)$ nodes.
WP4 release schedule

**2001**
- **EDG 1.0**
  - LCFG
  - CE Info Providers

**2002**
- **EDG 1.4.x**
  - EDG-LCFGng
  - RMS
  - LEMON

**2003**
- **EDG 1.2**
  - LCAS + edg_gatekeeper

**2004**
- **EDG 2.0**
  - LCMAPS, LCAS, VOMS

- Quattor started
- Quattor first released
Next Steps after development

Move from testbeds to production fabrics

- Functionality
  - Performance and scalability

- Risks
  - Destabilisation
  - Workload

- Simplification, Automation
  - Focus on providing a service
  - Process and procedure
  - Availability and reliability
  - Stability and robustness
EDG WP4 addresses an important need for **fabric automation** at CERN required for LHC Computing

- ~ 6000 CPU and ~ 2000 disk servers to be managed with reduced human intervention in 2008
- However, EDG WP4 does not address many others: Mass Storage, Networking, Fabric Infrastructure (Space/Power/Cooling), etc.

CERN selected quattor and lemon to be at the core of its Extremely Large Fabric Management system (ELFms).

- Integrating with existing solutions eg. LSF as batch scheduler, CASTOR for mass storage, site-specific user handling, ...

EDG developers and CERN service managers collaborated closely together during the whole lifetime of EDG

Remaining developments and maintenance of quattor and lemon will continue coordinated by CERN under the scope of ELFms.
In 2003, quattor and lemon replaced the legacy management tools in the CERN computer centre

- Gradual phase-out / phase-in of tools, procedures and techniques
- Required development of site- and service specific plug-ins (monitoring sensors, configuration components) and visualization tools (eg. lemon status display pages)

Clear benefits in terms of uniform, automated and reproducible installations, and accurate performance, inventory and exception indicators

- Examples: 15min LSF rollout on 1100 nodes; rapid security deployments

Developed LCG-2 WorkerNode components for fully integrating LXBATCH into LCG

CERN will support quattor into LHC operation (LCG, EGEE) and help with deployment at other sites....
Production deployment: CERN (III)

- A high-level State and Hardware Management System (called LEAF) has been developed on top of quattor and lemon, thanks to LCG manpower
  - Handles complete lifecycles and workflows of nodes and complete racks, from initial (physical) installation to final decommissioning

- Still work to be done, eg.
  - More Quality of Service metrics
  - Integrating LEMON with the LHC controls Alarm system
  - Intelligent resource administration, eg. automated reallocation of nodes between clusters
Other deployments of EDG WP4

WP4 products have been deployed within the EDG testbed and within other production sites and Grid projects/environments:

- LHC Computing Grid project (LCG)
- EGEE project
- CrossGrid project
- GridIce project
- Virtual laboratory for E-science project
- FlowGrid project
- INFN grid project

- CERN Computing Centre (>2000 nodes)
- Universidad Autonoma de Madrid (Spain)
- University of Liverpool (UK)
- NIKHEF (The Netherlands)
- LAL (Orsay, France)
- ZIB (Berlin, Germany)
- KIP (Heidelberg, Germany)
- Fermilab (U.S.)
- BARC (India)
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- BARC, India

These deployments will ensure the maintenance and evolution of the WP4 framework after the end of the DataGrid project.
Lessons learned (I)

- Fabric Management components are not grid components themselves but they are essential for a working grid.

- Correct configuration is critical in Grids
  - Configuration errors may affect not only a site, but the whole Grid response and stability
  - Requires automated enforcement of configuration changes

- Fabric management components need to be deployed, stabilized and understood by system administrators before the rest of the middleware components
  - This was not taken into account in the original project planning

- Balance between central control and site autonomy is difficult to find
  - Not every site wants to change its management tools! But..
  - Manageability, stability and security of Grid environments require precise and binding policies for all sites

- Experience and feedback with existing tools helped to get requirements and early feedback from users and site administrators

But interim solutions tend to live longer than expected!
Lessons learned (II)

- There is a real need to be able to install, configure and manage the small-medium-big sites (complexity is the same!)

- Sites find it very difficult to change fabric management framework
  - It implies learning a new framework: new procedures, new tools
  - It has to coexist with legacy and site specific tools, services and procedures, hence it has to be modular and with very clean interfaces so they can be incrementally replaced, without affecting service stability
  - The EDG sites were testbeds, where tools and procedures could be imposed. This is not the case for production sites

- Close collaboration with sysadmins required to get feedback and understand their requirements and get feedback
  - In particular, with CERN and LCG service managers
  - EDG did not formally identify this user community!
EDG WP4 has delivered a complete and evolvable fabric management framework.

Experience and feedback with existing tools and prototypes helped to get requirements and early feedback from users.

Deployments at CERN and other production sites show that the framework is accepted.

The growing user community ensures the continued existence of the core developments of WP4 after the end of the DataGrid project.

More information:

- [http://cern.ch/elfms](http://cern.ch/elfms) (ELFms project)