Empowering Grids – the EGEE gLite middleware

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Disclaimer

- This presentation is based on contribution from many gLite developers
- It uses pictures, numbers and sometime even whole slides from many other EGEE related presentations given at different fora
- Even if not explicitly referenced, all these information sources are highly appreciated

- Thanks to the whole JRA1 team

EGEE Projects

- **Pre-history**
  - DataGrid, focused on the initial middleware development (EDG)
  - 3 years, from 2001 to March 2004
- **EGEE**
  - Production oriented, based on middleware development in DataGrid, EDG, LCG and initial gLite middleware
  - 2 years, April 2004 to March 2006
  - 71 partners, 27 countries, operation federated (ROCs)
- **EGEE II**
  - Full scale deployment, the gLite middleware
  - 2 years, April 2006 to March 2008
  - 91 partnes, 32 countries, 13 Federations

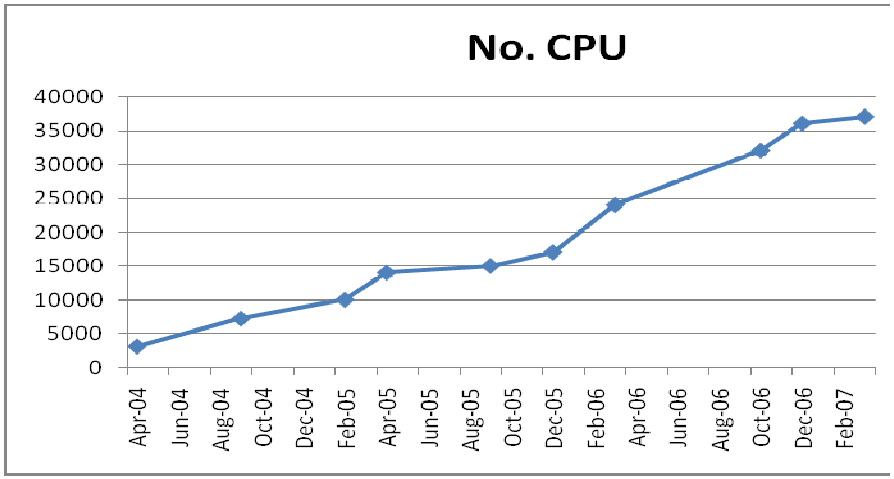
EGEE Future

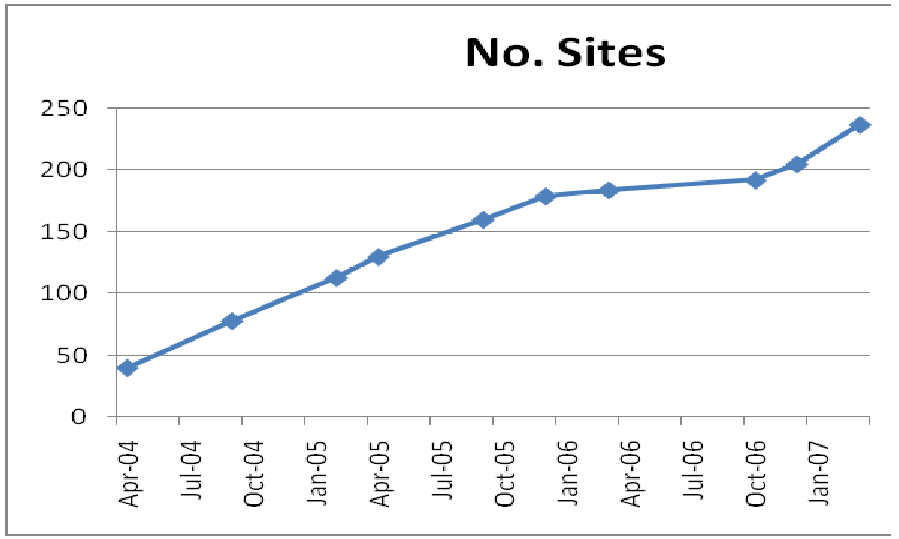
- **EGEE III**
  - Just to be submitted (September 20th)
  - 94 partners, 34 countries,12 federations
  - Real production (LHC deployment in 2008)
  - Strong support for other applications
    - Computational Chemistry
    - Astrophysics
    - Bioinformatics and medicine
    - Earth Sciences
    - *(Grid Observatory)*
  - Continued middleware development and support
- **EGI (European Grid Initiative)**
  - Post EGEE future
  - Design Study project (Started September 1st)

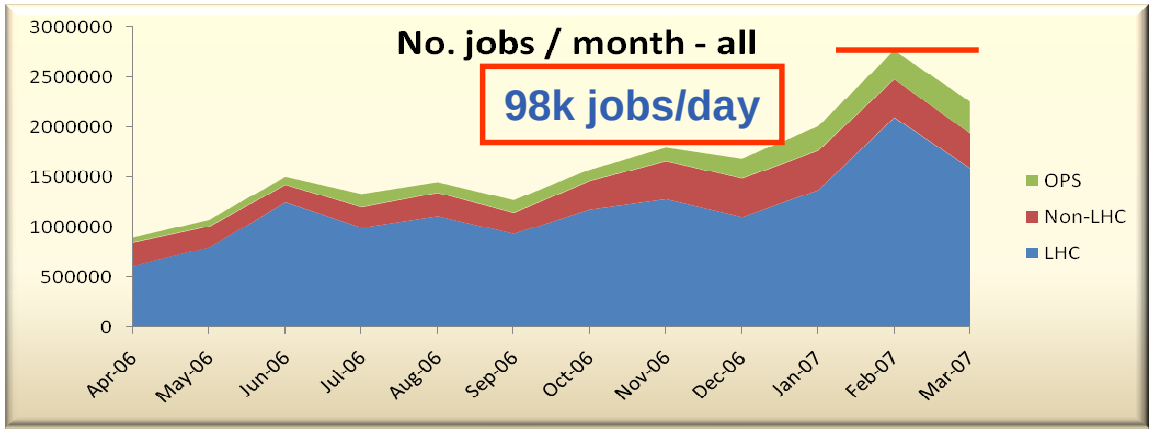
EGEE Mission

- **Large-scale production quality e-infrastructure**
  - HEP the main user
  - But other communities actively looked for and supported
- **High-throughput production environment**
  - Emphasis on large number of CPUs, sites, and independently submitted and run jobs
  - Goals: Tens to hundreds thousands jobs per day on the whole infrastructure
- **Data intensive (data Grid)**
  - Able to process PB of data
  - Data catalogues, access methods, …
  - Low, medium and high security requirements

Scale of EGEE Service







EGEE Middleware

- **Brand name: gLite**
- **Production quality**
  - Novelty less important
  - Must pass the real-use test
- **Testing and Integration**
  - Independent activity
  - Stay between development and operations
- **Foundation Services**
- **Higher Level Grid services**

Middleware – Foundation Services

- **Security infrastructure**
- **Information system, monitoring and accounting**
  - Information schema, simple resource discovery
  - Resource monitoring and notification interfaces
  - Accounting to provide appropriate aggregation and views
- **Compute Element (CE)**
  - Set of services to provide homogeneous secure access to heterogeneous computing resources
- **Storage Element (SE)**
  - Set of services to provide access to storage resources
  - SRM Interface
  - POSIX like I/O

Higher level Grid services

- **Job services**
  - Workload Management System (WMS)
    - Resource brokerage
    - Job Input and Output handling
    - Automatic resubmission and persistence
    - Job tracking – Logging and Bookkeeping service
    - Permanent job information – Job Provenance service
- **Data management services**
  - Reliable asynchronous file transfer system
  - File and replica catalogues
  - Secure data management
  - Data encryption

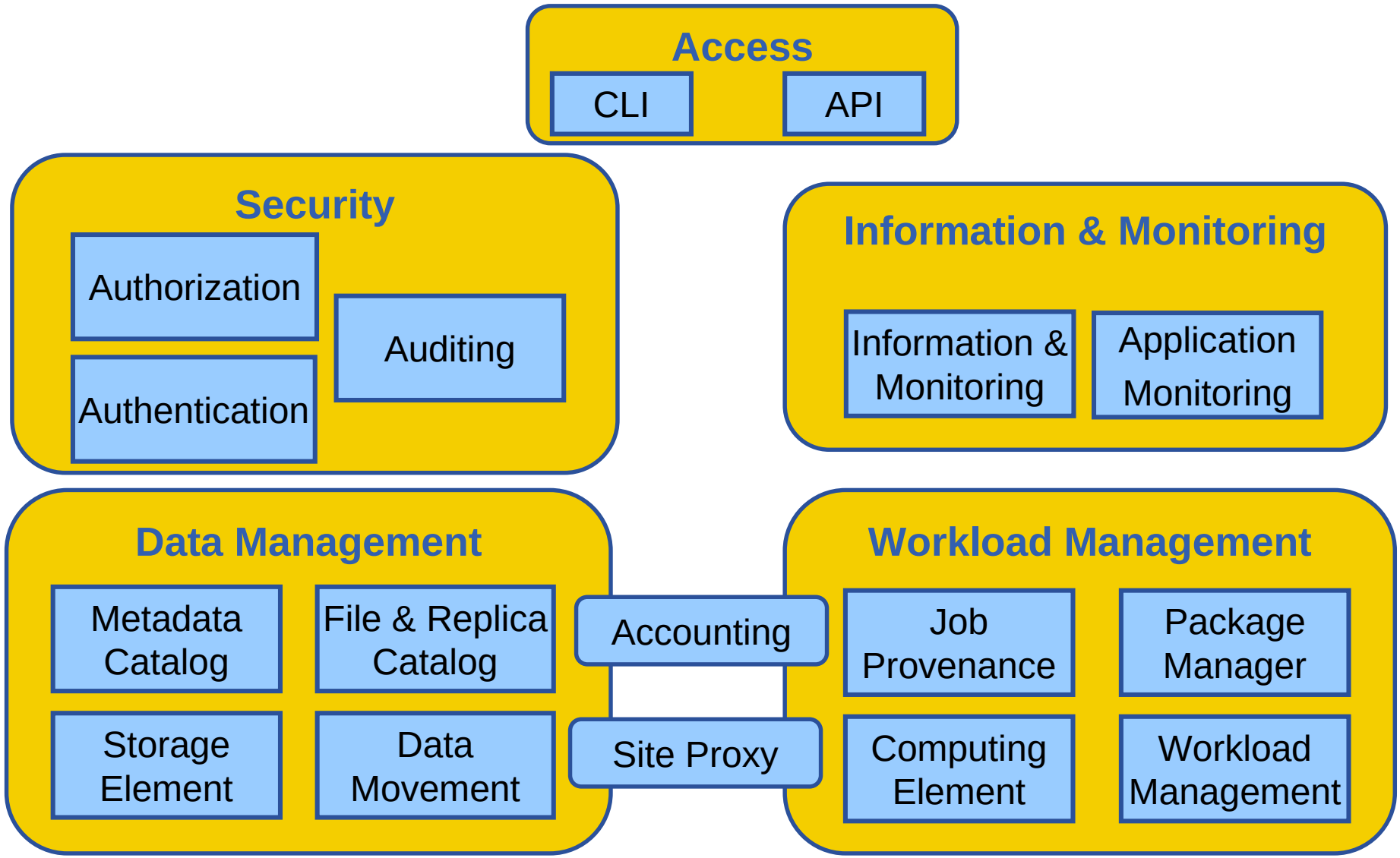
gLite evolution

- **EDG middleware**
  - DataGrid project
  - Maintained by the LHC Computing Grid – LCG middleware
  - LCG releases up to 2.7 (2005)
- **gLite middleware**
  - EGEE projects
  - Overlap with the LCG, but independent up to version 1.5 (2005)
- **gLite middleware 3.0**
  - Merge of gLite 1.5 and LCG 2.7 (2006)
  - Production release in EGEE project
- **gLite 3.1**
  - Increased stability and throughput, released

gLite services

- **Security**
  - Authentication
  - Authorization
  - Accounting
- **Computing Element**
- **Storage Element**
- **Information and Monitoring**
- **Workload Management**
  - Brokerage
  - Logging and Bookkeeping and Job Provenance
- **Data Management**
  - File transfers, Catalogues, Replicas

gLite services – diagram

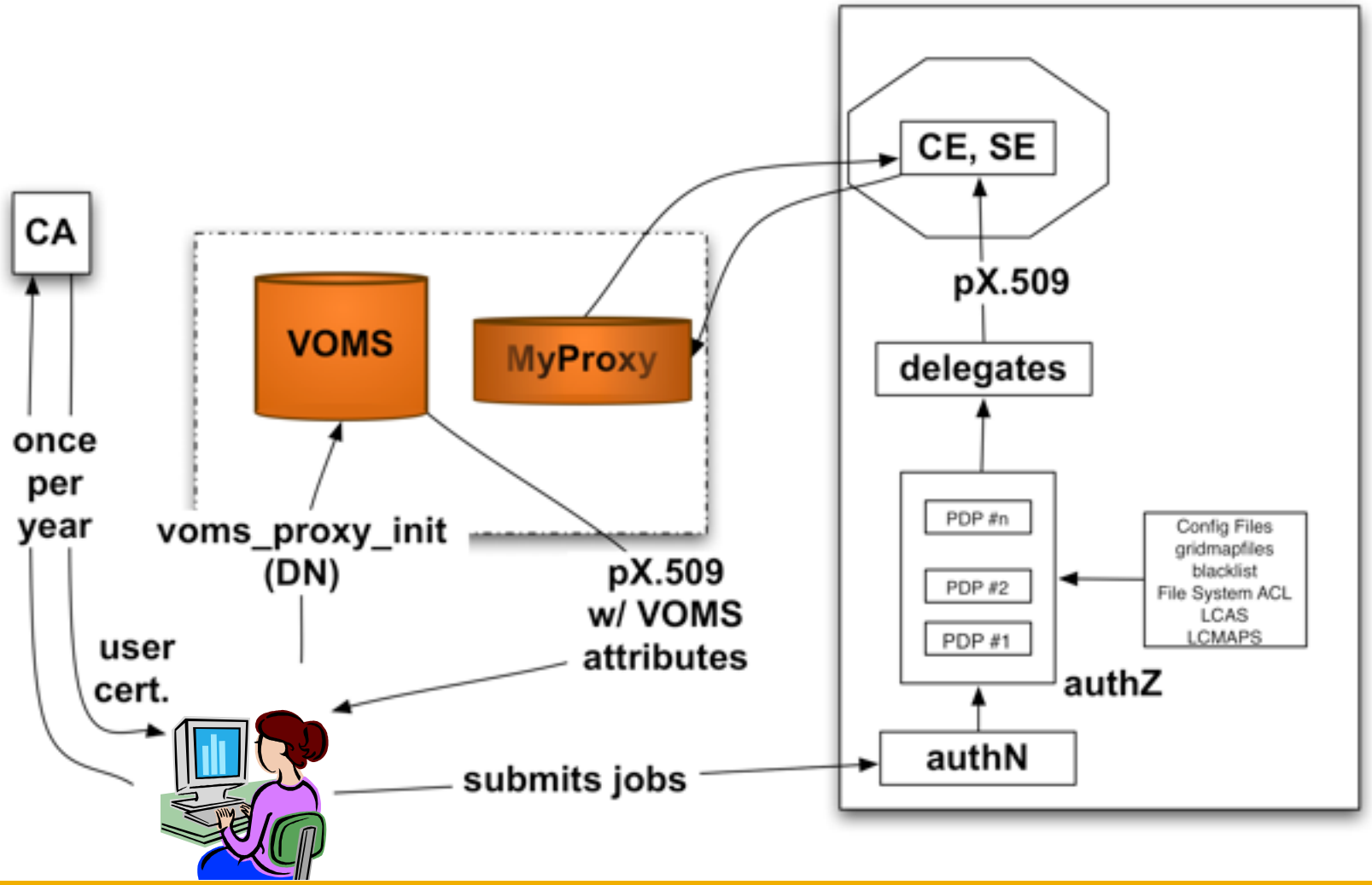


Overview paper http://doc.cern.ch//archive/electronic/egee/tr/egee-tr-2006-001.pdf

Security

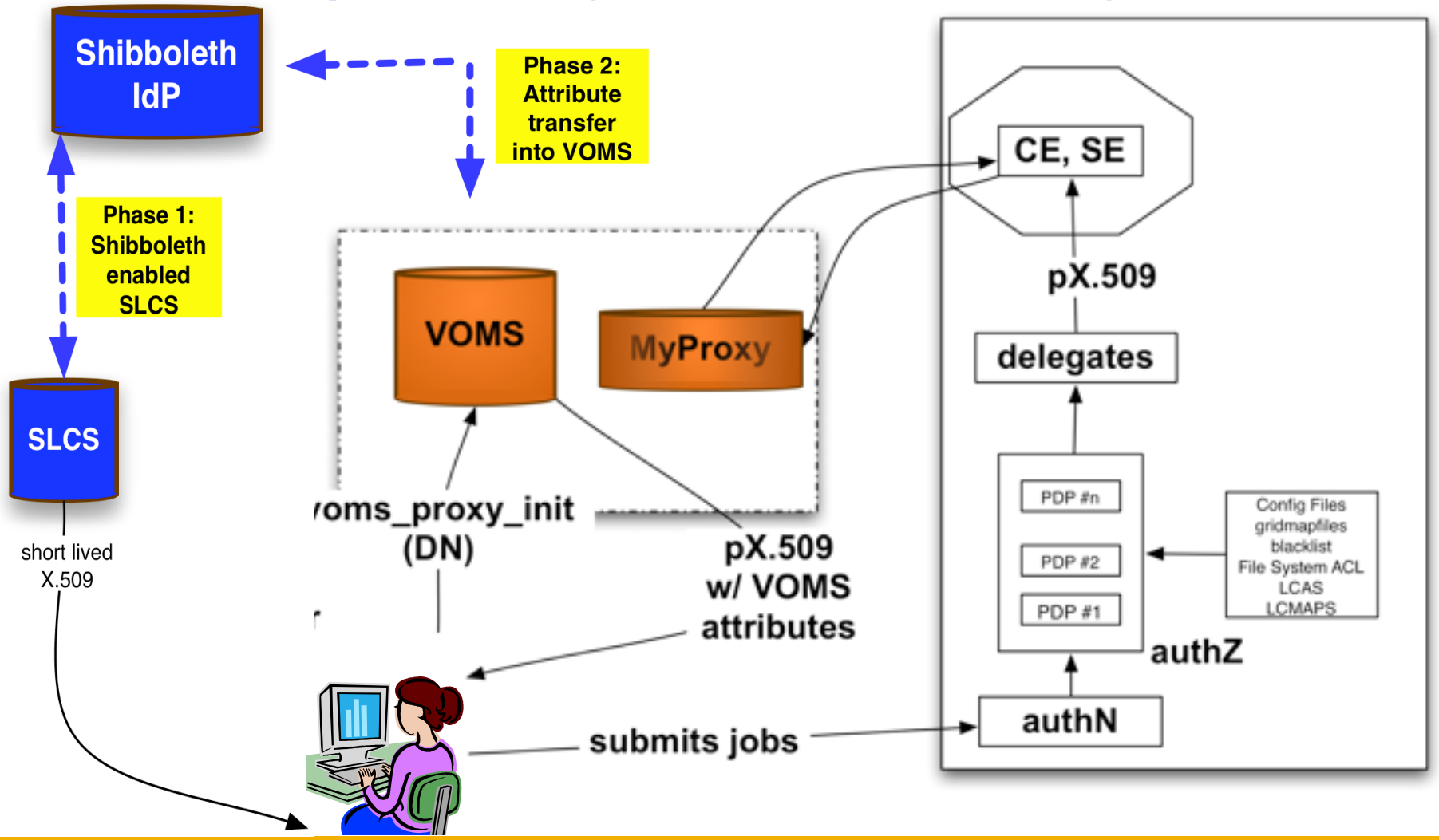
- **Authentication**
  - PKI with X.509 certificates providing single sign-on
  - Maintained list of trusted CA (EUGridPMA, IGTF)
  - Use of short term proxy credentials (lower risk)
    - Proxy delegation, MyProxy,
- **Authorization**
  - Virtual Organizations (VO)
    - User must be member of at least one VO
  - Resources are “assigned” to VOs (negotiation, includes priorities, access policies, etc.)
  - VOMS (VO Management Service)
    - Attribute certificates, capability based authorization
      - *“Attached” to proxy certificate*
    - Authorization information stored in VOMS servers

Security - overview



Coming: Shibboleth SLCS

Long lived certificates may be replaced by short lived certificates provided by a Shibboleth identity Provider



Computing Element

- **Abstraction of a computational resource**
  - Common set of interfaces/services for heterogeneous resources
- **Cluster a typical CE**
  - Head node
  - Several worker nodes (WN)
  - Single (local) batch system to dispatch jobs among WNs
- **Different realizations (interfaces)**
  - LCG-CE
  - gLite-CE
  - CREAM

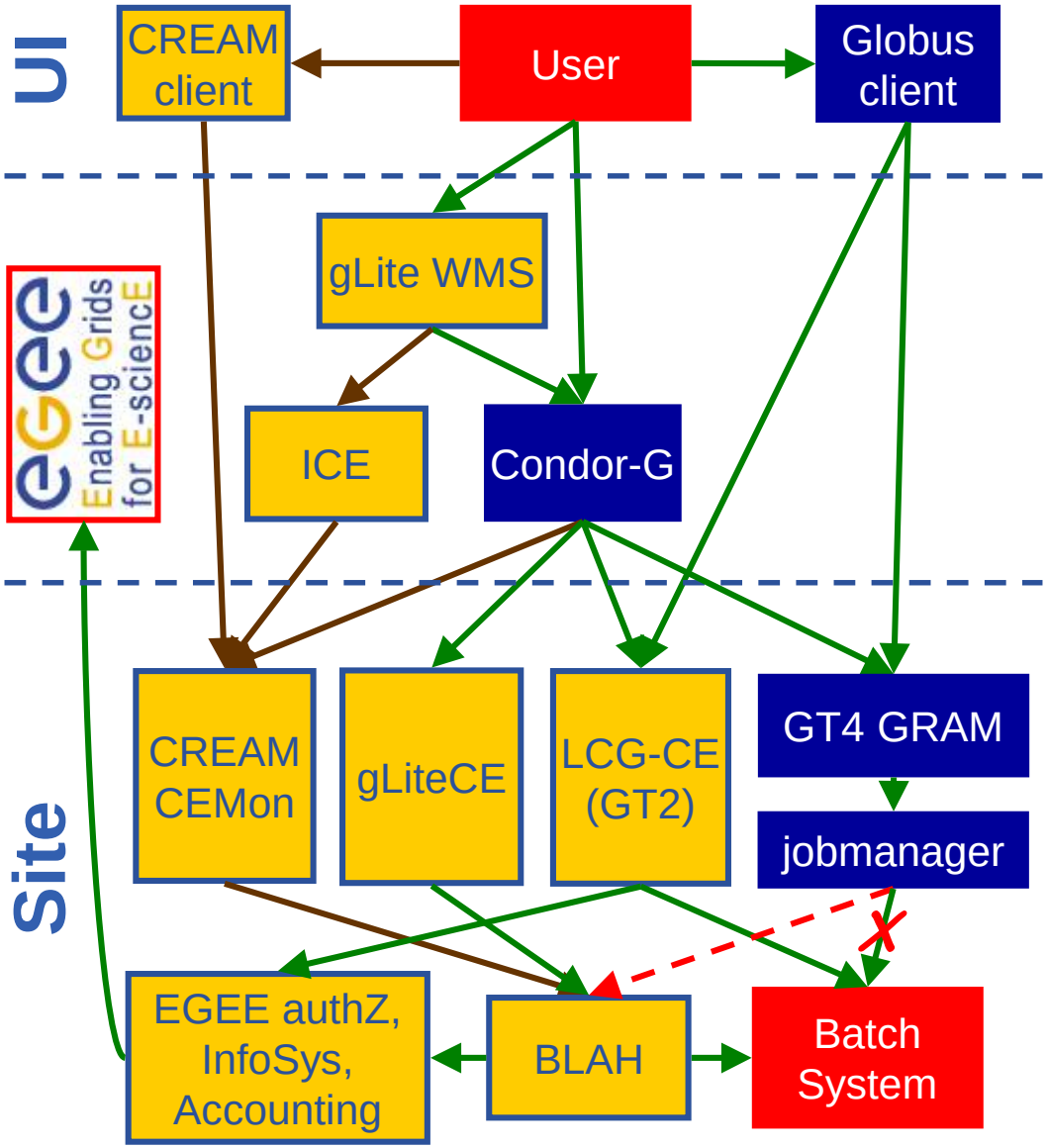
X-CE

- **LCG-CE**
  - Globus Toolkit version 2 GRAM service
  - Never ported to GT4
  - Deprecated
- **gLite-CE**
  - GSI-enabled Condor-C
  - Still needs some tuning
  - Phased out
- **CREAM**
  - WS-I interface (OGF-BES)
  - BLAH (Batch Local Ascii Helper) connector
    - Job management operations
    - Job status changes

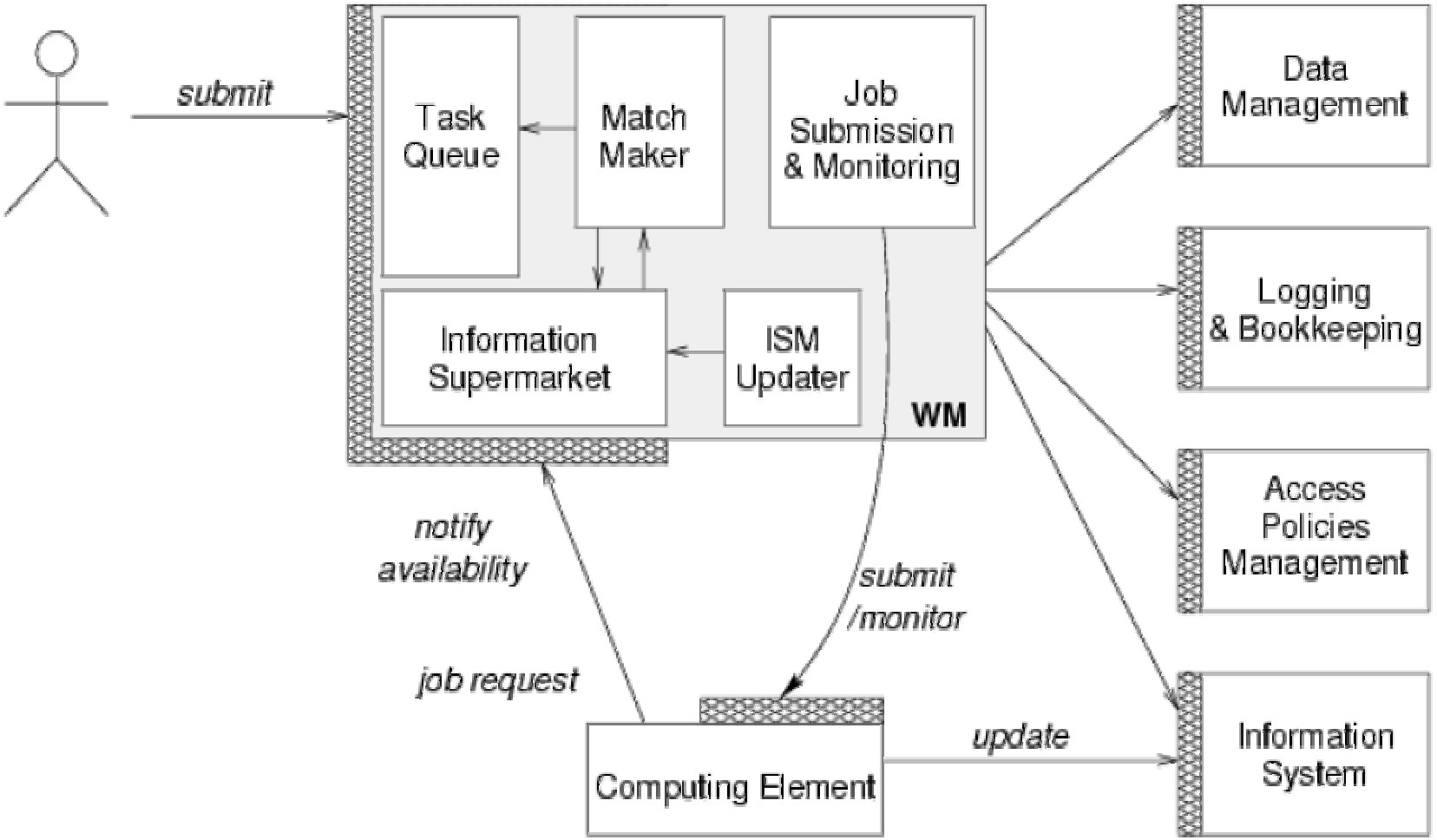
Computing resource access

gLite component | non-gLite component | User / Resource

In production
Existing prototype
Possible development



WMS Components



Workload management system

- **Resource brokering**
  - Matchmaking: user requirements vs. grid state
  - CE selection
- **Workflow management**
  - Compound jobs
- **I/O management**
  - Takes into consideration also data resources

- **Additional features**
  - Persistency
    - Deep and shallow resubmission
    - Recovery from WMS crashes
  - Security
    - Proxy renewal

Supported job types

- **“Normal” (batch like)**
- **DAG workflow**
- **Collection**
- **Parametric**
- **MPI**
- **Interactive**

- **Deprecated**
  - Checkpointable
  - Partitionable

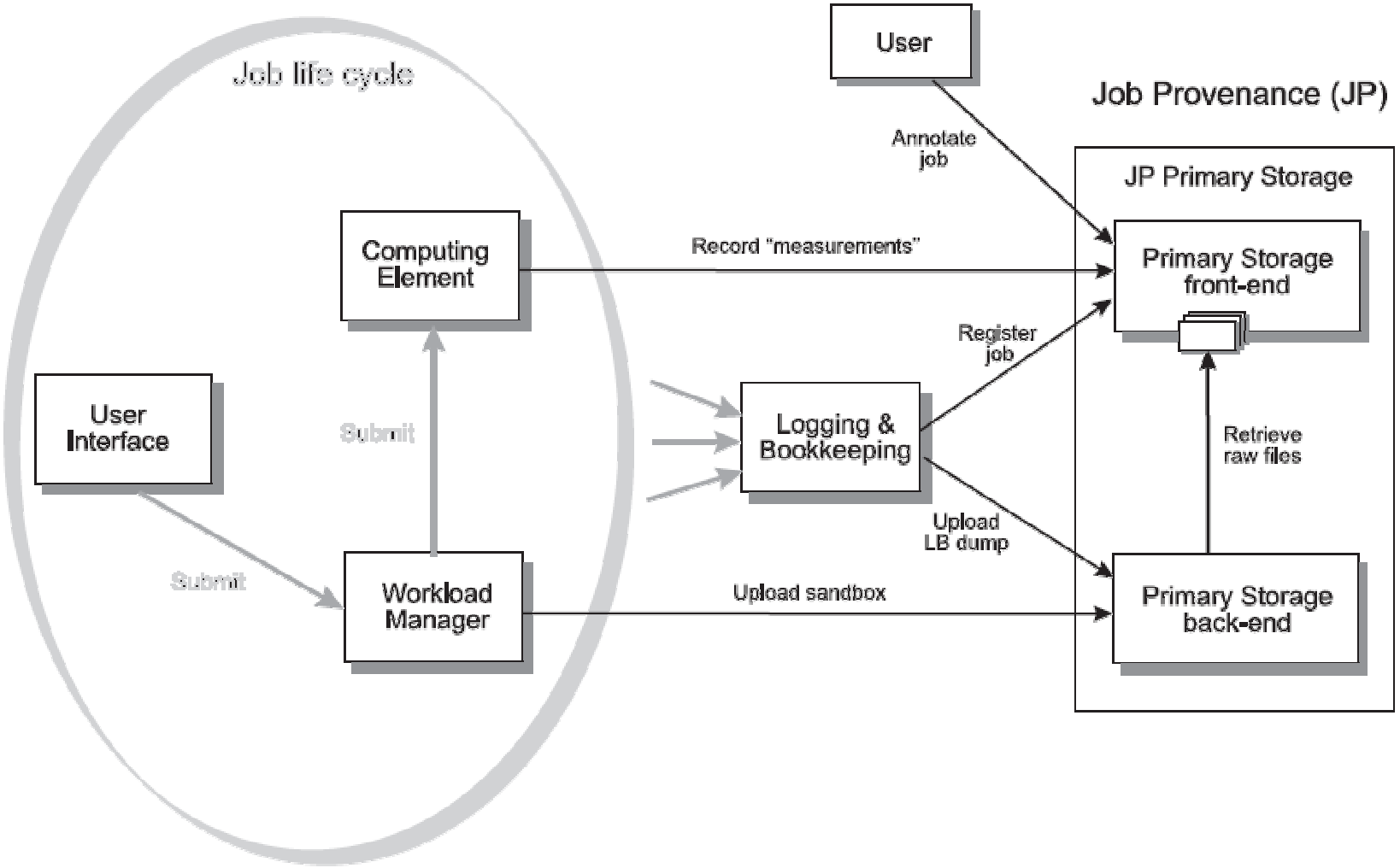
Real time job tracking

- **Logging and Bookkeeping Service**
  - Keep track of Grid jobs across components
    - Reliable and secure collection of events (non-blocking)
    - Multiple event sources (redundancy)
  - Capture job control flow
  - Provide job state information
    - Job state updated on new event arrival
  - Support user generated events
  - Secure
    - Mutual authentication of all components
    - Encrypted data transmission
    - VOMS based authorization
  - All data collected on LB server
    - Multiple instances (one job – one LB server)

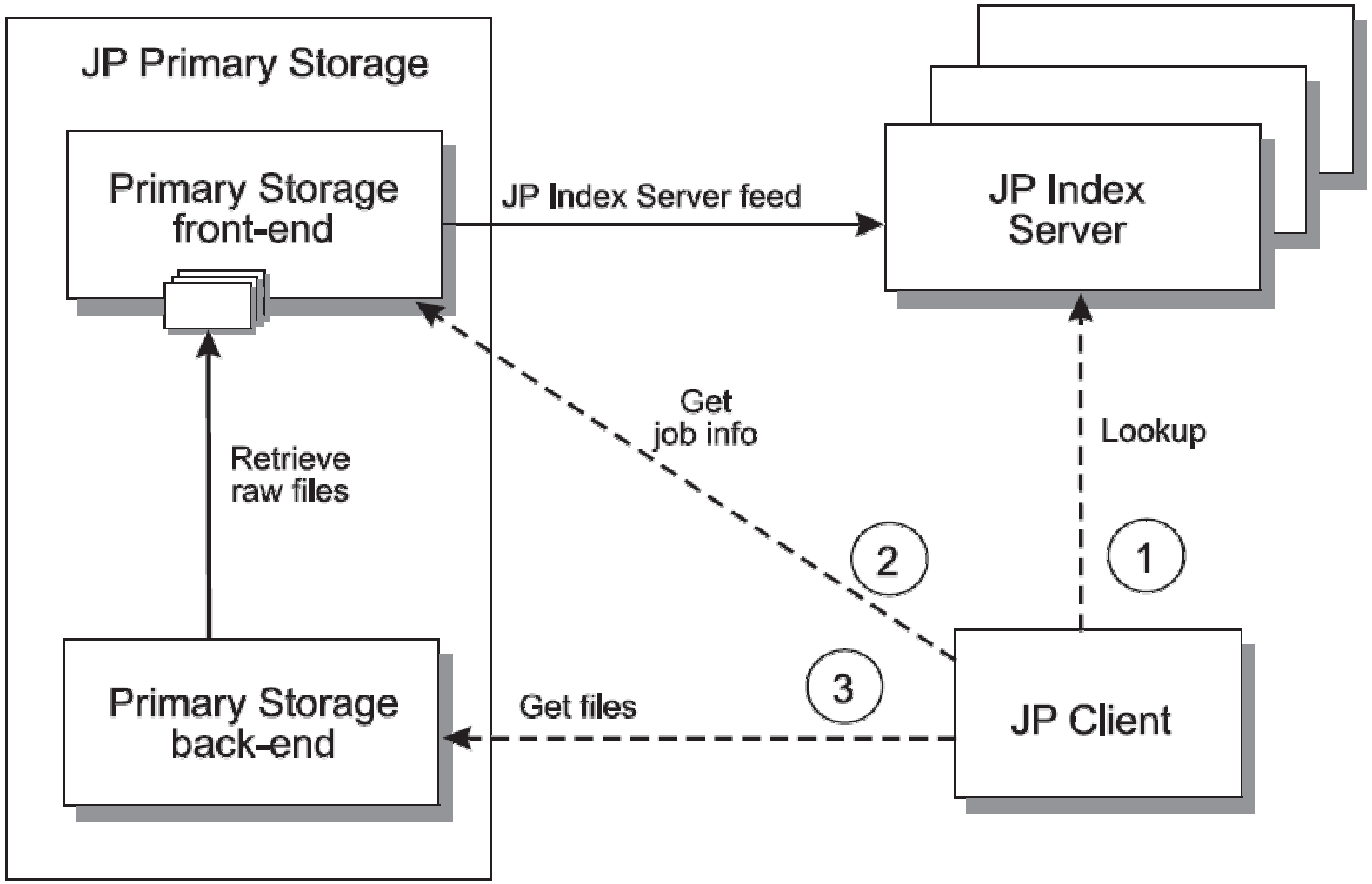
Job Provenance

- **Long term preservation of information about Grid jobs**
  - Information on job control flow and execution environment complements actual job results
  - Based on data from LB, extended by input and sandbox, small output files, additional user annotations
- **Architecture optimized for storage AND retrieval**
  - JP Primary Server
    - One for several VO
    - Huge amount of raw data
    - Fast write
  - JP Index Servers
    - Many instances per JP PS (registration, support for >1 PS)
    - Provide “views” on data
  - Support for data-mining
- **Assist job re-submission**

Job tracking architecture



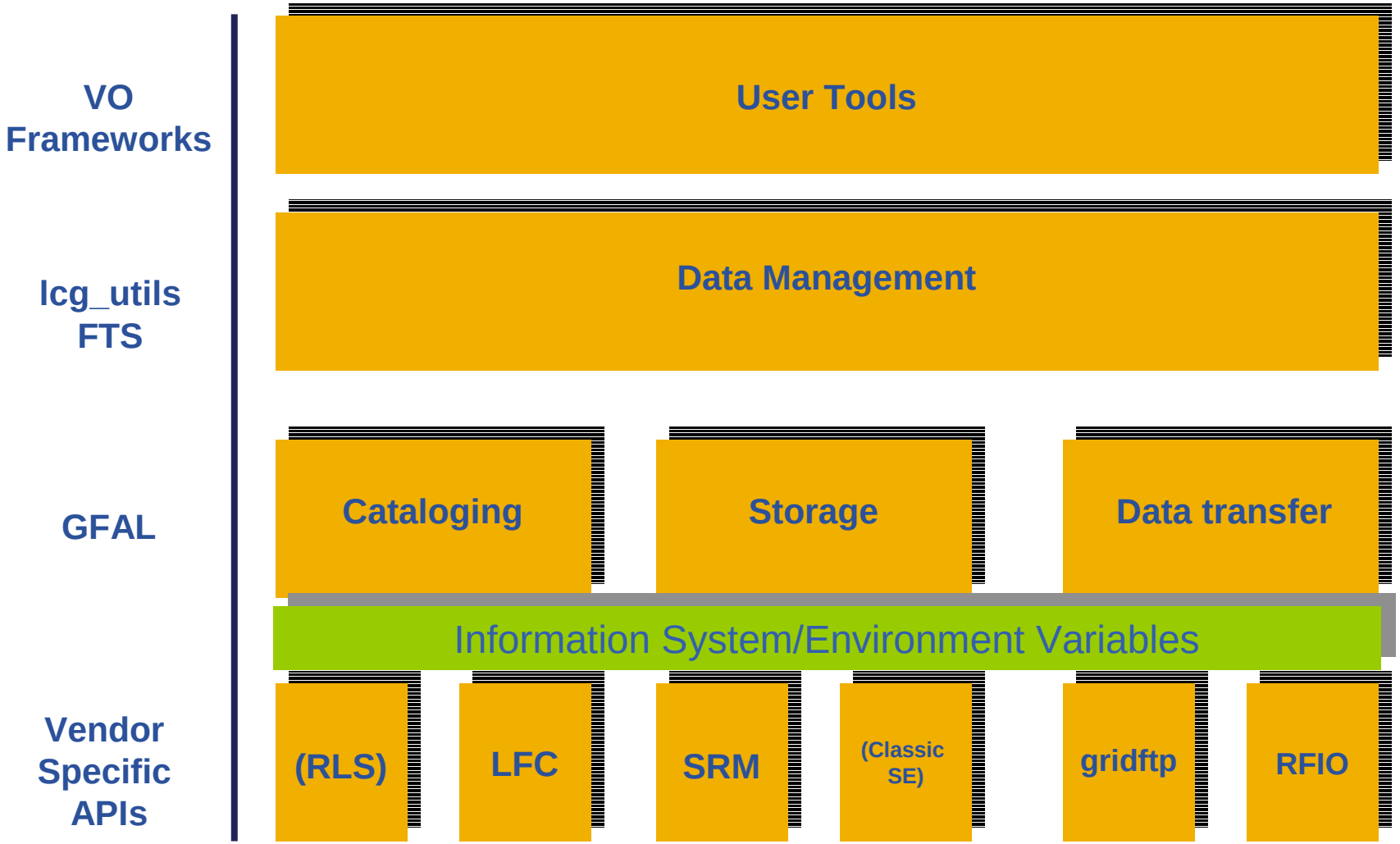
JP Architecture



Accounting

- **Collection of data on resource usage**
  - By VO, group or a single user
- **Metering sensors on all resources**
- **Pricing – cost of use of resources**
  - If enabled, market-based resource brokering
- **High privacy**
  - Access to data granted to authorized personnel
  - Information collected in GOC (Grid Operation Centre)
- **Functionality provided by APEL**
  - Uses R-GMA to propagate job accounting information for infrastructure monitoring
- **Full support via DGAS**
  - Complex architecture (site and central databases)
  - Used by INFN, gLite certification pending

Data Management overview



Storage element

- **Abstraction of file storage**
- **Interface: SRM (Storage Resource Management)**
  - Current version 2.2
- **Handles authorization**
- **Various implementations**
  - Disk based: DPM, dCache
  - Tape based: Castor, dCache
- **POSIX like I/O (rfio)**
  - GFAL (Grid File Access Layer)

Disk Pool Manager (DPM)

- **Manages storage on disk servers**
- **SRM support**
  - 1.1
  - 2.1 (for backward compatibility)
  - 2.2 (released in DPM version 1.6.3)
- **GSI security**
- **ACLs**
- **VOMS support**
- **Targets small to medium sites**
  - Single disks or several disk servers

LFC

- **LCG File catalogue**
- **Stores mapping between**
  - Users' file names
  - File locations on the Grid
- **Provides**
  - Hierarchical Namespace
  - GSI security
  - Permissions and ownership
  - ACLs (based on VOMS)
  - Virtual ids
    - Each user is mapped to (uid, gid)
  - VOMS support
    - To each VOMS group/role corresponds a virtual gid

File Transfer Service (FTS)

- **Reliable data movement fabric service**
  - Performs bulk file transfers between multiple sites
  - Transfers are made between any SRM-compliant storage elements (both SRM 1.1 and 2.2 supported)
- **It is a** multi-VO **service**
  - Balance usage of site resources according to the SLAs agreed between a site and the VOs it supports
- **VOMS aware**
- **Secure**
  - All data is transferred securely using delegated credentials with SRM / gridFTP
  - Service audits all user / admin operations
- **Deployment**
  - Tier 0 at CERN (target 1GB/s 24/7 service)
  - Among ~10 Tier 1 centers and also Tier 1 – Tier 2 transfers

Encrypted data storage

- **Request from medical community**
- **Strong security requirements**
  - anonymity (patient data is separate)
  - fine grained access control (only selected individuals)
  - privacy (even storage administrator cannot read data)
- **Solution based on many components:**
  - image ID is located by AMGA (metadata management)
  - key is retrieved from the Hydra key servers
  - file is accessed by SRM (access control in DPM)
  - data is read and decrypted block-by-block in memory only (GFAL and hydra-cli)

Some statistics

- **Stress tests performed by the HEP experiments**
  - ATLAS and CMS
- **gLite 3 with “standard” testing and certification procedure**
  - Results not satisfactory for end users
- **gLite 3.1**
  - Closed loop between developers and users
  - Intensive work on started in 2007
  - Visible improvements

Requirements for the gLite WMS

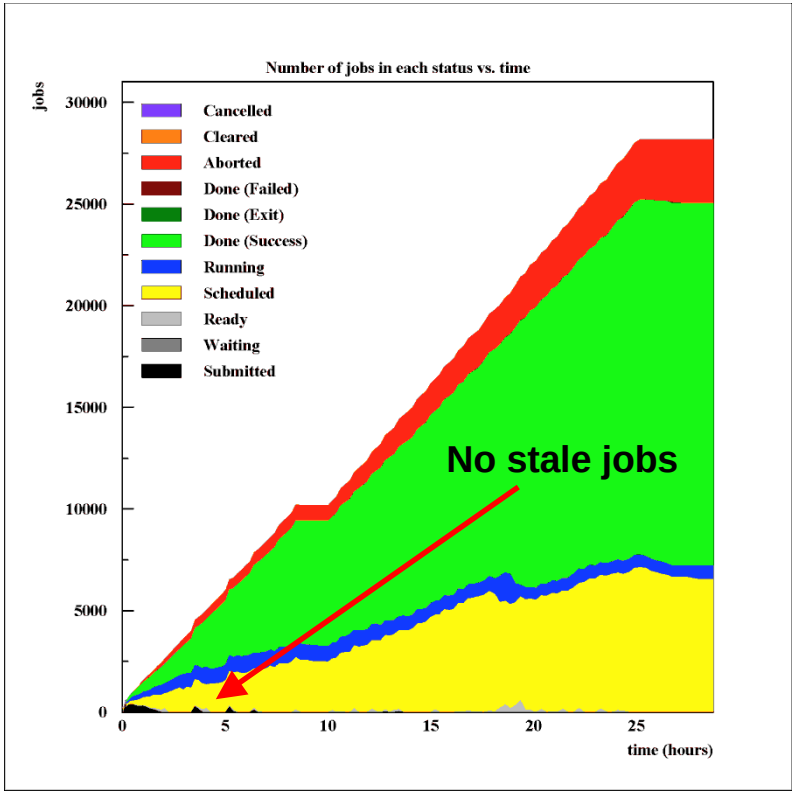
	CMS	ATLAS
Performance		
2007	50K jobs/day	20K production jobs/day + analysis load
2008	200K jobs/day (120K to EGEE, 80K to OSG) Using <10 WMS entry points	100K jobs/day through the WMS; Using <10 WMS entry points
Stability		
		<1 restart of WMS or LB every month under load

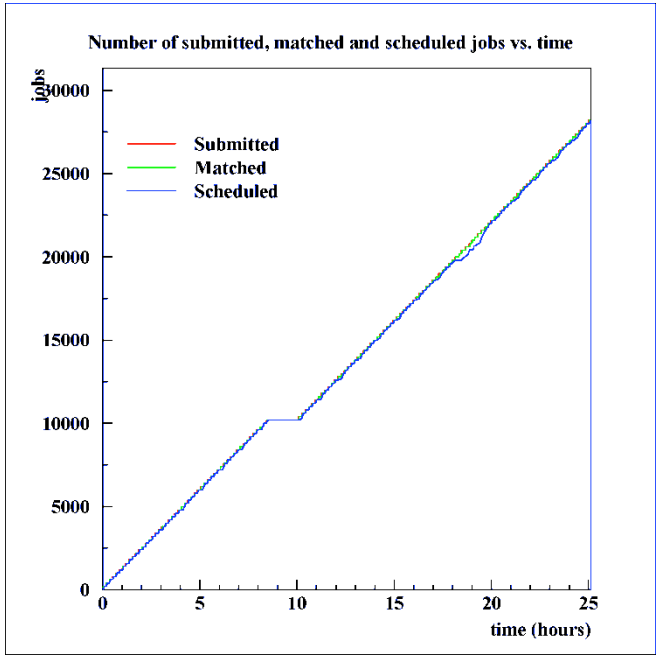
WLCG acceptance criteria

- **Based on the experiment requirements, some criteria have been defined to decide if the gLite WMS satisfies the requirements**
  - At least 10000 jobs/day submitted for at least five days
  - No service restart required for any WMS component
  - The WMS performance should not show any degradation during this period
  - The number of zombie jobs should be less than 0.5% of the total

Results of the acceptance test

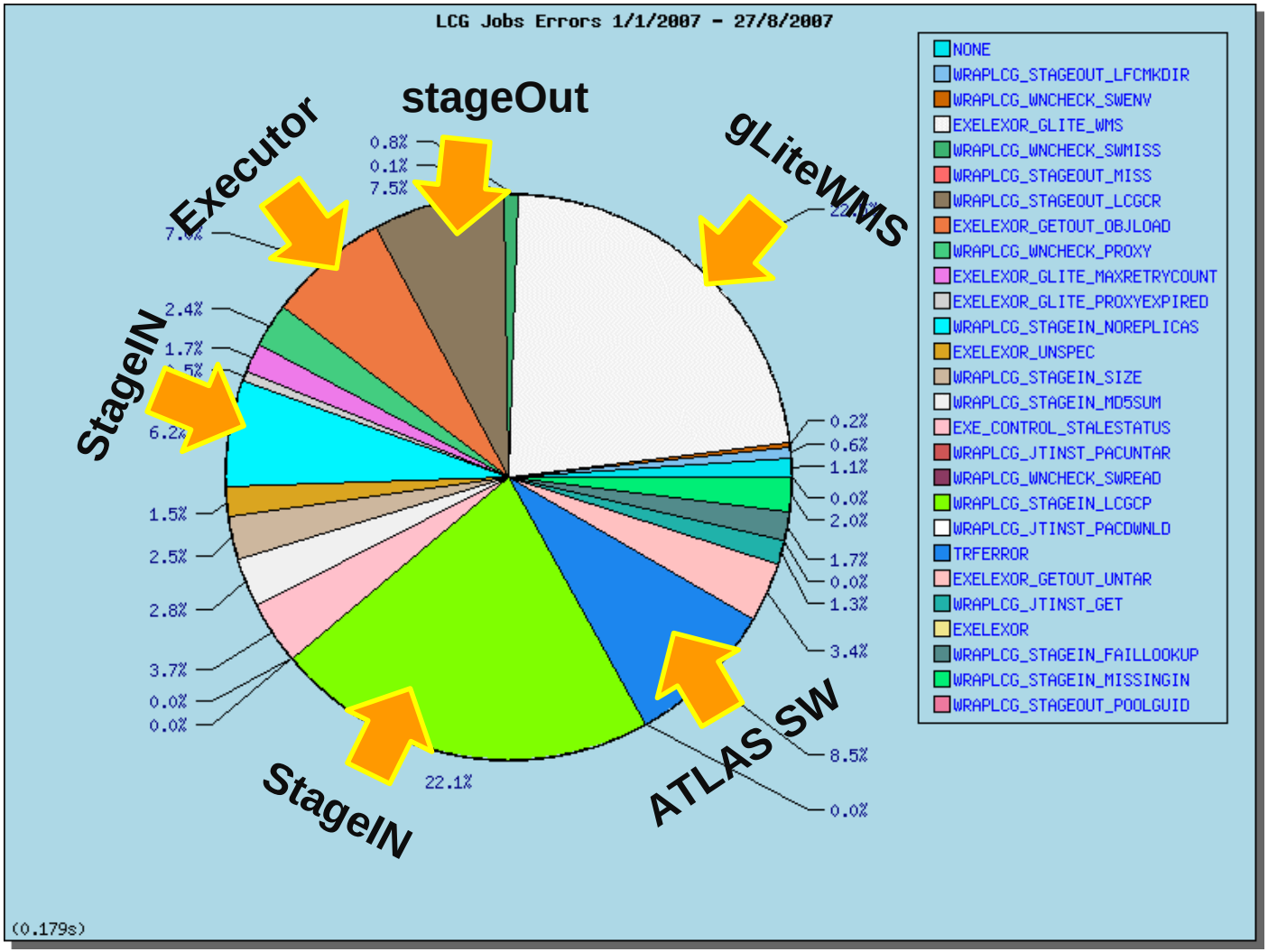
- **115000 jobs submitted in 7 days**
  - ~16000 jobs/day well exceeding acceptance criteria
  - The "limiter" prevented submission when load was very high (>12)
- **All jobs were processed normally but for 320**
  - ~0.3% of jobs with problems, well below the required threshold
  - Recoverable using a proper command by the user





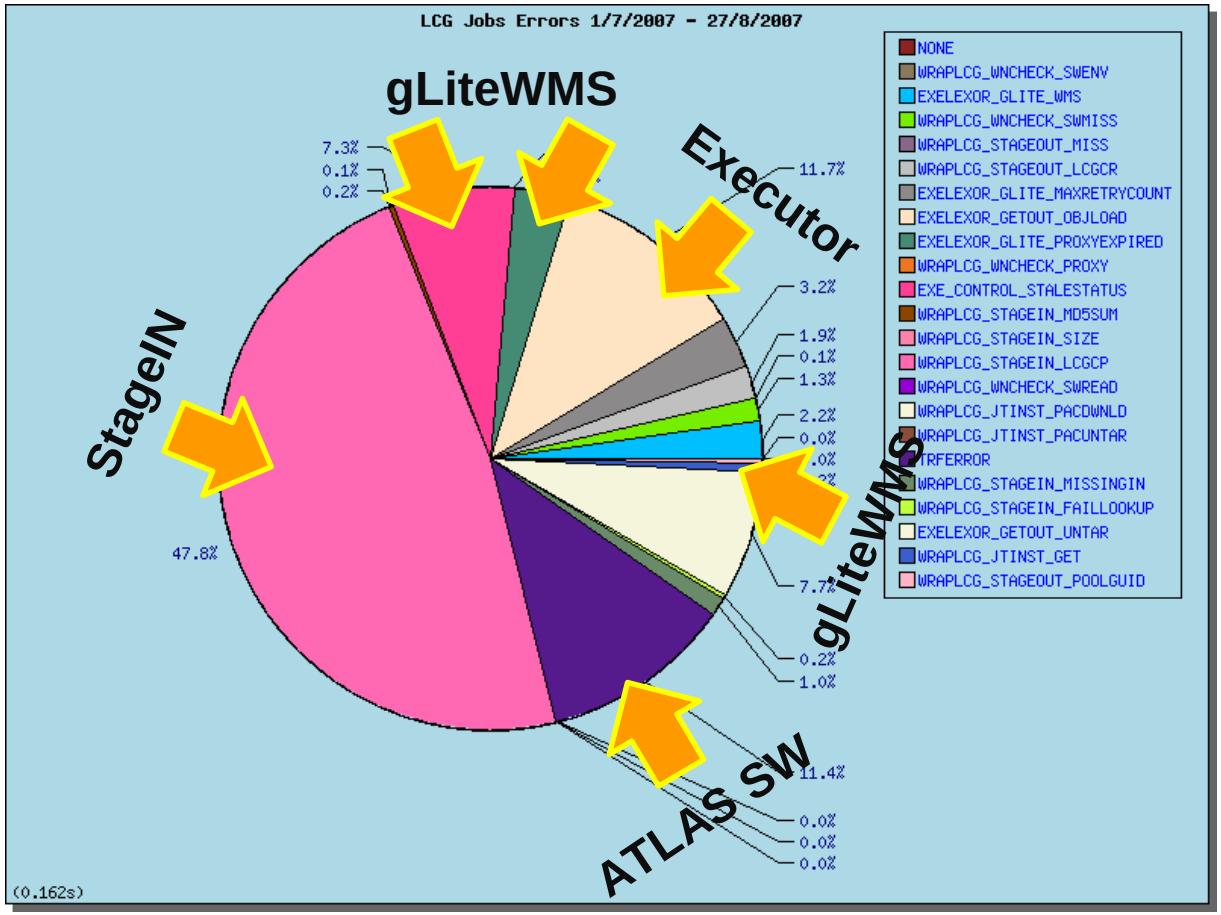
- **The WMS dispatched jobs to computing elements with no noticeable delay**
- **Acceptance tests were passed**

Number of Jobs Error Breakdown: January to August 2007



gLite WMS: ~22% **Data Management: 36%** **ATLAS SW: 8%**

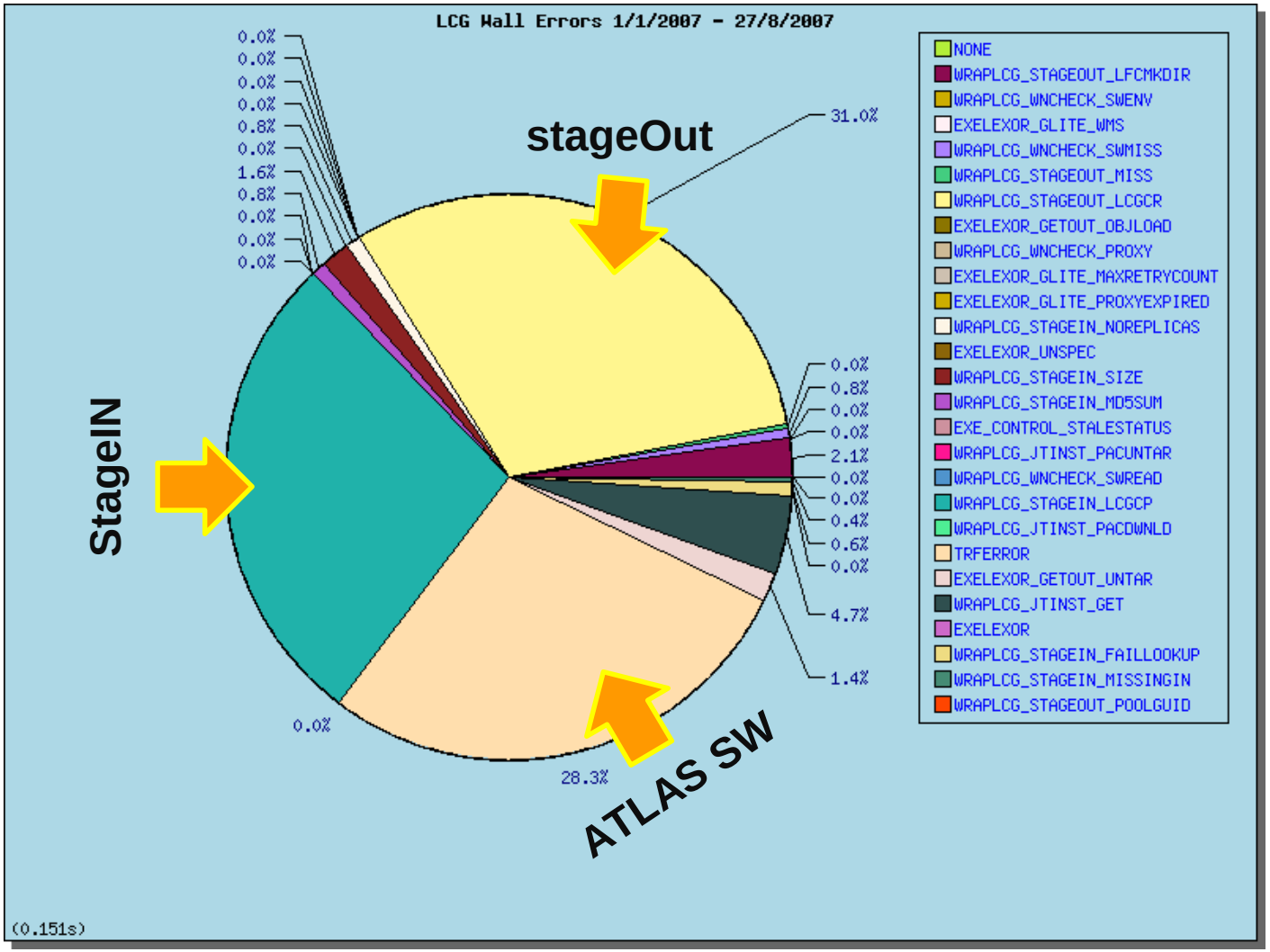
Number of Jobs Error Breakdown: July and August 2007



gLite WMS: ~13% **Data Management: 47%** **ATLAS SW: 11%**

gLite WMS category includes also site specific issues and problematic job distribution (with subsequent proxy expiration).

WallClockTime Error Breakdown: January to August 2007

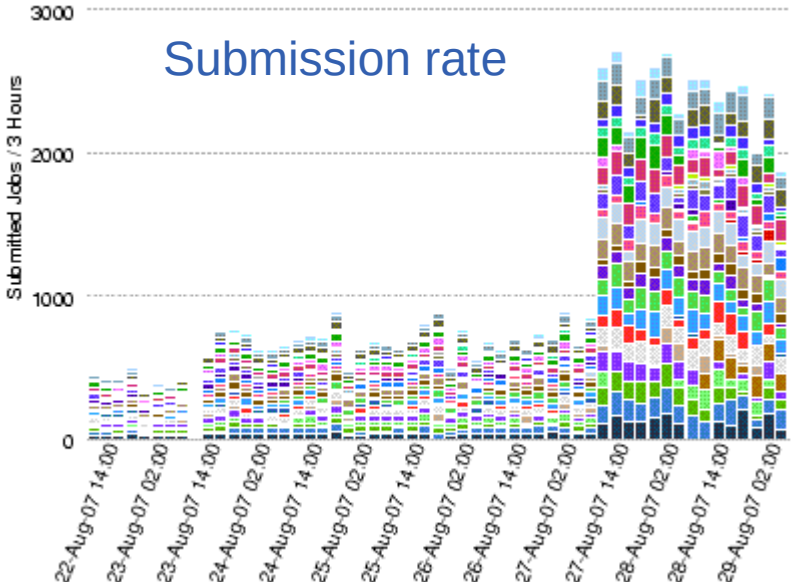


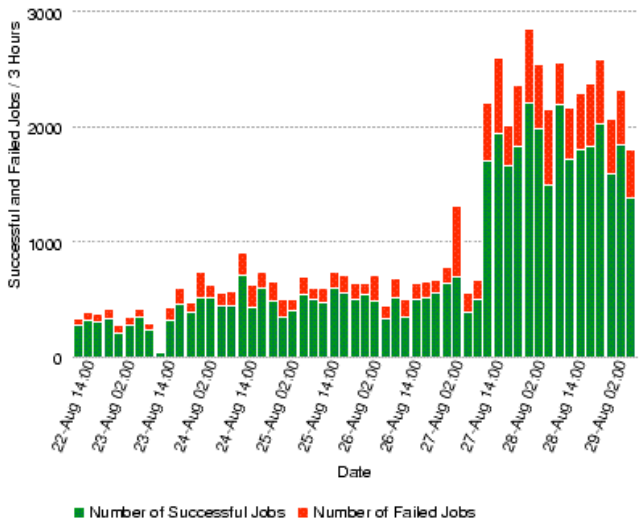
gLite WMS: negligible **Data Management: ~60%** **ATLAS SW: 28%**

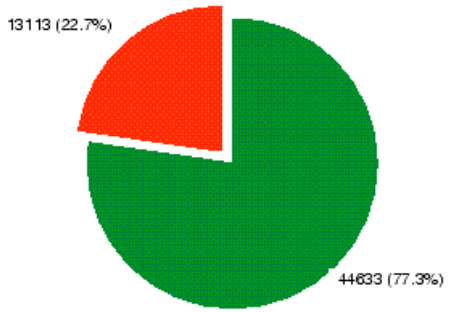
The WMS in CMS data analysis

- **CMS supports submission of analysis jobs via WMS**
  - Using two WMS instances at CERN with the latest certified release
  - For CSA07 the goal is to submit at least 50000 jobs/day via WMS
  - The Job Robot (a load generator simulating analysis jobs) is successfully submitting more than 20000 jobs/day to two WMS

Submission rate







Success rate

Summary

- **gLite middleware reached production quality**
  - Large scale deployment on an EGEE Grid
  - Hundreds of sites, tens thousands jobs every day
    - Scalability limits much higher
    - Multiple deployment of key services possible
  - File transfers at PB level already achieved (over half a year)
- **On-going performance tuning**
  - Closer collaboration between users and developers beneficial to fast development of high performing components
    - Experimental services approach
- **On-going reliability improvements**
- **Ready for use – new users welcome**