Grid Information Systems: Past, Present and Future
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20 Years Of Grid Computing

- CHEP 2000
  - Discussions on the emerging field of Grid computing
  - Two matching fundamental concepts:
    - The integration of distributed computing resources
    - The provision of authentication and authorization
      - Enabling access resources in different administrative domains
  - The Globus Tool Kit
    - Grid Resource Information Protocol (GRIP)
    - Grid Resource Registration Protocol (GRRP)
    - Grid Resource Access and Management (GRAM)
    - Grid File Transfer Protocol (GridFTP)
    - Grid Security Infrastructure (GSI)
Grid Information Systems

- Support coordinated resource-sharing and problem-solving
  - VOs need to obtain information about the **structure** and **state** of Grid services
    - which are widely distributed geographically.
- Information describing a Grid service is provided by the service itself
  - hence the Grid service is the primary information source
- The information provided conforms to an **information model**
  - More details later
- **Assumption that the information source is up-to-date**
  - that is the values represent the real state of the Grid service
- Queries may consider **thousands of information sources**
  - in order to enable efficient Grid functions that may utilize multiple cooperating services
- The goal is to efficiently execute:
  - **many queries**
  - from **many clients**
  - for **many information sources**
MDS and the BDII

- The **Metacomputing Directory Service (MDS)** from the Globus project
  - two information protocols (GRIP and GRRP) from the proposed Grid architecture
    - information providers and information indexing services,
    - separation between inquiry and discovery
- The MDS implementation adopted the standard **Lightweight Directory Access Protocol (LDAP)**
  - GRRP messages mapped onto LDAP add operations
  - GRIP where it is used to define the data model, query language and transport protocol

- **Not only is the LDAP data representation extensible and flexible, but LDAP is beginning to play a significant role in Web-based systems. Hence, we can expect wide deployment of LDAP information services, familiarity with LDAP data formats and programming, and the existence of LDAP directories with useful information.** – Aug 1997
  DOI: 10.1109/HPDC.1997.626445
  - Predictions are dangerous, especially when related to the future!
- The **Berkeley Database Information Index (BDII)**
  - Replaced GRRP with an information cache based on static registrations (Fake II)
  - To work around the stability issues with the initial deployment of MDS in DataGrid project
  - Became a standard component of the EDG Middleware in December 2002

First short term hack becomes a long term solution
Information Models

- Ensure agreement on the meaning of information
- They describe:
  - The real entities
  - The relationships between those entities
  - Their semantics
- A data model
  - Defines the syntax by which information is exchanged
- The MDS information model described
  - the physical and logical components of a compute resource
- The EDG described the Compute (CE) and Storage Elements (SE)
GLUE Information Model

• Grid Laboratory Uniform Environment
  • Defines a uniform representation of Grid resources
    • An information model
      • and LDAP data model

• A collaborative effort between:
  • DataTAG, US-iVDGL, Globus and EDG
  • Enabled transatlantic Grid interoperability

• GLUE 1.3
  • OSG/EGEE interoperability
    • Put the W in WLCG (thanks to Ruth!)
10 Years Of GLUE 2.0

- GLUE Working Group
  - in the Open Grid Forum
  - GFD.147 (2009-03-03)

- Describes Grid Services
  - As opposed to resources/protocols

- Official renderings in XML, JSON and LDIF
  - GFD.209 Reference Realization to XML Schema
  - GFD.219 Reference Realization to JSON Schema
  - GFD.218 Reference Realization to LDAP Schema

- 45 phone conferences
  - ~ 3 days talking
  - ~ 2 months FTE

- 40 versions of the document
  - 347 days
  - 46 pages, 12787 words
  - 254 Attributes
    - 28 Objects
Information Validation

- Information providers
  - Distributed data sources
- Conformance goes a long way
  - Checks before information is published

- Limitations on information and data models
  - Information missing or not existing?
  - Reflects the actual state of the system?
    - Assumption that the information source is up-to-date
    - Correctness (using [bytes] vs [Gbytes])
Architecture and Realisation

Users

- BDII service Provider
- site-level BDII
- resource BDII
- Provider

Monitoring

- top-level BDII

Services

- DIRAC

Visualizations

- VOs

- Users

- Monitoring

- Services

- Visualizations
Evolution Of The Grid

- **CHEP 2007**
  - Scalability and performance analysis of the EGEE information system
    - 251 sites which provided 1428 Services.
    - 2 million connections per day (lcg-bdii.cern.ch)
    - ~100MB in the Top BDII

- **Daily snapshots since March 2010**
  - Archived !!!

- **Sep 2019 (OSG stopped publishing in 2015)**
  - 209 sites providing 883 Services (GLUE 2.0)
  - 200 sites providing 909 Services (GLUE 1.3)
  - 1 million queries per day (lcg-bdii.cern.ch)
  - ~32MB in the Top BDII
Evolution Of The Grid

The Number Of Sites and Services Seen

Goodbye
ResourceBroker Nov 2010
CASTOR-SE Nov 2011
RGMA June 2012
GridIce Dec 2012
org.edg.gatekeeper Feb 2014
GUMS March 2015

Hello
ARC-CE (Nov 2011)
org.ogf.bes (Oct 2014)
HTCondorCE (March 2015)
## Top Ten Queries

### 2007

<table>
<thead>
<tr>
<th>Q/h</th>
<th>Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>6075</td>
<td>Close CE to an SE</td>
</tr>
<tr>
<td>5475</td>
<td>VO’s SA for an SE</td>
</tr>
<tr>
<td>5043</td>
<td>All SRMs</td>
</tr>
<tr>
<td>4791</td>
<td>An SE</td>
</tr>
<tr>
<td>2432</td>
<td>Close SE to a CE</td>
</tr>
<tr>
<td>2117</td>
<td>All Services for a VO</td>
</tr>
<tr>
<td>664</td>
<td>All CEs for a VO</td>
</tr>
<tr>
<td>638</td>
<td>All SAs for a VO</td>
</tr>
<tr>
<td>479</td>
<td>All SubClusters</td>
</tr>
<tr>
<td>448</td>
<td>GlueVOView for a CE</td>
</tr>
</tbody>
</table>

### 2019

<table>
<thead>
<tr>
<th>Q/h</th>
<th>Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>5960</td>
<td>A specific Cluster</td>
</tr>
<tr>
<td>5923</td>
<td>All entries linked to a Cluster</td>
</tr>
<tr>
<td>5377</td>
<td>EEs of a Cluster</td>
</tr>
<tr>
<td>4898</td>
<td>GLUE2Shares for a VO</td>
</tr>
<tr>
<td>2928</td>
<td>A specific Site</td>
</tr>
<tr>
<td>909</td>
<td>SRM endpoint of a SE</td>
</tr>
<tr>
<td>305</td>
<td>Find all CEs for a VO</td>
</tr>
<tr>
<td>217</td>
<td>Find a specific CEs for a VO</td>
</tr>
<tr>
<td>193</td>
<td>A specific GLUE2 share</td>
</tr>
<tr>
<td>134</td>
<td>Cream CEs for a VO</td>
</tr>
</tbody>
</table>

*Italics show GLUE2 queries*
HTCondor CE Provider

• New provider required for HTCondorCE
  • Only publishes GLUE 2.0 information
  • Published initially minimal information
    • Responded to requests for additional information

• Included upstream
  • As part of the HTCondor CE distribution
  • Adoption by other sites

• Observations:
  • Compute Service information is required
  • GLUE 1.3 no longer needed
  • GLUE 2.0 is being used
Future

- The system is still used
  - The usage is decreasing
- There still seems to be a need
  - E.g. htcondor provider
- Options are the same as presented in 2011*
- Lazy:
  - Do nothing
- The Radical:
  - Decommission
- The Slow and Steady
  - Remove site-bdiis
  - Drop GLUE 1.3
  - Streamline GLUE 2.0 usage
- The Rocky
  - Separate the use cases
  - Centralized and reliable service discovery system
  - Provide a single system for experiment annotation and configuration

*https://indico.cern.ch/event/106645/
Summary

- 20 Years of Grid Computing
- 10 Years of GLUE 2.0
- Service Discovery and Status Still Relevant
  - ~900 services, ~200 sites
- Information providers are necessary!
  - To provide the status of services
    - Information models for complex services
    - Information models matter, representations don’t
- The Grid is shrinking
  - Peak ~2012 (in number of sites)
- The roads ahead are the same as 2011
  - Lazy, slow and steady, radical or rocky
- Validation, Validation and Validation
  - Provider, system-wide and cross-checks