Challenge and Future of Job Distribution at a Multi-VO Grid Site

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Introduction: A short reminder of the Grid idea

> Grid Blueprint by Kesselmann/Foster (1999)
  - Collaborative problem solving → VOs

> “Three Point Checklist” Foster (2000)
  - No centralized controls (NOT like distributed computing)
  - Standard, open, general-purpose protocols
  - Non-trivial quality of services (NOT like web)

> EDG → LCG → gLite → EMI, NorduGrid → …

> Virtual Organization (VO) w/ individual groups and roles to identify job classes
The Grid: Initial Concept

VO1: group role

VO2

VO3

VO4

Grid

'qsub'

Site 1
sched
LRMS

Site 2
sched
LRMS

Site 3
sched
LRMS

SE

SE

SE

Identify job classes by group and role

SE

SE

SE

wn

wn

wn

wn

wn

wn

wn
The Grid: **Local Resource Management System (LRMS)**

**Job**  
- **JDL**  
  - **CE (CREAM)**
  - **Batch System**
    - **Queueing**
      - **Scheduling**
        - **WN**

**Credential mapping to local accounts:**
- `ilc:/ilc` → `ilcusr175`
- `ilc:/ilc/Role=lcgadmin` → `ilcsgm007`
- `ilc:/ilc/Role=production` → `ilcpnd018`
- `ilc:/ilc/de` → `ilcger234`
- `ilc:/ilc/Role=pilot` → `ilcplt079`
Most sites based their installations on the initial concepts

DESY is an example for a big multi-VO site as Tier-2 w/ many disciplines

- **2003:** First look into Grid computing as key technology to access resources
- **2004:** LCG_2-1 Grid infrastructure H1 and ZEUS, IceCube, ILC, ILDG
- **2004:** EU-Project EGEE(2/3), EGI
- **2004:** Tier-2 for ATLAS, CMS, LHCb
- **2005:** D-Grid (DGI(2) and HEPCG)
- **2011:** DESY is world-wide biggest Tier-2 center for CMS
- **2012:** scheduler studies because of scaling problems
- **2013:** BELLE2 added; major contributions to MC campaings
- **2015:** multi-core support started
The Grid infrastructure reflects DESY’s manifold scientific programme:

- DESY is the *home* of 10 VOs (6 global), incl. non-HEP
- Tier-2 for ATLAS, CMS, LHCb, BELLE2 in Germany (Tier-1: GridKa), LHCone
- Tier-0/1 for ILC VOs incl. Testbeams w/ tape back-end

One *complete generic* Grid infrastructure for *all* VOs

- All necessary Grid services (VOMS, LFC, WMS, PX, CVMFS-stratum0/1 ...)
- *Federated* resources w/ *opportunistic* usage ("everybody profits")
- Roughly 2/3 of the resources for WLCG and 1/3 for BELLE2 and ILC

Operational aspects

- Stable operations (no crashes, no local resource exhaustion)
- VO requirements (MoUs, shares)
- Utilization of resources (cpu, memory, disk, network)
DESY-HH: Local Resource Management System (LRMS)

- Initial standard set-up TORQUE / MAUI didn't scale beyond ~10k jobs
  - Instabilities
  - Blocking of submissions
  - Low occupancy
  - Configuration problems
  - Exhaustion of resources

- Heterogeneous Worker Nodes
  - 8 – 64 cores (Intel, AMD) (partially w/ HT)
  - 2-4 GB/core RAM
  - 20 GB/core disk
  - 11k cores == 12 kHS06 (2015-04-01)
myS(c)hed: A Scheduler Study

- Tailored to HEP (job-parallel)
- Scalable (number of jobs; number of slots)
- Optimize resource utilization (maximize diversity per node)
- Configurable (config file) with shares and rules
- Based on the torque C-API (libtorque.so.2)
- Light-weighted (CPU and memory usage)

- myS(c)hed algorithm:
  - Re-order job list according to shares (multi-core jobs first)
  - Find suitable node for job

Re-order jobs by share:

<table>
<thead>
<tr>
<th>VO1</th>
<th>VO2</th>
<th>VO3</th>
<th>VO4</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>02</td>
<td>03</td>
<td>04</td>
</tr>
<tr>
<td>05</td>
<td>06</td>
<td>07</td>
<td>08</td>
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<tr>
<td>09</td>
<td>10</td>
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<tr>
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</tr>
</tbody>
</table>
DESY-HH: Jobs 2014 (~120 kHS06)

Jobs running per VO in 2014

Weeks 4 to 52

- Others
- ATLAS
- BELLE2
- ILC
- LHCb
- CMS
- Slots
The Grid: **Current Situation**

- **Main VOs use pilot factories (major impact on sites)**
  - The Grid Information system is not used
  - Scheduling is done outside sites (by pilot factory)
  - Job classes (MC, analysis, etc.) can not be identified (anymore)
  - Very few (one) user per VO
  - The classical (local) scheduling approaches don't work

- **Small sites fade**
  - Middleware and operational support decreasing
  - Know-how and awareness of computing leaves

- **Clouds?**
The Grid: Initial Concept

- **VO1:** group role
- **VO2**
- **VO3**
- **VO4**

**Grid**

- **WMS**
- 'qsub'

**Identify job classes by group and role**

**Site 1**
- SRM
- SE
- LRMS
- wn
- ...
- wn

**Site 2**
- SRM
- SE
- LRMS
- wn
- ...
- wn

**Site 3**
- SRM
- SE
- LRMS
- wn
- ...
- wn
The Grid: Recent developments

VO1: group role

Site 1
- sched
- LRMS

Site 2
- sched
- LRMS

Site 3
- sched
- LRMS

WMS

pilot1

pilot2

'Grid'

VO2

VO3

VO4

No more groups and roles for the job classes

SE

SRM

work-load

wn

...
Future: From Grid to Cloud?

- **Clouds**
  - Non-Grid approach
  - Sites just may provide their infrastructure as a service

- **Vacuum approach**
  - Pilots are started directly by the site
  - Save Grid overhead (WMS, CE)
  - Simple resource allocation model

- **Small scale classical Grid sites for minor VOs?**
  - Still demands
  - Even major VOs have regional groups
Summary and Conclusions

➢ The Grid has proven to be a key technology for WLCG, in HEP, and elsewhere

➢ Sites were set up based on the ideas of Kesselman and Foster ~10 years ago

➢ Introduction of pilot factories and multi-core jobs required massive changes

  ▪ Focus on big sites as small sites vanish
  ▪ Classical LRMS approach reaches limits

➢ Future of computing resource provisioning seems questionable

  ▪ Give up on Grid as is and focus clouds instead?
  ▪ What about small VOs?
  ▪ How does this fit to scientific program of sites
~11,000 cores in 2015