Unified Workload Management for the Cray XC System with Univa Grid Engine

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Who is Univa?

Univa is a leading developer of Workload Optimization solutions

- Global reach – based in Chicago with offices in Markham, Canada, Munich and Regensburg, Germany
- Fast growing enterprise software company
- “Home of Grid Engine.” All Grid Engine developers work at Univa, including founder of the Grid Engine project
- Support global Fortune 500 companies

Customer Use-Cases

The most innovative companies are optimized on our platform:

BIG DATA	ENTERPRISE TECHNICAL	ENTERPRISE APPLICATION	ISV/HVS
ARCHIMEDES Quantifying Healthcare	bp	sears	SYNOPSYS®
CenturyLink™	NOVARTIS	Danske Bank	Mentor Graphics®
TransUnion®	ارامكو السعودية Saudi Aramco	NUANCE	ANSYS®
epsilon®	SAMSUNG	DB Mobility Networks Logistics	JEPPESEN A BOEING COMPANY
VERTEX	MARVELL®	BMO	Microsoft
CSH Cold Spring Harbor Laboratory	BMW	nielsen	

Univa Solutions

Univa Grid Engine

20 Years of History

- **1992: Initial developments @ Genias in Regensburg**
- **1993: First Customer Shipment (as CODINE)**
- **1996: Addition of GRD policy module**
  - Collaboration with Raytheon & Instrumental Inc
- **1999: Merger with Chord Systems into Gridware**
- **2000: Acquisition through Sun**
  - Re-launch as Sun Grid Engine
- **2001: Open Sourcing**
- **Until 2010: Massive growth in adoption (>10,000 sites)**
- **2010: Acquisition through Oracle**
  - Open Source gets orphaned
- **2011: Key engineering team joins Univa**
- **2013: Acquired all IP and assets from Oracle**
- **Soon: 5th major release of Univa Grid Engine**

Major 8.1 Features & Benefits

Feature	↑ Throughput	↑ Utilization	↓ Effort	↓ Cost	How
Job Classes		✔	✔	✔	**Templates** providing ease of use, control and best fit
Resource Maps	✔	✔			Optimal mapping of resources to jobs
Core / NUMA Binding	✔	✔		✔	Tuned utilization of CPU and memory architectures / **per NUMA node** memory reporting and accounting
Database Spooling	✔	✔		✔	Increased uptime @ top performance
Fair Urgency	✔	✔			Balanced utilization of critical resources
MPI Integrations		✔	✔	✔	Tuned, out-of-the-box integration with MPI versions
Improved Diagnostics			✔	✔	Faster time to resolution of issues

Major 8.2 Features & Benefits

Feature	↑ Throughput	↑ Utilization	↓ Effort	↓ Cost	How
Cgroups integration	✔	✔	✔		Better workload **isolation** and **resource limitation** on Linux
Native Windows Support			✔	✔	Supports Windows as submit and execution host without requiring UNIX emulation layer
DRMAA2 API			✔	✔	Implements **open, standardize API** for job monitoring, job workflow management, and job submission
New read-only thread pool	✔	✔		✔	**Highly improved scalability** due to new, separate components in qmaster
...				✔	Dozens of smaller improvements based on direct feedback of our customers reducing management overhead and simplifies product usage

Major 8.3 Features & Benefits

Feature	↑ Throughput	↑ Utilization	↓ Effort	↓ Cost	How
Short Jobs Add-on	✔	✔			Capability of running **100s of jobs per second** through high performance message bus
Real Preemption		✔		✔	Freeing Grid Engine resources when job is preempted
Web Services API			✔		Access Univa Grid Engine through **REST Style API** (status / configuration)
Universal Resource Broker Add-on			✔	✔	Running **Spark** or other Mesos frameworks on top of Univa Grid Engine

Special Support for Cray XC Systems

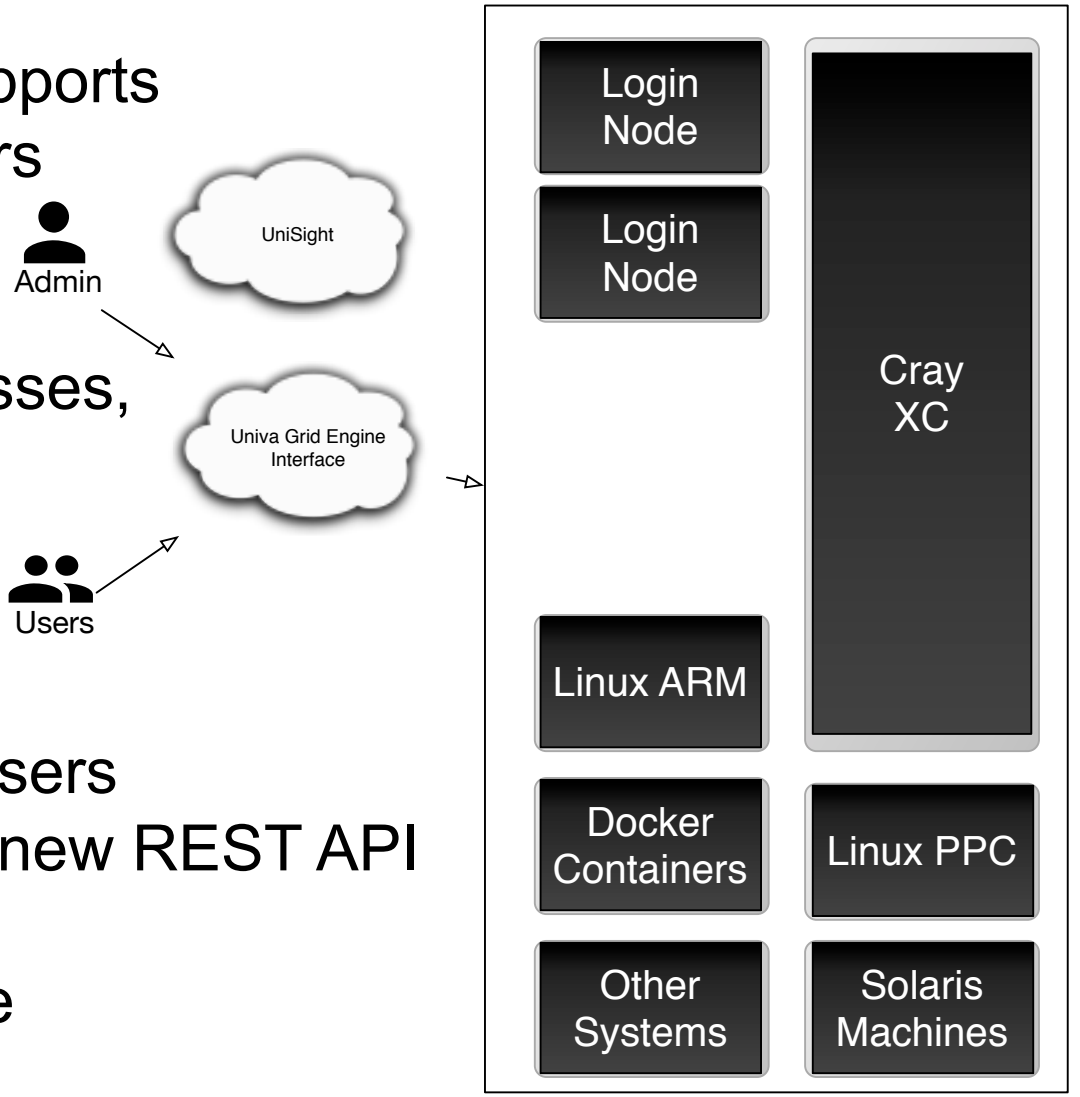
Customer Quote

- "Grid Engine has enabled us to integrate both **Cray and non Cray jobs** into the **same scheduler**. It allows us visibility of all our jobs in **one place**."
- "It allows us to use the **advanced scheduling capabilities** of GE to further enhance the Cray internal scheduler. GE effectively acts as a **meta-scheduler** for the Cray."
- "The GE environment has proven to be **very stable** environment scheduling on top of the Cray system."

Chris Semple, PGS

One Single Shared Resource Pool

- Univa Grid Engine supports heterogeneous clusters
- Global policies and rules for jobs / job classes, users, projects, departments, resources
- Single interfaces for users and admins including new REST API
- Fast, scalable, reliable



Workload @ Cray XC using ALPS / BASIL

- Job Types:
  - Login node jobs (some use it for compilation)
  - Cray XC jobs (using aprun): **Batch** and **Interactive**, **Array Jobs**
- Cray XC node requests:
  - **-q cray.q** for routing to the Cray machine
  - **-pe cray <nodes>** for selecting the amount of nodes
  - Optional: *mppwidth mppdepth mppnppn cray_nodes*
- Cray XC Job:
  - Runs by using automatically reserved resources via **aprun**
  - Can use subset of **reserved resources** / can use **resources multiple times** sequentially

Workload @ Cray XC

- RUR Integration:
  - Mapping of Cray measurements into Univa Grid Engine counterparts:
    - utime → ru_utime
    - stime → ru_stime
    - max_rss → ru_maxrss
    - wchar → ru_oublock
    - rchar → ru_inblock
- Get aggregated usage statistics with **qacct**

Complex	Semantic
cray_nodes	Global consumable resource for compute node limitation
cray_alps_version	Displays ALPS version detected at installation time
cray_basil_version	Displays BASIL version detected at installation time
cray_cores_per_host	Displays the amount of cores on a Cray compute node
cray_forced	This complex protects cray.q so that no other job runs in
cray_numa_nodes	Amount of NUMA nodes on a Cray compute node
mppwidth	Cray reservation request: Amount of Cray PEs to start up
mppdepth	Cray reservation request: Distance between two Cray PEs
mppnppn	Cray reservation request: Amount of Cray PEs on a node

Simple Job Submission

```
> qsub -q cray.q -pe cray 3 /home/crayadm/job_script.sh
Your job 279 ("job_script.sh") has been submitted

> qstat -j 279
...
hard resource_list:         cray_forced=1,cray_nodes=1,mppwidth=3,mppdepth=32,mppnppn=0
```

```
> apstat -a
Total placed applications: 1
Apid ResId    User PEs Nodes    Age State    Command
3824  4262 crayadm   3     3 0h00m    run worker.sh
```

Automatic Alignment of Requests

```
> qsub -q cray.q -pe cray 3 -l mppwidth=4,mppnppn=2  /home/crayadm/job_script.sh
Your job 295 ("job_script.sh") has been submitted

> apstat
Compute node summary
 arch config      up   resv    use  avail   down
   XT     24      23      2      2     21      1

> qstat -j 295
...
account:                    sge
hard resource_list:         mppwidth=4,mppnppn=2,cray_forced=1,mppdepth=1,cray_nodes=1
mail_list:                  crayadm@nid00034
notify:                     FALSE
job_name:                   job_script.sh
jobshare:                   0
hard_queue_list:            cray.q
env_list:
script_file:                /home/crayadm/job_script.sh
parallel environment:  cray range: 2
context:                    reservation_1=4303
...
```

Interactive Job Example

```
> qrsh -pe cray 2 -q cray.q

# now on login node

> aprun -B /home/crayadm/installation/examples/jobsbin/lx-amd64/work 10
Forking -1 times.
Forking -1 times.
Application 3872 resources: utime ~200s, stime ~0s, Rss ~3572, inblocks ~0, outblocks ~0

# using the reservation requests: -B
> aprun -B /home/crayadm/installation/examples/jobsbin/lx-amd64/work -w 5
Forking -1 times.
Forking -1 times.
Application 3876 resources: utime ~10s, stime ~0s, Rss ~3572, inblocks ~0, outblocks ~0

> aprun -n 2 -d 32 /home/crayadm/installation/examples/jobsbin/lx-amd64/work -w 5
Forking -1 times.
Forking -1 times.
Application 3877 resources: utime ~10s, stime ~0s, Rss ~3572, inblocks ~0, outblocks ~0

> aprun -n 3 -d 32 /home/crayadm/installation/examples/jobsbin/lx-amd64/work -w 5
apsched: claim exceeds reservations node-count
```

Univa Grid Engine Features @ Cray XC

- Resource reservation for jobs / Advance Reservation
- Backfilling
- REST API
- Job dependencies between Cray XC and non-Cray jobs
- Job array support
- Job array inter-dependencies on task level
- Resource quotas on job classes, global level (Cray / non-Cray)
- Automatic resource alignment on Cray reconfiguration
- …lots of policies and more

What is Cooking?

- UGE 8.4 is on the way → June 2016
  - **Docker ready: Automatic detection of Docker enabled nodes. Execution of jobs in automatically created containers.**
- UniSight 4 is knocking at the door → July 2016
  - Major re-write of UniSight 3
  - Now with **live dashboard** functionality for monitoring cluster
- Navops.io → Fastest way for deploying **Kubernetes** on bare metal or on cloud service providers (AWS, Google)
  - Free download! www.navops.io

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Questions?

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Thank You!

Speak with us! ☺