Karlsruhe Institute of Technology

Multi-Core Job Support (UGE) at GridKa

WLCG Multi-Core Task Force 2014-03-04

Manfred Alef


```
# qacct -slots -f /tmp/accounting-02-2014
SLOTS     WALLCLOCK           UTIME          STIME                CPU
================================================================================
    0             0           0.000          0.000              0.000
    1   30045925533 19190341698.755 322568683.359 26836528747.830
    2         14574           4.552          1.674          29163.498
    3        113341           3.781          3.935         184506.117
    4        183696          16.268         16.760         735472.000
    8      83796513   513975203.321   1177782.105   605994381.126
#
```

LRMS at GridKa

- Multi-VO support
  - Alice, Atlas, BaBar, Belle II, CDF, CMS, Compass, LHCb, ...
- Size of the compute farm and number of jobs
  - 12,828 job slots
  - About 20 millions of jobs processed in 2013
    - ➔ (Alice: 3.4, Atlas: 9.2, CMS: 1.9, LHCb: 3.2 millions)
- Very high cluster utilization – most often queued jobs waiting

LRMS at GridKa

- Grid Engine (by Univa) since mid 2012
  (has replaced PBS-Professional)
  - Fast and stable
  - Fair-share scheduling
    - ➔ Share-tree policy (using history, halftime=1000h) – 50% weight
    - ➔ Functional ticket policy (not using history) – 50% weight
    - ➔ Override tickets (high-priority jobs: OPS, SGM)
  - One queue published by BDII
    - ➔ 120h maximum walltime
    - ➔ In the past (PBS setup): short / medium / long / extralong queues
      - Users submitted either solely to extralong queue,
        or stupidly round-robin like (s, m, l, xl, s, m, l, xl, s, ...)

LRMS at GridKa

- Grid frontends
  - CREAM
- Multi-core usage
  - Atlas: continously since several weeks
  - CMS: only a rew test jobs
  - No interest so far from other VOs

Multi-Core Job Support: LRMS Configurations

- No separate queue
  - Jobs request number of slots in JDL
    - ➔ Parallel environment (PE) has been configured to support multi-core jobs
    - ➔ Any number of slots supported
      (should be less than or equal to maximal number of slots per host :-)
    - ➔ Memory limits set by profile script (according to number of cores), not by UGE
- Dynamic scheduling
  - No sub-clusters (neither VO nor multi-core specific)
- How does a multi-core job start?
  - By default (without draining) it most probably won't because all slots are continuously occupied by single-core jobs

Multi-Core Job Support: LRMS Configurations

- Resource reservations
  - Max_reservation set to ~10 ... 20
    - ➔ Up to 60 ... 120 slots idling to boost 8-core jobs
      - (0.5 ... 1.0 % of total capacity)
- Cron job to provide extra flags to queued multi-core jobs:
  - **`qalter -R y`** `$list_of_pending_multicore_jobs`
    - ➔ '-R y': Add mandatory flag to enable job reservations
      - Should be implemented in /usr/libexec/sge_submit.sh script running on CREAM's

Multi-Core Job Support: LRMS Configurations

- How reservations are handled by the scheduler (snippet of sched_conf manpage):

max_reservation

The maximum number of reservations scheduled within a schedule interval. When a runnable job can not be started due to a shortage of resources a reservation can be scheduled instead. A reservation can cover consumable resources with the global host, any execution host and any queue. For parallel jobs reservations are done also for slots resource as specified in sge_pe(5). As job runtime the maximum of the time specified with -l h_rt=... or -l s_rt=... is assumed. For jobs that have neither of them the default_duration is assumed. Reservations prevent jobs of lower priority as specified in sge_priority(5) from utilizing the reserved resource quota during the time of reservation. Jobs of lower priority are allowed to utilize those reserved resources only if their prospective job end is before the start of the reservation (backfilling). Reservation is done only for non-immediate jobs (-now no) that request reservation (-R y). If max_reservation is set to "0" no job reservation is done.

Note, that reservation scheduling can be performance consuming and hence reservation scheduling is switched off by default. Since reservation scheduling performance consumption to is known grow with the number of pending jobs, the use of -R y option is recommended only for those jobs actually queuing for bottleneck resources. Together with the max_reservation parameter this technique can be used to narrow down performance impacts.

Multi-Core Job Scheduling

- How reservations are handled by the scheduler
  - Limitations:
    - ➔ Configured number of max_reservations
    - ➔ Job priorities – looking at GridKa monitoring dashboard (20 max_reservations):

Project	Queued jobs (or JAT's)	Running jobs	Allocated slots		Nominal share		Normalized tickets	Average CPU efficiency
Alice	41	2939	2939	24 %	24 %	30000 HS06	0.00014	72 %
Atlas-Pilot	24	287	287	2 %	6 %	7975 HS06	0.00036	96 %
Atlas-Prod	212	5077	5322	44 %	25 %	31900 HS06	0.00009	95 %
Auger	0	87	87	1 %	2 %	2182 HS06	0.00036	94 %
Belle	6	53	53	0 %	3 %	4200 HS06	0.00104	80 %
CMS-MCP	2461	2660	2660	22 %	13 %	16625 HS06	0.00009	86 %
CMS-Pilot	2031	147	147	1 %	1 %	875 HS06	0.00008	82 %
D-Grid-2007-HEP	0	29	29	0 %	4 %	5487 HS06	0.00269	93 %
LHCb	2	636	636	5 %	15 %	19200 HS06	0.00042	91 %
SGM	2	2	2	0 %	0 %	0 HS06	1.00000	8 %
Total	4779	11917	12162	100 %	–	–	–	ø 84 %

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Cluster utilization by Atlas (role=production) in the past above the nominal share ...

...may result in lower priority than other VOs

Nevertheless Atlas multi-core production jobs were starting because of low number of pending jobs from other VOs at that time!

Multi-Core Job Scheduling

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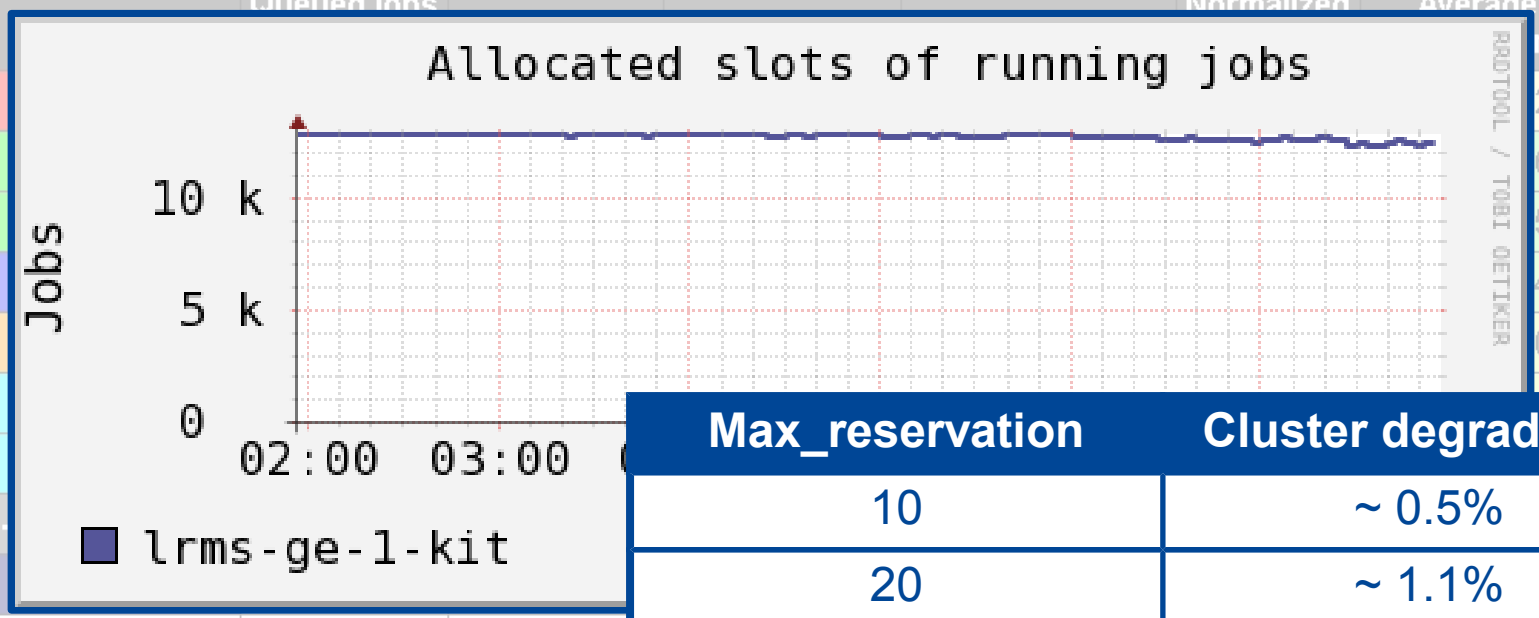
Decreased cluster utilization when reservations become scheduled, insufficient entropy to backfill gaps (maximal available slots: 12804)
Scheduler configuration: max_reservation=20

Multi-Core Job Scheduling



Max_reservation	Cluster degradation
10	~ 0.5%
20	~ 1.1%

SGM	2	2	2	0 %	0 %	0 HS06	1.00000	8 %
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Multi-Core Job Scheduling

- How reservations are handled by the scheduler
  - Backfilling:
    - ➔ Jobs of lower priority are allowed to utilize the reserved resources only if their prospective job end (i.e. the declared wallclock usage) is before the start of the reservation
    - ➔ Job execution time: 0...120 h
      Average: ~5.6 h
    - ➔ Very few jobs which declare their estimated runtime, therefore almost no backfilling in effect

Multi-Core Job Scheduling

- How reservations are handled by the scheduler
  - Ramp-up by 2...5 jobs per hour
    - ➔ If respective VO share at top
    - ➔ If no single-core jobs with higher priority are waiting
  - Again and again – multi-core job queue idling
    - ➔ Wavelike submission of multi-core jobs detected
    - ➔ Slots of ending multi-core job become occupied by single-core jobs when no more multi-core jobs are waiting
    - ➔ Reservations, and degradation of cluster utilization, become permanent

Accounting

- Multi-core jobs are handled correctly by APEL

- Fairshare configurations and accounting at GridKa are based on reserved (aka wallclock) usage
  - Entry in 'qconf -mconf':
    execd_params SHARETREE_RESERVED_USAGE=true \
    ACCT_RESERVED_USAGE=true

Conclusions

- UGE provides knobs to boost multi-core jobs
  - max_reservations
- Reservations bring degradation in cluster utilization because the job mix arriving at our site prevents effective backfilling
  - Average job execution time (2013): 5.6 h
  - No declarations of the estimated job runtime
- Degratation of utilization depending on max_reservation configurations
  - Up to around 0.5 % idling per 10 reservations
- Wavelike submission of multi-core job detected
  - Slots of ending multi-core job become occupied by single-core jobs when no more multi-core jobs are waiting
  - Causing new reservations when multi-core jobs are submitted again