EMCON Technologies℠

Sun Grid Engine Workshop 2007

Internal/External Resource Management

FlexLM Integration (via load sensors)

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Company Information

- OEM emission technology – light and commercial vehicles
  - $3 billion business, 19 countries, 7,500 employees
  - privately owned – One Equity Partners (JPMorgan Chase & Co)

- Simulation in Augsburg (Europe/Asia Headquarters)
  - Acoustics, CFD, FEA
  - 60-cpu Linux cluster
  - Abaqus, GT-Power, Nastran, OpenFOAM, Star-CD

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Resource Management Goals

- Integrate shared external resource
  - eg, software licenses
- Reliable scheduling without collisions
- Give *GridEngine* maximum control
- Simple installation / maintenance

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Terminology

- Load Sensors
  - *qconf -sconf global*
    - load_sensor pathToLoadsensor
    - load_report_time 00:00:60
- Non-Managed Complexes
  - *qconf -se global*
    - complex_values NONE
- Managed Complexes
  - *qconf -se global*
    - complex_values attr=value[,attr=value,…]

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Terminology (2)

- Internal Count
  - Total number of allocated consumable complexes
  - *qstat -u * -xml -r -s prs*

```
<?xml version='1.0'?>
<job_info  xmlns:xsd="http://www.w3.org/2001/XMLSchema">
<queue_info>
<job_list state="running">
    <JB_job_number>jobNumber</JB_job_number>
    <JB_owner>userName</JB_owner>
    <state>[prs]</state>
    <queue_name>queue@host.domain</queue_name>
    <slots>N</slots>
   <hard_request name="license“ …>N</hard_request>
</job_list>
</queue_info>
</job_info>
```


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Standard Resource Management Approaches

- Consumable Resource Management
  - Managed consumables
  - No load sensor
- Simple Load Sensor Management
  - No managed consumables
  - Load sensor
- Combined Load Sensor Management
  - Managed consumables
  - Load sensor

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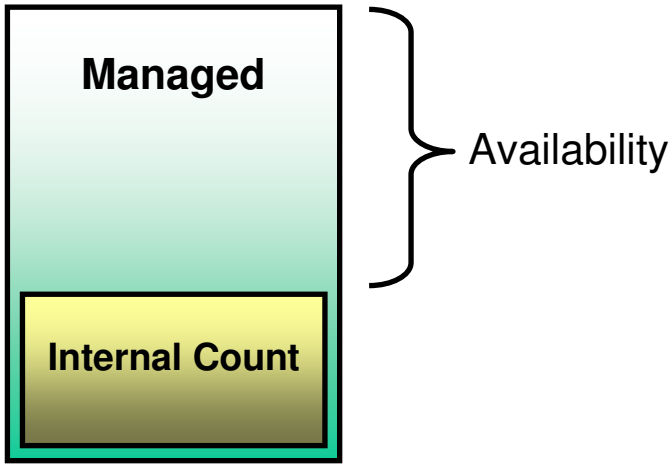
Consumable Management

- No load sensor report for this complex
- Managed consumables
  - complex_values != NONE
- Resource Availability
  = total - internal
- Pros
  - Correct internal accounting
  - No internal race condition
- Cons
  - No external information!



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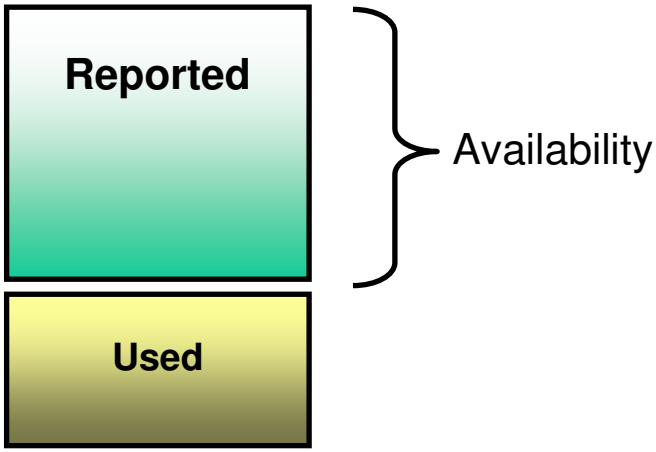
Simple Load Sensor Management

- Non-managed consumables
  - complex_values == NONE
- Load sensor report for this complex

```
begin
global:resource:N
end
```

- Resource Availability
  = reported
- Pros
  - External information
- Cons
  - No internal accounting!



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Simple Load Sensor Management (2)

- Possible Race Condition?
  - *"Unfortunately, due to the loadsensor's delay, it can't be 100% excluded that batch jobs are dispatched and started although the license has been acquired by an interactive job."* †
- Not really race condition … more of a crash!

† http://gridengine.sunsource.net/project/gridengine/howto/resource_management.html

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Example Crash Condition

- Submit N jobs, with "-l license=4“
  - Load sensor: 60 sec
  - Scheduler: 5 sec

- t<0 (no licenses)

complex_values	NONE
(internal_count)	NONE
load_values	license=0
(available)	license=0

- t=0 (licenses become available)

complex_values	NONE
(internal_count)	NONE
load_values	license=4
(available)	license=4

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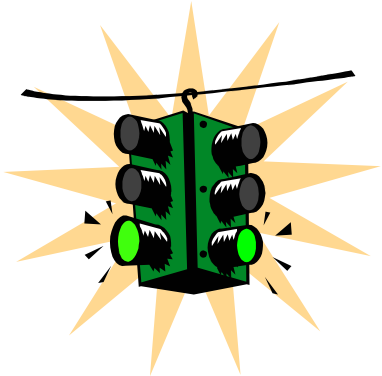
Example Crash Condition (2)

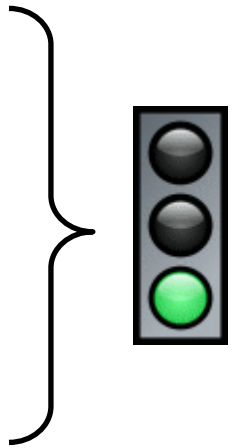
- t=5s (1st interval)
  - available license=4
  - **N** jobs start
  - **N-1 jobs fail**



- t=10s (2nd interval)

…

complex_values	NONE
(internal_count)	NONE
load_values	license=4
(available)	license=4



- t=55s (11th interval)

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Summary – Simple Load Sensor Management

- Fails immediately

Not useful for **any** consumable resource!

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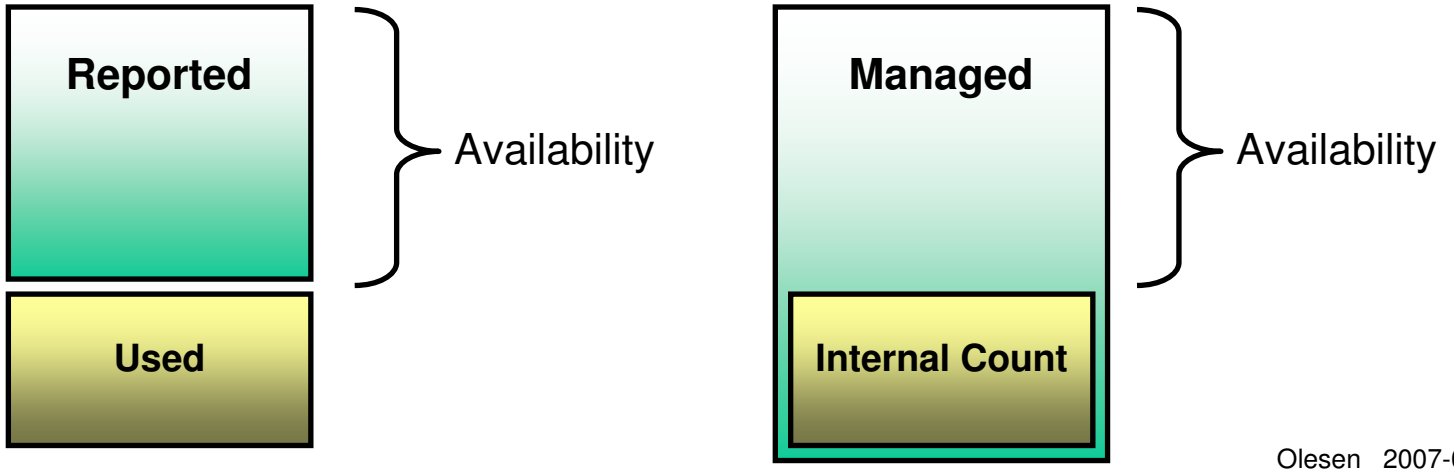
Combined Load Sensor Management

- Load sensor report for this complex

```
begin
global:resource:N
end
```

- Managed consumables
  - complex_values != NONE
- Availability

  = *min*(reported, managed – internal count)



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Combined Load Sensor Management (2)

- Pros
  - Correct internal accounting
  - No internal race condition
  - Additional external information

- Cons
  - None obvious

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Any Crashes?

- Submit 2 jobs, with "-l license=4“
  - Load sensor: 60 sec
  - Scheduler: 5 sec

- t<0 (no licenses)

complex_values	license=4
(internal_count)	NONE
load_values	license=0
(available)	license=0

- t=0 (licenses become available)

complex_values	license=4
(internal_count)	NONE
load_values	license=4
(available)	license=4

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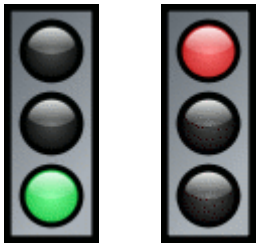
No Crash!

- t=5s (1st interval)
  - available license=4 (but consumable)
  - 1 job starts, 1 job waits



- t=10s (2nd interval)

complex_values	license=4
(internal_count)	license=4
load_values	license=4
(available)	license=0

…

- t=60s (report interval)

complex_values	license=4
(internal_count)	license=4
load_values	license=0
(available)	license=0

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Really No Crashes?

- Submit 2 jobs, with "-l license=2“

- t<0 (no licenses)

complex_values	license=4
(internal_count)	NONE
load_values	license=0
(available)	license=0

- t=0 (some licenses become available)

complex_values	license=4
(internal_count)	NONE
load_values	license=2
(available)	license=2

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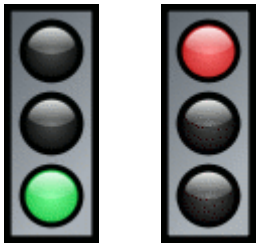
Fewer Crashes

- t=5s (1st interval)
  - available license=2 (but consumable)
  - 1 job starts, 1 job waits



- t=10s (2nd interval)

complex_values	license=4
(internal_count)	license=2
load_values	license=2
(available)	license=2

  - **HELP – the 2nd job starts!!**

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Summary – Combined Load Sensor Management

- No crashes if resources are exclusive to GridEngine
  - *Just use internal resource management instead*

Not useful for shared consumable resources!

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The *only* solution?

- Let *GridEngine* do the bookkeeping
  - Add some of our own creative bookkeeping
- Don't *use* load sensors
  - But misuse them if desired
- Reference Implementation *'qlicserver'*
  - http://gridengine.sunsource.net/servlets/ProjectDocumentList
  - http://gridengine.info/files/qlicserver-1.26.tar.gz

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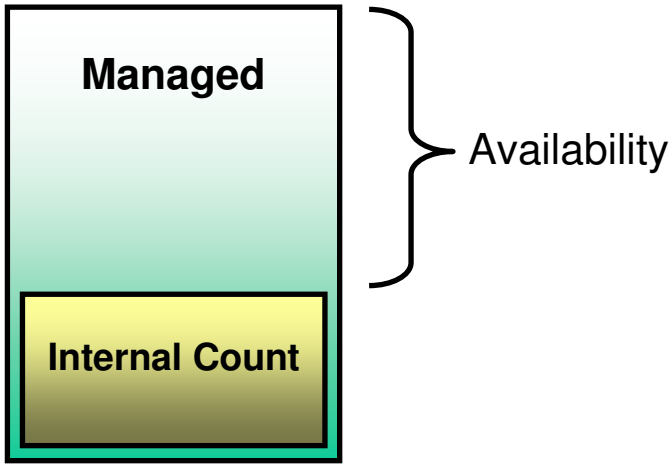
The Adjustable Resource Management Approach

- No load sensor report for this complex
- Managed consumables
  - adjust complex_values *on-the-fly*
- Resource Availability
  = managed – internal count
- Pros
  - More correct accounting
  - Fewer race conditions
- Cons
  - Need some code to adjust values



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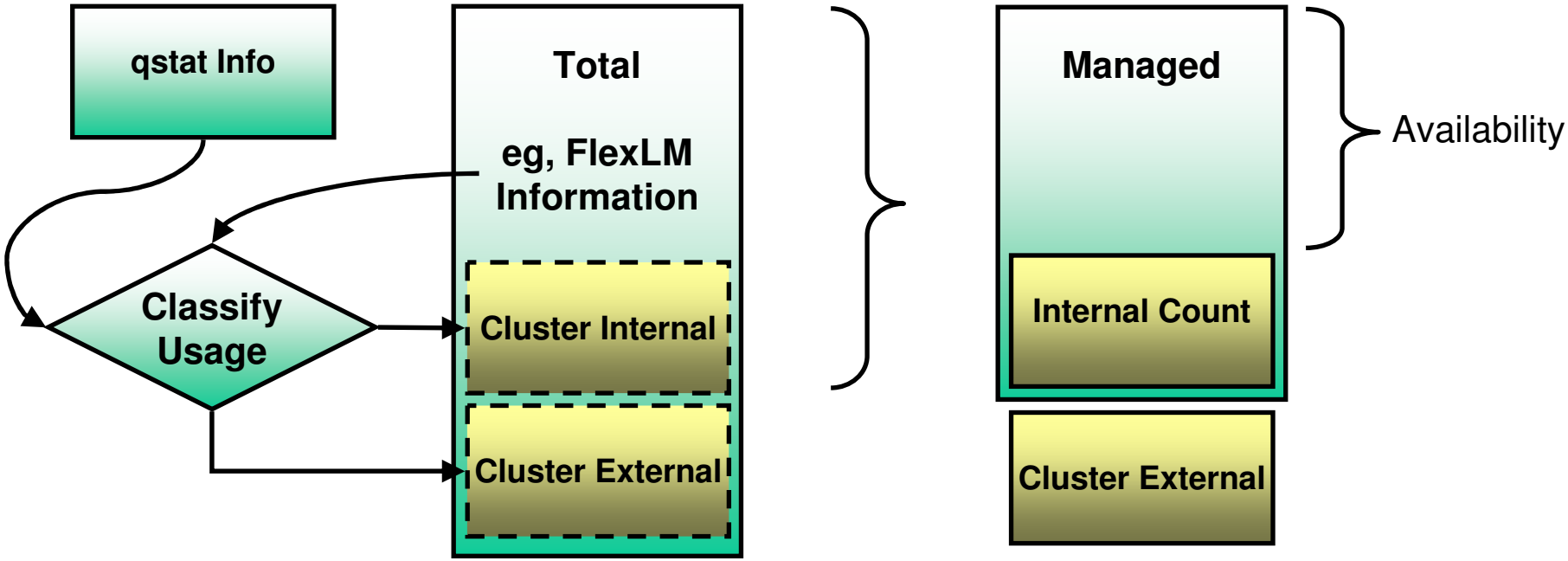
Overview – Adjustable Resource Management

- Adjustment of managed complexes
  - *qconf -mattr exechost complex_values … global*

- *Classification*



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Classification – Adjustable Resource Management

- Sample FlexLM output
  - *lmutil lmstat –a –c $LM_LICENSE_FILE*

Users of **NASTRAN**: (Total of **3** licenses issued; Total of 3 licenses in use)
"NASTRAN" v2006.1130, vendor: MSC
floating license
user1 host1 /dev/tty (v2003.0715) (server/27005 566), start Mon 8/27 18:29
user1 host2 /dev/tty (v2003.0715) (server/27005 488), start Mon 8/27 18:44
user2 host3 /dev/tty (v2005.0501) (server/27005 354), start Mon 8/27 19:41

- Extract
  - feature user@host nLicenses

- Re-cast FlexLM *feature* → GridEngine *complex*
  - eg, “GTpowerX” → “gtpower”

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Classification (2) – Adjustable Resource Management

- What is external usage*?*
  - Any feature/user@host combination not matched in *qstat -u * -xml -r -s prs*

- Matching heuristics
  - Best match for parallel jobs
    - feature/user@host with nLicenses == nSlots
  - But also consider “flattened” results

- Managed

  = Total – External

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Adjustment – Adjustable Resource Management

- *Query current definitions*
  - *qconf –se exec global*
    - *complex_values … global*
- *Modify as required*
  - *qconf -mattr exechost complex_values … global*
- *Implementation in Perl*
  - *Portable. No compilation required*
  - *Regular expressions, threads, etc.*
  - *Quickly modified*
  - *Fast enough*

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Where to bolt this in?

1. Must run periodically
   - daemon or cron process are okay

2. Failsafe
   - avoid '*qconf*' on a stopped cluster
   - handle qmaster migration

3. "Startsafe"
   - Always start with the qmaster

4. Allow some diagnostics (nice to have)
   - eg, cache results – allows *qlic* auxiliary program

- Convenient solution
  - Use a load sensor on the qmaster to call *qlicserver*

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Characteristics of qloadsensor

- qmaster host(s) should be admin and exec hosts
  - eg, add queue with 0 slots

- Load sensor code snippet

```
while :
do
        read input || exit 1
        [ "$input" = quit ] && exit 0
        echo begin
         …
        echo end
        # qlicserver runs between load reports
        # monitor SGE_CELL/common/act_qmaster to catch migration
        if [ “$HOST” = “$SGE_qmaster”]; then
                # cache results (for diagnosis)
                $SGE_site/qlicserver >| $cache_file.TMP 2>> qloadsensor.err
                [ -s $cache_file.TMP ] && cat $cache_file.TMP >| $cache_file
        fi
done
exit 0
```


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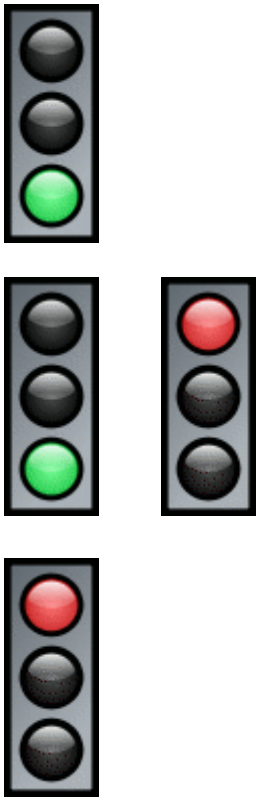
Crash Analysis

- Submit 2 jobs, with "-l license=4“
  - Modification interval: 60 sec
  - Scheduler: 5 sec
- t=0 (licenses become available)

complex_values	license=4
(internal_count)	NONE
(external_count)	license=0
(available)	license=4

- t=5s (1st interval)
  - 1 job starts, 1 job waits
- t=10s (2nd interval)

complex_values	license=4
(internal_count)	license=4
(external_count)	license=0
(available)	license=0



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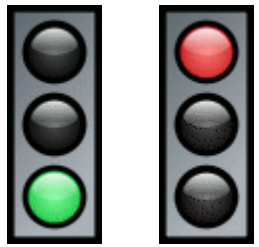
Crash Analysis (2)

- Submit 2 jobs, with "-l license=2“
- t=0 (some licenses available)

complex_values	license=2
(internal_count)	NONE
(external_count)	license=2
(available)	license=2

- t=5s (1st interval)
  - 1 job starts, 1 job waits



- t=10s (2nd interval)

complex_values	license=2
(internal_count)	license=2
(external_count)	license=2
(available)	license=0

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Remaining Race Condition

- t=0 (all licenses available)

complex_values	license=4
(internal_count)	NONE
(external_count)	license=0
(available)	license=4

- t=10s – start external job with license=4

complex_values	license=4
(internal_count)	NONE
(external_count)	license=0
(available)	license=4

- t=20s – submit job with "-l license=4“
  - **HELP – the job starts!!**
  - Check availability in prolog
    - exit 99 (resubmit)

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Remaining Race Condition

- t=0 (all licenses available)

complex_values	license=4
(internal_count)	NONE
(external_count)	license=0
(available)	license=4

- t=9.5s – start external job with license=1

- t=10s – start job with "-l license=4“
  - Prolog check ok
  - External job acquired licenses after prolog check
  - **Race condition**

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Summary – Adjustable Resource Management

- No collisions
- Prolog check avoids many race conditions
- Remaining race condition
  - perhaps minor?

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qlicserver – Quick Install

- Download qlicserver package
  - *qlicserver –h* # -h = help
- Environment settings
  - export LM_LICENSE_FILE=…
- Query FlexLM features
  - *qlicserver -i* # -i = info

```
lookup => {  # license features from server
  "-GTise"   => "gtise",   ## reported but unmanaged
  "GTpowerX" => "gtpower",
  "GTtools"  => "gttools", ## new
},
```


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qlicserver – Quick Install (2)

- Edit qlicserver code
  - Add ‘lookup’ and other config entries
  - No external configuration file – no parse problems
  - External ‘limit’ could be useful

- Add new complex definitions
  - *qlicserver –c* # -c = complex
  - *qconf –mc* …

- Initialize managed complexes
  - *qlicserver -C* # -C = complex
  - *qconf -mattr exechost complex_values … global*

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qlicserver – Quick Install (3)

- Dry-run
  - *qlicserver -n* # '-n' = as per make

- Add into load sensor script
  - Normally triggers automatic re-read
  - daemon mode at your own risk

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Problem Diagnosis using *qlic*

- Check overall usage
  - *qlic*
- Who is using which licenses, where
  - *qlic –w* # -w = who/where
- Query what *qhost -F* is reporting
  - *qlic –q* # -q = query
- View cache contents
  - *qlic –d* # -d = dump

```
host = dealog01
age  = 0:00:43

feature       total limit extern intern wait free
-------       ----- ----- ------ ------ ---- ----
abaqus           12     .      .      5    .    7
ansys             1     .      .      *    .    1
foam             40     .      *      .    .   40
gtise             4     .      2      *    .    2
gtpower           7     4      .      .    .    4
hexa              2     .      .      *    .    2
med               3     .      .      *    .    3
nastran           4     3      .      3    5    .
proam             4     .      .      *    .    4
prostar           2     .      2      *    .    .
starcd           28    26      .     16    .   10
starjob           4     .      .      1    .    3
starp            24     .      .     16    .    8
stars             4     2      .      .    .    2
tetra             1     .      .      *    .    1
thomat            .     .      .      .    .    .
```


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Prolog Safety Net

- Get requested resources
  - *rclist=`qstat -r -j $JOB_ID | sed -ne 's/^.*hard *resource_list: *//p'`*
- Check availability
  - *available=`qlicserver –l $rclist,slots=$NSLOTS,JOB_ID=$JOB_ID`*
  - *exitcode=$?*
- Exit 99 (re-queue) or other
  - *exit $exitcode*
- Caveat
  - *qstat* requires exec host be a submit host!

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Conclusions

- Adjustable Resource Management
  - best method for shared external resources
  - avoids most race conditions (with prolog check)
- Remaining race condition
  - difficult to avoid
  - hopefully infrequent
- *qlicserver* and *qlic* implementations
  - simple installation, integration and maintenance
  - in production use since 2005

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Possible Future Developments

- Config file for particular options
  - eg, limits (in testing)
- Cache qstat queries (in testing)
- Integrate with xml-qstat
  - eg, harmonize cache format
- Any new requirements with 6.1 quotas?
- Sharing licenses between clusters
  - is a problem

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