Grid Engine Administration

Configuration

This module covers

- Command line operation
- Host & hostgroup configuration
- ‘Cluster’ configuration
- Queue configuration
- Parallel Environments
- Resources & SGE Complex
- Load Sensors
- User access

Command-line Operation

Small number of binaries, but …

- … many arguments and options
- Must read the manpage for these commands to appreciate them

- `qconf`
- `qstat`
- `qmod`
- `qalter`
- `qdel`
- …
- `qsub|qrsh`

Core admin commands

- qconf
  - Primary admin tool for adding/changing/configuring just about everything in a Grid Engine system
- qstat | qhost
  - Primary tools for monitoring
- qmod
  - Modify|disable an existing queue, clear error states …
- qalter
  - Change attribute of pending job

Advanced Admin Syntax …

- Nobody uses ‘qmon’
- Most admins use “qconf -[smA]”
- Hardcore admins use “qconf -[adm]rattr”
- Wizards use “qconf -purge”

SGE Command Meta Syntax

- Template Driven
  - *Add* from file based template
    - `-A<cmd>  <param1> <param2> …`
  - *Delete* from file based template
    - `-D<cmd>  <param1> <param2> …`
  - *Modify* from file based template
    - `-M<cmd>  <param1> <param2> …`
- Example
  - Add a new parallel environment from file
    - `qconf -Ap ./my-predefined-parallel-environment.txt`

SGE Command Meta Syntax

- Interactive Use
  - *Add* something
    - `-a<cmd>  <param>`
  - *Delete* something
    - `-d<cmd>  <param>`
  - *Modify* something
    - `-m<cmd>  <param>`
  - *Show* something
    - `-s<cmd>  <param>`
- Example
  - Add a new parallel environment interactively
    - `qconf -ap`
    - … SGE will then open an interactive editor session
      - SGE uses ‘vi’ or whatever is defined by $EDITOR
    - Assuming no syntax error, changes are instantly made live

Meta Syntax Summary

- -A|a (add)
- -D|d (delete)
- -M|m (modify)
- -s (show)

- Capitalized argument means ‘read in from file’
- Lowercase means ‘do it interactively’
  - All SGE commands generally follow this structure
  - Read manpage for ‘qconf’ to see this in action

Configuring Hosts & Hostgroups

Hardcore: qconf -[admr]attr

- Non interactive, very scriptable
- Add, delete, modify, replace
- Primarily for list attributes

Hardcore: qconf -[admr]attr

- Syntax
  - `-[admr]attr obj_name attr_name value=[v] obj_id_lst`
- "*Add host, node1, to hostgroup @allhosts*"
  - `qconf -aattr hostgroup hostlist node1 @allhosts`
- "*Change np_load_avg to 2 in load_thresholds in the all.q cluster queue*"
  - `qconf -mattr queue load_thresholds np_load_avg=2 all.q`

Hardcore: Modify vs Replace

- -mattr changes the value of *a setting*
- -rattr replaces *the entire list* of settings

- Thought Exercise
  - Assume:
    - `load_thresholds np_load_avg=2,mem_used=2G`

- What is the effect of:
- `qconf -mattr queue load_thresholds np_load_avg=3 all.q`
- `qconf -rattr queue load_thresholds np_load_avg=2 all.q`

Hardcore: Modify vs Replace

- Thought Exercise Solution (-mattr)
- Command:
  - qconf -mattr queue load_thresholds np_load_avg=2 all.q
- Result:
  - load_thresholds np_load_avg=2, mem_used=2G

Hardcore: Modify vs Replace

- Thought Exercise Solution (-rattr)
- Command:
  - qconf -rattr queue load_thresholds np_load_avg=2 all.q
- Result:
  - load_thresholds np_load_avg=2

Hardcore: Replace vs. Purge

- Replace (-rattr) is for list attributes
  - Any attribute, not limited in scope to queues
- Purge (-purge) ONLY for queue instances
  - Removes any overridden settings
  - Example
    - "*Remove host-specific slots settings for node01 in all.q …*"
    - `qconf -purge queue slots all.q@node01`

Class Exercise:

- Create a new PE object called “dummy”
- Do all of the following without using ‘qmon’ or the ‘qconf -[Am]’ syntax …

1. Create a PE called dummy (via qconf -ap)
2. Add dummy to all.q
3. Remove make from all.q
4. Make make the only PE for all.q
5. Change load_thresholds setting to “np_load_avg=4”
6. Blow away all slot settings from all.q for any single queue instance
7. Extra: Add a slots setting for all.q for any single queue instance

Lab Solution

1. `qconf -aattr queue pe_list dummy all.q`
2. `qconf -dattr queue pe_list dummy all.q`
3. `qconf -rattr queue pe_list make all.q`
4. `qconf -mattr queue load_thresholds np_load_avg=4 all.q`
5. `qconf -purge queue slots all.q@node`
6. Bonus:
   `qconf -aattr queue slots '[node01=4]' all.q`

Hostgroups

- Convenient way to group hosts
- Hostgroup names must start with “@”
  - `@allhosts`
  - `@bigMemoryhosts`
  - `@1024CPUhosts`
- Hostgroup objects can be used …
  - Queue configurations, access control lists, qsub arguments, etc.

  - `qsub -q all.q@@bigMemoryhosts ./myjob.sh`

Some host group commands

- *New hostgroup (interactive)*
  - `qconf -ahgrp @<name>`
- *New hostgroup (from template file)*
  - `qconf -Ahgrp ./my-predefined-hostgroup.txt`
- *Modify hostgroup (interactive)*
  - `qconf -mhgrp @<name>`
- *List all configured hostgroups*
  - `qconf -shgrpl`
- *Show an existing hostgroup*
  - `qconf -shgrp @<name>`
    - `Example:  qconf -shgrp @allhosts`

Related: Reserved hostnames

- These hostnames can not be used within a Grid Engine system:
  - `global`
  - `template`
  - `all`
  - `default`
  - `unknown`
  - `none`

Some host configuration commands

- *List all execution hosts*
  - `qconf -sel`
- *Modify execution host*
  - `qconf -me <hostname>`
- *Delete execution host*
  - `qconf -de <hostname>`
- *Show* execution host configuration
  - `qconf -se <hostname>`

```
dag$ qconf -se chrisdag-aliased
hostname              dag-static
load_scaling          NONE
complex_values        NONE
load_values           arch=darwin-x86,num_proc=2,mem_total=4096.000000M, \
                      swap_total=0.000000M,virtual_total=4096.000000M, \
                      load_avg=0.558594,load_short=0.344238, \
                      load_medium=0.558594,load_long=0.482910, \
                      mem_free=119.156250M,swap_free=0.000000M, \
                      virtual_free=119.156250M,mem_used=3976.843750M, \
                      swap_used=0.000000M,virtual_used=3976.843750M, \
                      cpu=19.300000,np_load_avg=0.279297, \
                      np_load_short=0.172119,np_load_medium=0.279297, \
                      np_load_long=0.241455
processors            2
user_lists            NONE
xuser_lists           NONE
projects              NONE
xprojects             NONE
usage_scaling         NONE
report_variables      NONE
```

Host configuration parameters

- `hostname`
  - Hostname as SGE understands it
- `load_scaling`
  - Comma separated list of scaling factors to be applied to load values being reported by the sge_execd. Format: <load value>=<multiplier>, ..
- `complex_values`
  - Comma separated list. Sets value of host-managed resource attributes. Compared against available consumable resources listed in the SGE complex
    - For consumable resources, this can set a “quota” on new jobs. If the sum of resources consumed by running tasks exceeds a value defined here, no jobs can be placed
    - For non consumable resources, simple relop comparison occurs between job requests, SGE complex and the value reported here. If “true”, job can land on this host.

Host configuration parameters

- `load_values & processors`
  - *Can't be changed here, included so that "qconf -se" shows them*
- `usage_scaling`
  - Same format as load_scaling. Usefulness unknown. Only currently works with "mem=" and "cpu=".
- `user_lists & xuser_lists`
  - Comma separated list of named access lists defining who can and cannot make use of this host. If user is listed in both places, access will be denied.
- `projects & xprojects`
  - Same behavior as user lists applied to project membership
- `report_variables`
  - If reporting file is enabled, report this comma separate list of values into it. Settings here will override anything done at a global level

SGE “Cluster” Configuration

Cluster configuration

- “Cluster” means:
  - SGE information about site dependencies and configuration settings
- Show
  - `qconf -sconf | qconf -sconf global`
  - `qconf -sconf <host>`
- Modify / Edit
  - `qconf -mconf | qconf -sconf global`
  - `qconf -mconf <host>`

SGE ‘Cluster’ Config Params

```
# qconf -sconf
global:
execd_spool_dir              /opt/sge61/default/spool
mailer                       /usr/bin/mail
xterm                        /usr/X11R6/bin/xterm
load_sensor                  none
prolog                       none
epilog                       none
shell_start_mode             posix_compliant
login_shells                 sh,ksh,csh,tcsh
min_uid                      0
min_gid                      0
user_lists                   none
xuser_lists                  none
projects                     none
xprojects                    none
enforce_project              false
enforce_user                 auto
load_report_time             00:00:40
max_unheard                  00:05:00
reschedule_unknown           00:00:00
loglevel                     log_warning
administrator_mail           none
set_token_cmd                none
pag_cmd                      none
token_extend_time            none
shepherd_cmd                 none
qmaster_params               none
execd_params                 none
reporting_params
    accounting=true reporting=false \
    flush_time=00:00:15 joblog=false \
    sharelog=00:00:00
finished_jobs                100
gid_range                    20000-20100
qlogin_command               telnet
qlogin_daemon                /usr/libexec/telnetd
rlogin_daemon                /usr/libexec/rlogind
max_aj_instances             2000
max_aj_tasks                 75000
max_u_jobs                   0
max_jobs                     0
auto_user_oticket            0
auto_user_fshare             0
auto_user_default_project    none
auto_user_delete_time        86400
delegated_file_staging       false
Reprioritize                 0
```

Host ‘cluster’ settings

```
# qconf -sconf chrisdag-aliased
chrisdag-aliased:
mailer                          /usr/bin/mail
xterm                           /usr/X11R6/bin/xterm
qlogin_daemon                   /usr/libexec/telnetd
rlogin_daemon                   /usr/libexec/rlogind
```

Some cluster configuration parameters

- Full explanation of all parameters
  - sge_conf (5) man page

- `load_sensor`
  - Path to script for reporting custom load values, if configured here script will be run on ALL hosts in the cluster
- `prolog & epilog`
  - Global scripts that can be invoked before|after any job
- `shell_start_mode`
  - posix_compliant
    - POSIX batch standard says that systems must ignore first line of all scripts in favor of globally configured shell or user configured shell ("qsub -S /bin/csh …")
  - unix_behavior
    - Honor the environment defined by 1st line in a job script

Some cluster configuration parameters

- `reschedule_unknown`
  - Time to wait after a host enters ‘unknown’ state before rescheduling a job elsewhere
    - Lots of caveats, read the manpage …
- `max_unheard`
  - Mark queue instance in “u” state when no communication received within this interval. Docs say default is “00:2:30” but it may actually be “00:5:00”
- `loglevel = log_err | log_warn | log_info`
  - Adjusts detail/verbosity of the various messages files
  - Useful for debugging and troubleshooting, Default level is “log_info”
- `max_u_jobs & max_jobs`
  - “big stick” approach. Sets global limits on how many jobs can be in the system at one time.
- `qmaster_params, execd_params, reporting_params`
  - Check the sge_conf (5) man page, lots of good stuff can be configured here

More on shell_start_mode

- unix_behavior
  - Scripts: honor the “#!” line of jobscript
  - Binaries: honor the shell named by the queues shell attribute
- posix_compliant
  - Scripts & Binaries: always use queue shell attribute
  - Note: overridden by “-S <shell>” argument or embedded qsub option
- script_from_stdin
  - While still root, read in script
  - Feed script to shell via STDIN
  - Honor the queue shell attribute

shell_start_mode behavior

	Script	Binary
unix_behavior	Shell named by #! line of script	Shell named by queue's shell attribute
posix_compliant	Shell named by queue's shell attribute	Shell named by queue's shell attribute
script_from_stdin	Shell named by queue's shell attribute	Shell named by queue's shell attribute*

* script_from_stdin is ignored

Credit: Dan Templeton

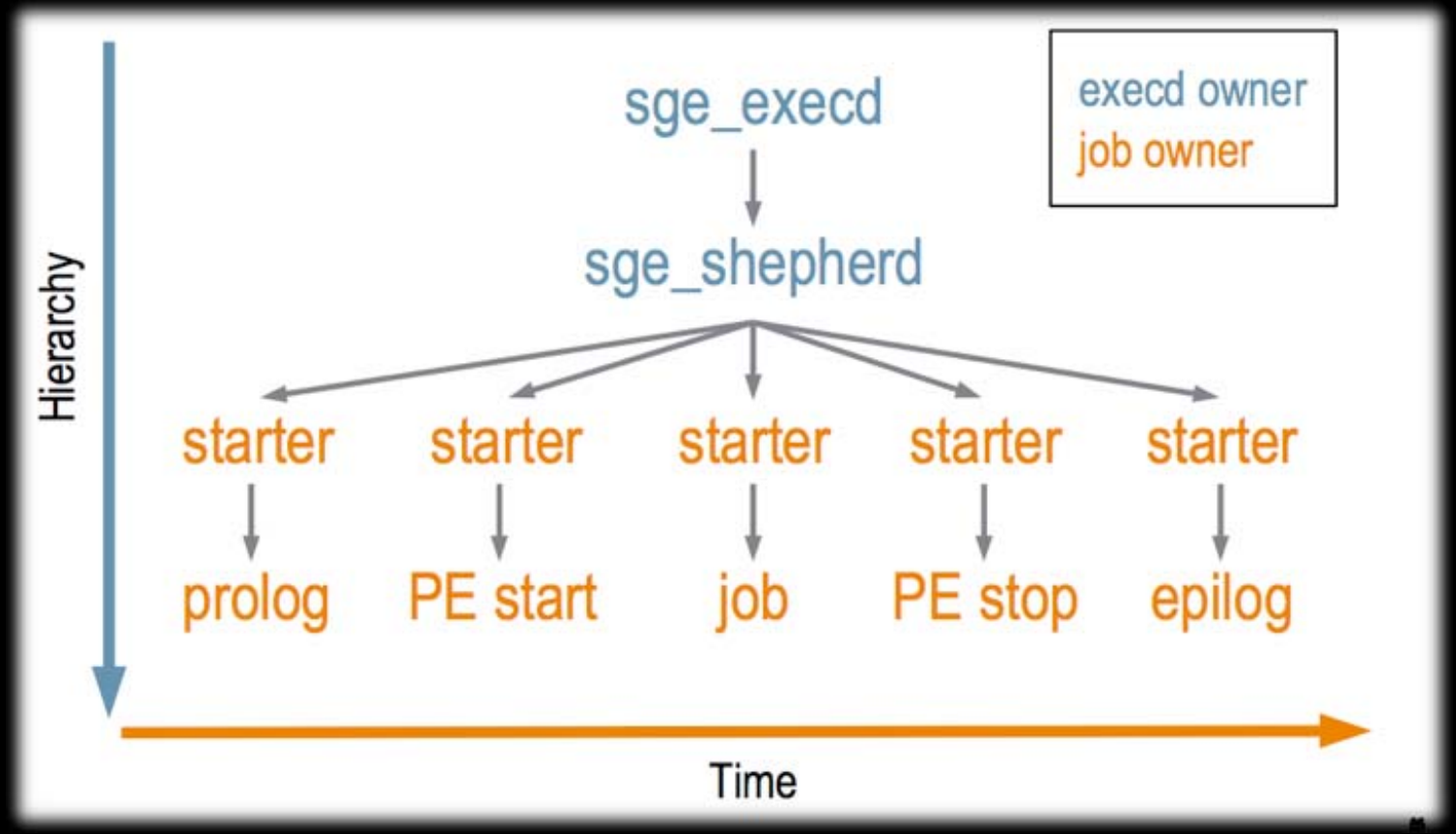
shell_start_mode: Override

- Passing the '-S <shell>' argument will override default shell selection when:
  - posix_compliant or script_from_stdin
- Ultimate Override
  - Configure a custom starter_method
    - Bypasses all other job launching hooks
    - Runs as job owner
    - Arbitrary script used to invoke the job

More on Prolog/Epilog

- Same starter rules as job
  - Except shell_start_mode always “unix_behavior”
- Has same ENV as job context
- Started by sge_shepherd
  - Runs under UID of job submitter
  - “Bookends” PE start/stop methods
- Which gets precedence?
  - Queue overrides Host overrides Global

Remember this?



Final word on Prolog/Epilog

- “Magic” exit codes of 99 and 100 can be used with prolog/epilog scripts
- Exit status code 0 means “success”
- Any other code means failure
  - This can hurt you badly
  - Prolog/Epilog scripts need to be robust and should not throw exit errors lightly
    - Why? Your queues go into E state

SGE Queue Configuration

Queue Configuration

- The usual syntax applies
  - “Show me”
    - `qconf -sq <queue name>`
  - “Let me change it”
    - `qconf -mq <queue name>`
  - “Show me all”
    - `qconf -sql`

```
# qconf -sq all.q
qname                 all.q
hostlist              @allhosts
seq_no                0
load_thresholds       np_load_avg=4.0
suspend_thresholds    NONE
nsuspend              1
suspend_interval      00:05:00
priority              0
min_cpu_interval      00:05:00
processors            UNDEFINED
qtype                 BATCH INTERACTIVE
ckpt_list             NONE
pe_list               make
rerun                 FALSE
slots                 4,[chrisdag-aliased=4]
tmpdir                /tmp
shell                 /bin/csh
prolog                NONE
epilog                NONE
shell_start_mode      posix_compliant
starter_method        NONE
suspend_method        NONE
resume_method         NONE
terminate_method      NONE
notify                00:00:60
owner_list            NONE
user_lists            NONE
xuser_lists           NONE
subordinate_list      NONE
complex_values        NONE
projects              NONE
xprojects             NONE
calendar              NONE
initial_state         default
s_rt                  INFINITY
h_rt                  INFINITY
s_cpu                 INFINITY
h_cpu                 INFINITY
s_fsize               INFINITY
h_fsize               INFINITY
s_data                INFINITY
h_data                INFINITY
s_stack               INFINITY
h_stack               INFINITY
s_core                INFINITY
h_core                INFINITY
s_rss                 INFINITY
h_rss                 INFINITY
s_vmem                INFINITY
h_vmem                INFINITY
```

Some interesting queue params

- `hostlist`
  - Whitespace or comma-separated. Can use hostnames or host groups.
  - *In SGE 6.1 the syntax will get even more flexible*
- `seq_no`
  - Use to influence exec host selection when all other thing are equal
- `load_threshold`
  - When threshold is exceeded, no new jobs are placed on host
  - Can use built-in values or values reported by custom load sensors (example: 'logged-in-users=5'). Default: "np_load_avg=1.75"
- `suspend_threshold, nsuspend, suspend_interval`
  - Similar to load_threshold but running jobs will actually be suspended/stopped. The 'nsuspend' param determines how many jobs per interval get suspend signals. 'suspend_interval' defaultsto 00:05:00.

Some interesting queue params

- `qtype`
  - Only “B” or “I” in 6.x
  - Parallel (“P”) and Checkpoint (“C”) are implicit if configured into queue config
- `pe_list`
  - What parallel environment (PE) objects this queue supports
- `slots`
  - Max number of tasks or jobs that this queue supports
- `shell_start_mode`
  - Same behavior as in cluster config
  - `unix_behavior`, `posix_compliant` …
- `prolog & epilog`
  - Same behavior as in cluster config. Custom scripts that run before|after a job
- `suspend_method, terminate_method, resume_method`
  - Used to override default signals SGE sends
  - Can also configure a path to a script that will run to handle these conditions

Some interesting queue params

- `owner_list`
  - Can delegate queue specific suspend/resume authority to named users
- `user_lists, xuser_lists`
  - Same behavior as in cluster config
- `subordinate_list`
  - Trigger suspension of less important queue instances on same host when value is exceeded
  - Syntax is a bit odd
    - <queue to suspend> = <slots in THIS queue that must be filled to trigger suspend>
- `complex_values`
  - Same behavior as in cluster config

Queue Hard & Soft Limits

- Soft Limits
  - `s_cpu`
    - per-process CPU time limit in seconds.
  - `s_core`
    - per-process maximum core file size in bytes.
  - `s_data`
    - per-process maximum memory limit in bytes.
  - `s_vmem`
    - same as s_data (if both are set the minimum is used).
- Hard Limits
  - `h_cpu`
    - per-job CPU time limit in seconds.
  - `h_data`
    - per-job maximum memory limit in bytes.
  - `h_vmem`
    - same as h_data (if both are set the minimum is used).
  - `h_fsize`
    - total number of disk blocks that this job can create.

How soft limits work

1. Job exceeds limit defined by a `s_*` value
2. Warning signal sent if “notify” is enabled
   - App should trap for these
     - For “`s_rt`” the signal is `SIGXUSR1`
     - For “`s_cpu`” the signal is `SIGXCPU`
3. If configurable “notify” period passes …
   - Job is sent a `SIGSTOP` signal (?)

How hard limits work

1. Job exceeds limit defined by a `h_*` value
2. Warning signal sent if “notify” is enabled
   - App should trap for these
   - When notify is enabled, these are sent before `SIGKILL`:
     - For “`h_rt`” the signal is `SIGXUSR2`
     - For “`h_cpu`” the signal is `SIGXUSR2`
3. Jobs exceeding `h_*` get `SIGKILL` signals

Trivial epilog usage - I

```
#!/bin/sh
# Simple epilog script

JOB_EXIT_STATUS="`sed -ne 's/^exit_status=//p' \
   $SGE_JOB_SPOOL_DIR/usage | tail -1`"

echo "--------"
echo "Job exited code: $JOB_EXIT_STATUS"
echo "--------"
```

Trivial epilog usage - II

```
…

STARVEDETECT="`grep -c "Licensed number of users already reached" \
   $SGE_O_WORKDIR/*.log `"

  if [ $STARVEDETECT -gt 0 ]
   then
     echo "License Error Pattern Detected in Output!"
      /bin/tcsh -c "cd $SGE_O_WORKDIR; \
     /cl/sw/bin/restart-failed-job.pl "
   else
     echo "No problems detected"
  fi

...
```

Queue Exercises

About the exercises

- Normally done live by attendees on demo clusters
  - Helps break up the boredom
- A set of progressively more interesting queue and policy configurations
- Goal: start simple and build towards an ideal configuration

Exercise: Priority Queues #1

- First pass approach
  1. Create 3 queues on your system
     - low.q, regular.q and high.q
  2. Make slot count equal to CPU count
  3. Set load_thresholds to NONE
  4. Set priority values on all queues
     - high.q = -20, low.q = 20
  5. Test all queues with simple.sh

Review - Priority Queues #1

- Queue priority parameter
  - -20 to +20 (*Lower is higher …*)
  - UNIX nice value
  - Has *nothing* to do with scheduling
  - Has *nothing* to do with “qsub -P … “
- Scheduler not looking at load

Review - Priority Queues #1

- What we did
  - Trivial approach to priority queues
  - UNIX nice values applied differently to tasks in each queue will have the effect of “prioritizing” low vs. high vs. regular jobs
- Concerns
  - Leaves “scheduling” to the OS
  - Possible to oversubscribe a system
  - No penalty for misuse of high.q
- *We can do better …*

Exercise: Priority Queues #2

- Same queue structure as #1
  1. Set notify to 60 for regular.q
  2. Set a soft wall clock limit for regular.q
     - 24 hours (86400 seconds)
  3. Set soft CPU time limit for high.q
     - 9 minutes (540 seconds)
  4. Set a hard CPU time limit for high.q
     - 10 minutes (600 seconds)

Review: Priority Queues #2

- Solution
  1. qconf -rattr queue notify 60 regular.q
  2. qconf -rattr queue s_rt 86400 regular.q
  3. qconf -rattr queue s_cpu 540 high.q
  4. qconf -rattr queue h_cpu 600 high.q
- Discussion
  - Main result: user behavior change
    - Unlimited use of low.q, strict limits on high.q
  - We can still do better …

Exercise: Priority Queues #3

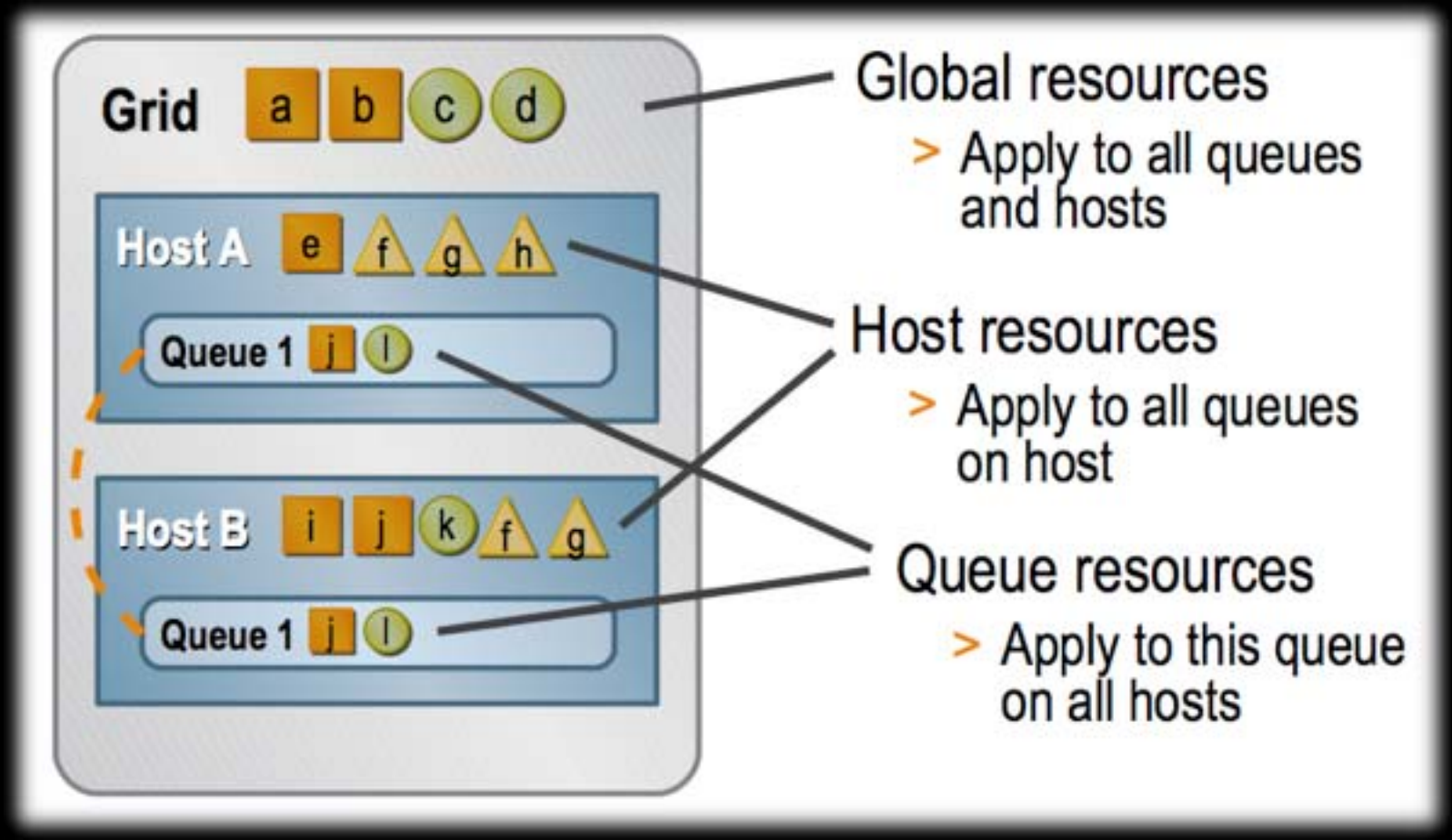
- Slot hacking
  1. Same queue structure as before
  2. Attach “slots=2” as a host resource on all nodes
  3. Submit test jobs to all queues

Review: Priority Queues #3

- The wizard solution:
  - qconf -aattr exechost complex_values slots=2 <host>
- What did we do?
  - Slot limits “solve” the oversubscription problem
  - Still have these problems:
    - FIFO job execution
    - Priority is handled by OS after SGE scheduling
- We can still do better (stay tuned)…

Resources

Resource Hierarchy



Graphic: DanT

Resources

- Three main types
  - Static
  - Consumable
  - Measured

Common Static Resources

- `'arch'`
- `'hostname'`
- *Custom boolean attribute*
  - nodeLockedLicense=1

Common Consumable Resources

- Free memory
- Available swap space
- Available software license entitlement

Common Measured Resources

- Server load
- Idle time
- Swap usage
- ...

How users request resources

- Via the "`-l`" argument
  - Static resource ("arch")
    - `qsub -soft -l arch=darwin-x86 ./myJob.sh`
  - Custom defined, consumable resource
    - `qsub -hard -l ifort=1 ./myCompileScript.sh`

Queue associated resources

- qname
- hostname
- notify
- calendar
- min_cpu_interval
- tmpdir
- seq_no

- s_rt
- h_rt
- s_cpu
- h_cpu
- s_data
- h_data
- s_stack
- h_stack
- s_core
- h_core
- s_rss
- h_rss

Host associated resources

- `slots`
- `s_vmem`
- `h_vmem`
- `s_fsize`
- `h_fsize`

Partial Complex Listing

```
$ qconf -sc

#name               shortcut   type        relop requestable consumable default  urgency
#-------------------------------------------------------------------------------------
arch                a          RESTRING    ==    YES         NO         NONE     0
calendar            c          RESTRING    ==    YES         NO         NONE     0
cpu                 cpu        DOUBLE      >=    YES         NO         0        0
display_win_gui     dwg        BOOL        ==    YES         NO         0        0
h_core              h_core     MEMORY      <=    YES         NO         0        0
h_cpu               h_cpu      TIME        <=    YES         NO         0:0:0    0
h_data              h_data     MEMORY      <=    YES         NO         0        0
h_fsize             h_fsize    MEMORY      <=    YES         NO         0        0
```

Anatomy of resource attribute

- Name
  - Attribute name
- Shortcut
  - Shortcut alias
- Type
  - SGE data type
    - Values: INT, DOUBLE, TIME, MEMORY, BOOL, STRING, CSTRING, RESTRING, HOST
- RelOp
  - Relational operator
    - Values: “==“, “<“, “>”, “<=“, “>=“

Anatomy of resource attribute

- Requestable
  - Is this something a user can request?
- Consumable
  - Does the resource decrease?
- Default
  - Default value when not explcitly requested
- Urgency
  - Increase entitlement of tasks requesting this attribute via the urgency sub-policy

Anatomy of resource attribute

- RESTRING
  - String with regular expression capability
  - 6.0 usage (6.1 expands this a bit …)
    - “*” - Zero or more of any char
    - “?” - Match any one char
    - “.” - This is the “.” char -- no special meaning (!)
    - “\” - Standard escape char
      - "\\" = "\”
      - "*" = "*”
    - “[…]” - Match one of chars within bracket
      - Note: “^” is not interpreted as logical NOT
    - “|” - Logical OR operator

Anatomy of resource attribute

- RESTRING examples
  - `-l arch="*x24*|sol*"`
    - Result:
      - `"arch=lx24-x86" OR "arch=lx24-amd64" OR "arch=sol-sparc" OR "arch=sol-sparc64" OR "arch=sol-x86" OR ...`
  - `-l arch="lx2[4-6]-x86"`
    - Result:
      - `"arch=lx24-x86" OR "arch=lx25-x86" OR "arch=lx26-x86"`

Resource Attribute Configuration

- The usual syntax applies
  - “Show me”
    - `qconf -sc`
  - “Let me change it”
    - `qconf -mc`

Creating custom attributes

1. Create it in the system complex
2. Associate it with one of the following
   - Queue
     - Add to “complex_values” in queue config
   - Host
     - Add to “complex_values” in host config
   - Global
     - (via special “qconf -me global” host setting)

Cliché Example

- Scenario:
  - 5,000 CPU cluster
  - But …
    - Only 50 commercial licenses for Intel Fortran Compiler (“ifort”)
  - The good news
    - Nobody uses ifort outside of the cluster
    - So we don’t need to track usage across the organization
    - Simple limit enforced within SGE will suffice
  - We need to:
    - Create a user requestable, consumable resource that will limit the use of ifort to no more than 50 concurrent jobs
    - How?

Cliché continued …

1. Add attribute to the SGE complex
   - "`qconf -mc`"
   - Insert values:

```
#name       shortcut type  relop req cons def urg
ifort_license  ifort INT  <=    YES YES NONE 0
```

2. Associate the attribute to the global host
   - "`qconf -me global`"
   - Insert value into param:

```
complex_values     ifort_license=50
```

Cliché continued …

- Verify that our attribute is scoped globally
  - “qstat -f -F ifort”

```
$ qstat -f -F ifort
queuename                      qtype used/tot. load_avg arch          states
---------------------------------------------------------------------------
all.q@chrisdag-aliased         BIP   0/4       0.99     darwin-ppc
        gc:ifort_compiller_lic=50
---------------------------------------------------------------------------
testQueue@chrisdag-aliased     BIP   0/4       0.99     darwin-ppc
        gc:ifort_compiller_lic=50
```

Cliché continued …

- Test!

```
$ qsub -cwd -hard -l ifort=2 ./sleeper.sh
Your job 37 ("Sleeper") has been submitted
chrisdag:/tmp dag$
```

Cliché continued …

- Nothing yet …

```
$ qstat -f -F ifort
queuename                      qtype used/tot. load_avg arch          states
---------------------------------------------------------------------------
all.q@chrisdag-aliased         BIP   0/4       1.10     darwin-ppc
        gc:ifort_compiller_lic=50
---------------------------------------------------------------------------
testQueue@chrisdag-aliased     BIP   0/4       1.10     darwin-ppc
        gc:ifort_compiller_lic=50

############################################################################
 - PENDING JOBS - PENDING JOBS - PENDING JOBS - PENDING JOBS - PENDING JOBS
############################################################################
     37 0.00000 Sleeper    dag          qw    04/15/2007 17:50:36     1
```

Cliché continued …

- Success!

```
$ qstat -f -F ifort
queuename                      qtype used/tot. load_avg arch          states
---------------------------------------------------------------------------
all.q@chrisdag-aliased         BIP   1/4       1.10     darwin-ppc
        gc:ifort_compiller_lic=48
     37 0.55500 Sleeper    dag           r     04/15/2007 17:50:47     1
---------------------------------------------------------------------------
testQueue@chrisdag-aliased     BIP   0/4       1.10     darwin-ppc
        gc:ifort_compiller_lic=48
```

Cliché continued …

- Test bounds …

```
$ qsub -cwd -hard -l ifort=50 ./sleeper.sh
Your job 38 ("Sleeper") has been submitted

$ qsub -cwd -hard -l ifort=50 ./sleeper.sh
Your job 39 ("Sleeper") has been submitted

$ qsub -cwd -hard -l ifort=1 ./sleeper.sh
Your job 40 ("Sleeper") has been submitted
```

```
$ qstat -j 39
==============================================================
job_number:                 39
exec_file:                  job_scripts/39
submission_time:            Sun Apr 15 17:54:58 2007
owner:                      dag
uid:                        501
group:                      dag
gid:                        501
sge_o_home:                 /Users/dag
sge_o_log_name:             dag
sge_o_shell:                /bin/bash
sge_o_workdir:              /private/tmp
sge_o_host:                 chrisdag-aliased
account:                    sge
cwd:                        /private/tmp
path_aliases:               /tmp_mnt/ * * /
hard resource_list:         ifort_compiller_lic=50
mail_list:                  dag@chrisdag-aliased
notify:                     FALSE
job_name:                   Sleeper
jobshare:                   0
shell_list:                 /bin/sh
env_list:
script_file:                ./sleeper.sh
scheduling info:            (-l ifort_compiller_lic=50) cannot run \
                            globally because it offers only \
                            gc:ifort_compiller_lic=0.000000
```

Optional Lab Time

- Do this for real on your systems
- Create, test and experiment:

1. Add attribute to the SGE complex
   - "`qconf -mc`"
   - Insert values:

```
#name      shortcut type  relop req cons def urg
ifort_license  ifort INT  <=    YES YES NONE 0
```

2. Associate the attribute to the global host
   - "`qconf -me global`"
   - Insert value into param:

```
complex_values     ifort_license=50
```

Load Sensors

Load Sensors

- Feed custom data to SGE scheduler
- Can be any executable
- Simple format:

  begin\n

  host:name:value\n

  end\n

Configuring Load Sensors

- Multiple sensors OK
  - Comma separated list
  - Must use full absolute paths
- If “global”
  - Sensor script(s) run on all hosts
- Automatically restarted by SGE
  - If sensor dies
  - If sensor is modified

Sensor scope

- Host sensor can report a host complex
- Global sensor can report a host complex
- Host sensor can report a global complex
- Global sensors should not report global complex values
  - “global” in load sensor speak means “run on every host…”
  - May cause conflict

Custom Load Sensors

- Roll your own …
- Must match particular format
  - Start with value “begin”
  - Each data report on its own line
    - Formatted:
      - `<host|global>:<attributeName>:<value>`
  - End with value “end”

Interactive Login Load Sensor

```
#!/bin/sh
myhost=`uname -n`

while [ 1 ]; do
     # wait for input
     read input
     result=$?
     if [ $result != 0 ]; then
          exit 1
     fi
     if [ "$input" = "quit" ]; then
          exit 0
     fi
     #send users logged in
     logins=`who | cut -f1 -d" " | sort | uniq | wc -l | sed "s/^ *//"`
     echo begin
     echo "$myhost:logins:$logins"
     echo end
done

# we never get here

exit 0
```

Interactive Login Load Sensor

```
$ ./load_sensor.sh

begin
chrisdag-aliased:logins:1
end

begin
chrisdag-aliased:logins:1
end

begin
chrisdag-aliased:logins:1
end
quit
```

Under documented Sensor Hints

1. The load_sensor configuration parameter will accept multiple comma separated script names
2. An executable program named “qloadsensor” installed into the SGE binary path on any execution host will automatically be run

Exercise

Custom Load Sensor

Exercise: Custom load sensors

1. Create a new complex called “logins”

   Non-requestable, non-consumable, INT
2. Get the load_sensor.sh script
3. Configure load_sensor.sh into the global configuration
4. Wait a bit …
5. View the complex status and value(s)

Solution: Custom load sensors

- “qconf -mc”
  - `logins al INT <= NO NO 0.0`
- “qconf –mconf”
  - Adjust load_sensor param
- “qstat –F logins”
- “qstat –F al”

Discussion: Load sensor exercise

- Scheduling decisions not being made based on “logins:” complex data
- But they could be …

More Queue Config Exercises

Priority Queues #4

Priority Queues #5

Exercise: Priority Queues #4

- Use resources and the Urgency sub-policy
- Create a new resource called “high_priority”
  - Requestable, non-consumable, boolean, Urgency=100
  - Add the new high_priority resource to the high.q configuration
- Do similar for new resource “low_priority”
  - Requestable, non-consumable, boolean, Urgency=-100
  - Add to low.q configuration
- Test
  - Look at urgency information for running/pending jobs

Solution: Priority Queues #4

- Complex entries:
  - `high_priority hp BOOL == YES NO FALSE 100`
  - `low_priority  lp BOOL == YES NO FALSE -100`
- `qconf -aattr queue complex_values hp=TRUE high.q`
- `qconf -aattr queue complex_values lp=TRUE low.q`
- `qsub -hard -l hp …`
- `qsub -hard -l lp …`
- Watch via “qstat -urg”

Review: Priority Queues #4

- We used the Urgency sub policy
- Jobs inherit the urgency values from the requested resource
  - Multiple resources get summed
- SGE scheduler now handling job prioritization; jobs run in priority order

Review: Priority Queues #4

- Still can do better …
- One annoyance in particular
  - “regular” jobs can still land in low.q or high.q

Forced Requestables

- In the SGE complex …
  - When “requestable=yes”
    - It can be requested by a task/job
  - When “requestable=force”
    - *Must* be requested by a job
    - Huh?
  - Queues or hosts associated with forced requestables become “exclusive”
    - Can only use that host/queue if you request the forced resource

Forced Requestables

- See where we are going here?
- What happens if we designate our “low_priority” and “high_priority” resources as FORCED?

Exercise: Priority Queues #5

1. Edit the high_priority and low_priority resources, set requestable to forced:
   - `high_priority hp BOOL == FORCED NO FALSE 100`
   - `low_priority  lp BOOL == FORCED NO FALSE -100`
2. Submit test jobs with no queue or resource requests
3. Confirm that these jobs can only land in regular.q
4. See what reason the SGE scheduler gives for not dispatching pending jobs

Review: Priority Queues #5

- Requestable resources
  - *Can* be requested by jobs
- Forced resources
  - *Must* be requested by jobs
- For queues or hosts with forced resources …
  - *Only* jobs requesting that resources can land there
- Effect
  - Jobs can't run in high.q or low.q without specific user action ("-l hp") or ("-l lp")
  - "qsub -q … " not required. SGE will figure it out
  - Now we are preventing 'accidental' misuse of queues

New topic: Subordinate Queues

New topic: Subordinate Queues

- Subordination is controlled via
  - “subordinate_list” queue attribute
    - Syntax:
      - queue=value (comma separated if multiples)
      - If no value, defaults to slot count for the queue
- When queue has “value” or more jobs active, suspend all the queues in *subordinate_list*
- When queue has fewer than “value” active jobs, subordinate queues will be resumed
- Potential gotcha
  - Suspended jobs do not relinquish requested resources

Exercise: Priority Queues #6

- First use of subordinate queues
  1. Delete the host specific “slots” complex from all your nodes if it still exists
  2. Make regular.q and low.q subordinate to high.q
  3. Test
- What happens when high priority jobs are scheduled?

Solution: Priority Queues #6

1. `qconf -dattr exechost complex_values slots=4 host`
2. `qconf -rattr queue subordinate_list regular.q=1 high.q`
3. `qconf -aattr queue subordinate_list low.q=1 high.q`

Priority Queues 1-6 Wrap-up

- Look how far we have come!
- 1st pass: simple UNIX nice hacks
  - FIFO, no protections, oversubscription, etc.
- Final pass:
  - Hard limits on high.q protect abuse
  - Requestable resources w/ urgency entitlements nicely handle prioritization
  - Forced requests keep ‘normal’ jobs in regular.q - users must specifically ask for anything else
  - Subordination
- Make sense?

Parallel Environment Configuration

```
$ qconf -sp make
pe_name            make
slots              999
user_lists         NONE
xuser_lists        NONE
start_proc_args    NONE
stop_proc_args     NONE
allocation_rule    $round_robin
control_slaves     TRUE
job_is_first_task FALSE
urgency_slots      min
```

Parallel Env Configuration

- *PE issues will also be covered in a later module*
- The usual syntax applies
  - "Show me"
    - `qconf -sp <PE name>`
  - "Let me change it"
    - `qconf -mp <PE name>`
  - "Create new from file"
    - `qconf -Ap ./my-PE-template.txt`
  - "Show me all configured PE's"
    - `qconf -spl`

Interesting PE parameters

- `start_prog_args & stop_proc_args`
  - Prepare, start and takedown the parallel environment
  - Usually a shell script specific to the parallel implementation; often site specific
  - *Special variables are available in the environment:*
    - *$pe_hostfile, $host, $job_owner, $job_id, $job_name, $pe, $pe_slots, $processors, $queue*
- `allocation_rule`
  - `<int>` – Fix # of PE slots per host
    - If “1” then all tasks must be on different hosts
  - `$pe_slots` – Force all PE slots to live within the same host
  - `$round_robin` – Rotate through available hosts, maximize host spread
  - `$fill_up` - Minimize host spread by filling up host slots before moving on

Configuring PE environments

- Grid Engine just picks *WHEN* and *WHERE* parallel tasks are placed; admins still must do lots of work
- Important to understand distinction between
  - Loose PE integration
  - Tight PE integration
- PE implementations are
  - Software specific (MPICH, LAM-MPI, MPICH2), etc.
  - Site specific (highly customized to local environment)
- Online HowTo's are better than official docs:
  - http://gridengine.sunsource.net/howto/howto.html

User Access

Grid Engine Roles

- **Manager**
  - Can control any aspect of grid engine
  - "`qconf -am <user>`"
- **Owner**
  - Suspend, resume and disable one or more queues that a user may 'own'
  - "`owner`" in Queue conf
- **Operator**
  - Same as manager but no ability to add, delete or change a queue configuration
  - "`qconf -ao <user>`"
- **User**
  - Can use and query system but can't change anything

Usersets

- Named sets of users
- Can be used with
  - SGE Roles
  - Access Lists
  - Departments
  - Projects

- Standard syntax
  - `qconf -sul`
  - `qconf -su <userset>`
  - …
  - …

User Objects

- Needed for policies where individual users must be considered
- Can be created/deleted automatically
  - "`enforce_user=auto`"
  - Etc.
- Standard syntax
  - `qconf -suserl`
  - `qconf -suser <name>`
  - `qconf -duser <name>`
  - `qconf -muser <name>`
  - …

Project Objects

- Project affiliation used in several policies
- Allow/deny by userset lists
- A user may be affiliated with more than one project

- Standard syntax
  - `qconf -sprjl`
  - `qconf -sprj <project>`
  - `qconf -dprj <project>`
  - `qconf -mprj <project>`
  - …

Department Objects

- Special form of SGE access list
  - Allow functional and override tickets to be applied
- User can only have one department affiliation
- Standard syntax
  - `qconf -sul`
  - `qconf -su <department>`
  - `qconf -du <department>`
  - `qconf -mu <department>`
  - …

Path Aliasing

- Allows
  - Resolve inconsistent file paths among different hosts
- Two possible locations:
  - `$SGE_ROOT/$SGE_CELL/common/sge_aliases`
  - `~/.sge_aliases`
- Format (and example)

```
#src-path              submit-host  exec-host  dst-path
/Volumes/XRAID/Users   *            *          /Users
```

Default requests (sge_request)

- Allows
  - Per-user or globally defined resource requests
- Three possible locations, sorted by precedence:
  1. `$SGE_ROOT/$SGE_CELL/common/sge_request`
  2. `$HOME/.sge_request`
  3. `./sge_request`
- "`qsub -clear`" will wipe any prior active requests
- Trivial per-user example:

```
# always assume current working directory
-cwd
# always request Apple/X86 architecture
-l arch=darwin-x86
```

Default requests (sge_qstat)

- Alias in commonly used qstat arguments
- Two possible locations, sorted by precedence:
  1. `$SGE_ROOT/$SGE_CELL/common/sge_qstat`
  2. `$HOME/.sge_qstat`
- Command line arguments to qstat trump all else

Exercise - sge_qstat

- Your task:
  - Create a personal .sge_qstat file that
    - Replicates the old SGE 6.0 behavior
      - “qstat” defaults to showing info for *all users*

Solution - sge_qstat

- $HOME/.sge_qstat
- Contents
  - `-u '*'`
  - `-f -u '*'`

Done!