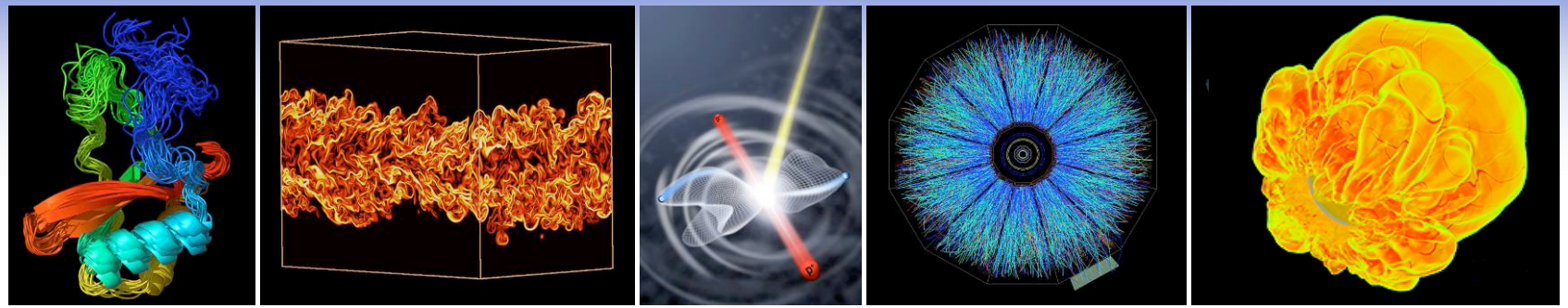

Understanding Aprun Use Patterns

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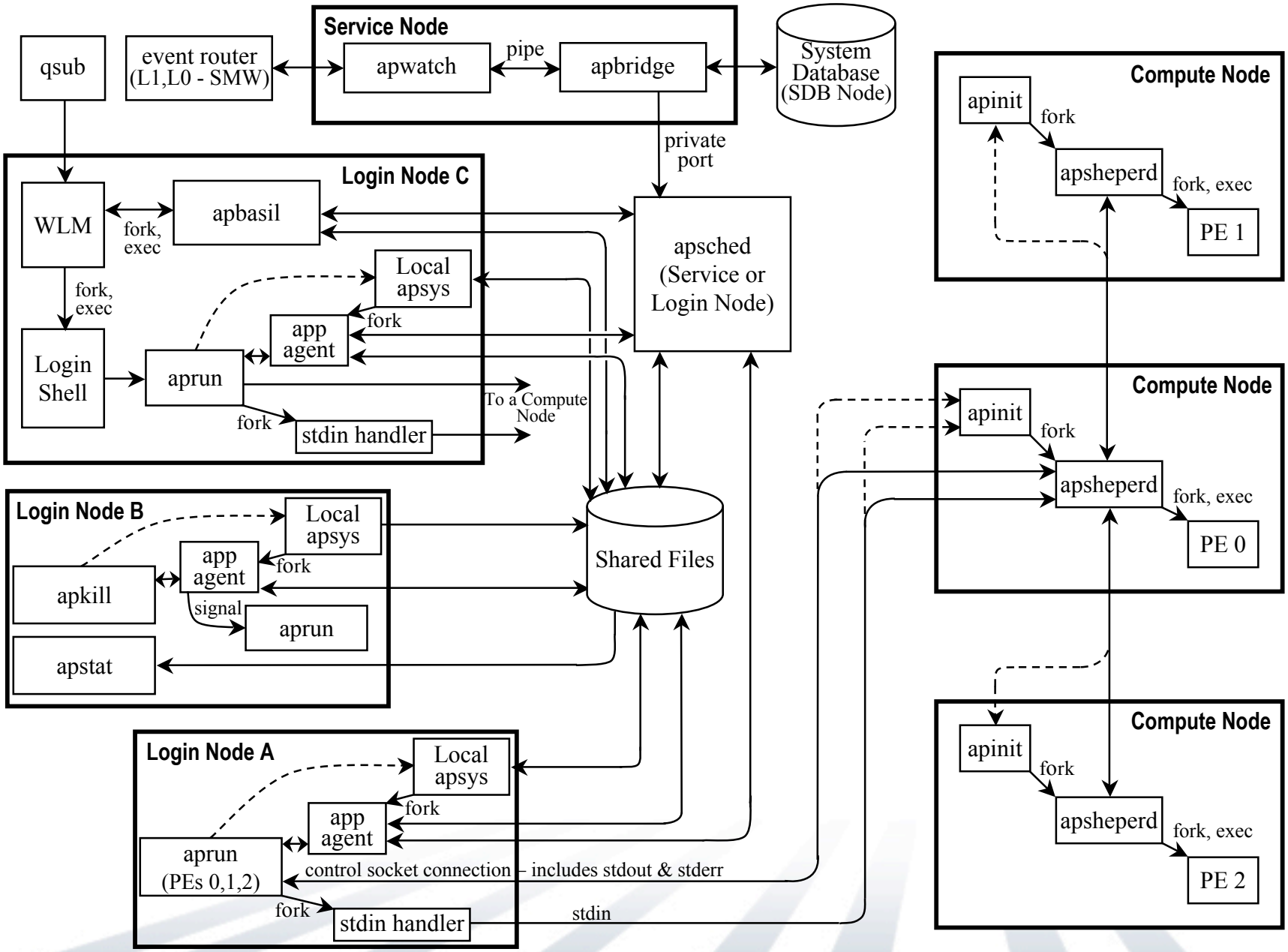
Motivation

- NERSC: a DOE site providing computing resources to researchers from various disciplines.
- Franklin: the newest addition -- Cray XT4 system with almost 10 thousand compute nodes
- NERSC policy: give discounts to large jobs to encourage scaling up programs
- Large jobs: jobs submitted to a routing queue then get dispatched to the large queue when high number of nodes (>=1024) requested

Do users take advantage of this policy? Do they ask for a large number of nodes, enough to get assigned to the large queue, but use them in independent applications that are launched in parallel?

The Players

- ALPS (Application Level Placement Scheduler)
  - Was described in detail at CUG 2006 by Michael Karo of Cray
  - Manages resources (nodes) via apsched
  - Uses resources via aprun
- Torque/Moab
  - Is the batch system choice of NERSC
  - Manages designated MOM (job scripts invocation) nodes
  - Enforces scheduling policy
  - Delegates resource management responsibility to ALPS
- Job life cycle
  - Next slide (borrowed from Karo) shows how ALPS and Torque/Moab work together


Service Node
qsub
event router
(L1,L0 - SMW)
apwatch
pipe
apbridge
System
Database
(SDB Node)
private
port
Compute Node
apinit
fork
apsheperd
fork, exec
PE 1
Login Node C
WLM
fork,
exec
apbasil
Local
apsys
fork,
exec
app
agent
fork
apsched
(Service or
Login Node)
Login
Shell
aprun
To a Compute
Node
fork
stdin handler
Compute Node
apinit
fork
apsheperd
fork, exec
PE 0
Login Node B
Local
apsys
app
agent
fork
apkill
signal
aprun
apstat
Shared Files
Compute Node
apinit
fork
apsheperd
fork, exec
PE 2
Login Node A
Local
apsys
app
agent
fork
aprun
(PEs 0,1,2)
control socket connection – includes stdout & stderr
fork
stdin handler
stdin

Data Gathering: Sources

- **Apsched logs (sdb:/var/log/alps/apsched*mmdd*)**
  - **Confirmed: one per job script invocation**
  - **Bound: one per job script invocation**
    - **a source for job ID in XT 2.1**
  - **Placed: one per aprun**
  - **Released: one per aprun**
  - **Canceled: one per job script invocation**

- **Syslog (sdb:/syslog/var/log/messages)**
  - **Set_job: one per job script invocation**
    - **a source for job ID in both XT 2.0 and 2.1**

Data Gathering: *aprundat*

- A Perl script
- Runs daily to process the previous day's apsched log and syslog, as well as the overflow file
- Generates one entry for each aprun with information gathered from the source records.
- Creates four files for each run
  - <date>_aprundat: contains aprun records for completed jobs; used by the reporting programs
  - <date>_overflow: contains overflow records to be processed the following day
  - <date>_expired: contains old overflow records
  - <date>_incomplete: contains old arpun records without a job ID

Data Consumption: *aprunrpt*

- A Perl script
- Processes the <date>_aprundat files whenever desired
- Usage: aprunrpt -m -A <date>_aprundat
  - -m multiple flag; report only for jobs with multiple apruns
  - -A <data>_aprundat input data file
- Easy to add more options, such as
  - -u <uid>
  - -s <start time>
  - -e <end time>
  - -n <node name>

Data Consumption: Web Page

Job details

Step ID	504759.nid00003	Job Name			STDIN
Owner	[redacted]	Account		Status	265
Execution queue	interactive	Submit class	interactive	Job type	
Nodes	64	Wall secs	1,928	Wall hrs	0.54
Available cores per node	2	Requested secs	1,800	Requested hrs	0.50
MPP secs	1,604,096	MPP hrs	445.58	Raw Secs	246,784
Submit	May-09-08 06:26:41	Start	May-09-08 06:26:54	Wait	00:00:13
Completion	May-09-08 06:59:02	systime	0	usrtime	0
Nodelist	12704-12735, 12800-12831				

*Indicates dispatch time

List of aprun commands executed in this job

Number of aprun commands: 4

Command	Nodes Used	Run Time (secs)	Start	Complete	Nodelist
RadHyd3D	64	4	May-09-08 06:28:24	May-09-08 06:28:28	12704-12735, 12800-12831
RadHyd3D	64	44	May-09-08 06:31:32	May-09-08 06:32:16	12704-12735, 12800-12831
RadHyd3D	64	25	May-09-08 06:32:43	May-09-08 06:33:08	12704-12735, 12800-12831
RadHyd3D_check	64	135	May-09-08 06:54:18	May-09-08 06:56:33	12704-12735, 12800-12831

Data Gathering Example: Single Aprun

```
#PBS -q debug
#PBS -l mppwidth=64
cd $PBS_O_WORKDIR
aprun -n 64 ./ping_pong
```

```
17:37:35: Confirmed apid 411088 resId 349 pagg 0 nids: 12622-12627,12632-12641
17:37:36: Bound Batch System ID 5820466 pagg 73126 to resId 349
17:37:37: Placed apid 411089 resId 349 pagg 73126 uid 40877 cmd ping_pong
            nids: 12622-12627,12632-12641
17:37:57: Released apid 411089 resId 349 pagg 73126 claim
17:38:15: Canceled apid 411088 resId 349 pagg 73126
```

```
Apr  7 17:37:36 nid00576 pbs_mom: set_job, /opt/moab/default/tools/partition.create.xt4.pl
            --confirm -p 349 -j 5820466.nid00003 -a 73126
```

```
5820466;12622-12627,12632-12641;1239151057;1239151077;hclin;ping_pong;12622-
    12627,12632-12641
```

Data Gathering Example: Sequential Apruns

```
#PBS -q debug
#PBS -l mppwidth=64
cd $PBS_O_WORKDIR
aprun -n 64 ./ping_pong
aprun -n 32 ./ping_pong
aprun -n 48 ./ping_pong
```

```
17:42:12: Confirmed apid 411111 resId 356 pagg 0 nids: 12800-12815
17:42:13: Bound Batch System ID 5820474 pagg 852 to resId 356
17:42:13: Placed apid 411112 resId 356 pagg 852 uid 40877 cmd ping_pong nids: 12800-12815
17:42:34: Released apid 411112 resId 356 pagg 852 claim
17:42:34: Placed apid 411113 resId 356 pagg 852 uid 40877 cmd ping_pong nids: 12800-12807
17:42:45: Released apid 411113 resId 356 pagg 852 claim
17:42:45: Placed apid 411115 resId 356 pagg 852 uid 40877 cmd ping_pong nids: 12800-12811
17:43:00: Released apid 411115 resId 356 pagg 852 claim
17:43:11: Canceled apid 411111 resId 356 pagg 852
```

Data Gathering Example: Sequential Apruns (cont.)

Apr 7 17:42:13 nid04096 pbs_mom: set_job,
/opt/moab/default/tools/partition.create.xt4.pl
--confirm -p 356 -j 5820474.nid00003 -a 852

5820474;12800-12815; 1239151333;1239151354; hclin;ping_pong; 12800-12815
5820474;12800-12815; 1239151354;1239151365; hclin;ping_pong; 12800-12807
5820474;12800-12815; 1239151365;1239151380; hclin;ping_pong; 12800-12811

Data Gathering Example: Parallel Apruns

```
#PBS -q debug
#PBS -l mppwidth=64
cd $PBS_O_WORKDIR
aprun -n 8 ./ping_pong &
aprun -n 32 ./ping_pong &
aprun -n 16 ./ping_pong
wait
```

```
17:43:14: Confirmed apid 411117 resId 357 pagg 0 nids: 12800-12815
17:43:14: Bound Batch System ID 5820475 pagg 1162 to resId 357
17:43:15: Placed apid 411119 resId 357 pagg 1162 uid 40877 cmd ping_pong nids: 12800-12803
17:43:15: Placed apid 411120 resId 357 pagg 1162 uid 40877 cmd ping_pong nids: 12804-12805
17:43:15: Placed apid 411121 resId 357 pagg 1162 uid 40877 cmd ping_pong nids: 12806-12813
17:43:18: Released apid 411120 resId 357 pagg 1162 claim
17:43:20: Released apid 411119 resId 357 pagg 1162 claim
17:43:25: Released apid 411121 resId 357 pagg 1162 claim
17:44:14: Canceled apid 411117 resId 357 pagg 1162
```

Data Gathering Example: Parallel Apruns (cont.)

Apr 7 17:43:14 nid04096 pbs_mom: set_job,
/opt/moab/default/tools/partition.create.xt4.pl
--confirm -p 357 -j 5820475.nid00003 -a 1162

5820475;12800-12815; 1239151395;1239151398; hclin;ping_pong; 12804-12805
5820475;12800-12815; 1239151395;1239151400; hclin;ping_pong; 12800-12803
5820475;12800-12815; 1239151395;1239151405; hclin;ping_pong; 12806-12813

Data Gathering Example: MPMD Application

```
#PBS -q debug
#PBS -l mppwidth=64
cd $PBS_O_WORKDIR
aprun -n 8 ./ping_pong : -n 32 ./ping_pong : -n 16 ./ping_pong

17:54:29: Confirmed apid 411173 resId 370 pagg 0 nids: 5787-5789,6586-6598
17:54:30: Bound Batch System ID 5820529 pagg 4171 to resId 370
17:54:31: Placed apid 411174 resId 370 pagg 4171 uid 40877 MPMD cmd ping_pong
            nids: 5787-5789,6586-6596
17:54:51: Released apid 411174 resId 370 pagg 4171 claim
17:55:10: Canceled apid 411173 resId 370 pagg 4171

Apr  7 17:54:30 nid04096 pbs_mom: set_job, /opt/moab/default/tools/partition.create.xt4.pl
            --confirm -p 370 -j 5820529.nid00003 -a 4171

5820529;5787-5789,6586-6598;1239152071;1239152091;hclin;ping_pong;5787-5789,6586-6596
```

Data Consumption Example: *Aprunrpt* Output

Job ID	Reserved	Used	Start	End	User	Command
5820466	16	16	09/04/07 17:37:37	09/04/07 17:37:57	hclin	ping_pong
5820474	16	16	09/04/07 17:42:13	09/04/07 17:42:34	hclin	ping_pong
		8	09/04/07 17:42:34	09/04/07 17:42:45	hclin	ping_pong
		12	09/04/07 17:42:45	09/04/07 17:43:00	hclin	ping_pong
5820475	16	2	09/04/07 17:43:15	09/04/07 17:43:18	hclin	ping_pong
		4	09/04/07 17:43:15	09/04/07 17:43:20	hclin	ping_pong
		8	09/04/07 17:43:15	09/04/07 17:43:25	hclin	ping_pong
5820529	16	14	09/04/07 17:54:31	09/04/07 17:54:51	hclin	ping_pong

- Job 5820475 ran multiple apruns in parallel, but was not gaming the system

Challenges

- Constructing timestamps
  - Different format in source files
  - Timestamps for apsched log entries no date
    - month/day: from the file name
    - year: current year
    - -y <year> for processing 12/31 apsched log on 1/1
- Finding job ID in syslog
  - Syslog switches at boot time every so often
  - Syslog contains multiple days' worth of entries
  - First attempt: use reservation ID as the hash key
    - Not unique due to rapid recycling of reservation ID
  - Second attempt: use reservation ID AND session ID as the key
    - Not unique when syslog spanned many days
  - Finally: save set_job record time for breaking a tie

Future Enhancements

- **Data gathering**
  - **Would like to include aprun command line options**
    - **syslog**

```
Apr 11 20:26:40 nid00576 aprun[63195]: apid=437384, Starting, user=32407,\
   cmd_line="aprun -n 32 -d 1 cpl : -n 32 –d 1 csim : -n 16 -d 1 clm : \
              -n 96 -d 1 pop : -n 64 -d 1 cam",num_nodes=60, node_list=6454-6513
```

  - **Would like to include aprun exit status**
    - **console log**

```
[2009-04-14  13:22:15][c5-4c0s2n0]  Out  of  memory:  Killed  process 30142 (jfdtd3d).
            apid: 453270
[2009-04-14 13:16:42][c10-3c0s2n3] nwchem[30104]: segfault at 00000003204b1dd0 \
            rip 0000000000ff5e35 rsp 00007fffffffb930 error 4
```

- **Data consumption**
  - **Would like to add more flags for records selection**

Conclusion

No, we did not see patterns to indicate users gaming the system

- **Were surprised to see a job containing 41,007 apruns ran sequentially and in parallel**
- **Found unexpected uses of data**
  - **Frequencies of software package use**
  - **Association between applications and node failures**
- **Proved two-step approach wise**
  - **Collect more info about applications from other system logs**
  - **Expect more uses for the data**

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- Follow-up e-mail: send to hclin@lbl.gov