Building a Linux Cluster

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Outline

- What is PDSF and a little about its history.
- Growth problems and solutions.
  - Storage
  - Network
  - Hardware
  - Administration
  - Software
- In the future
- Conclusion

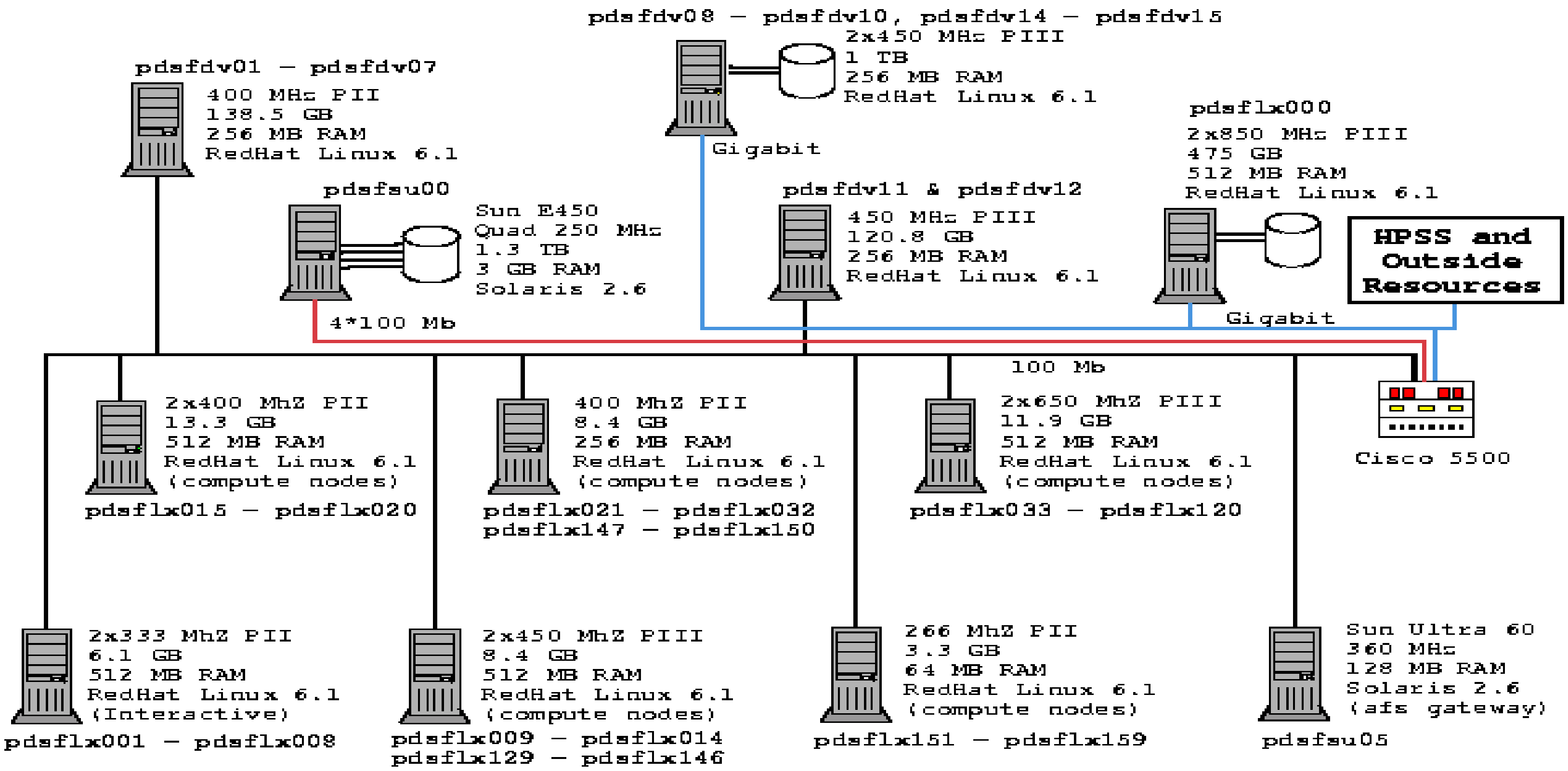
PDFS

- Linux cluster who's primary service is to the High Energy Physics (HEP) community
  - Parallel Distributed System Facility (PDSF)
  - Runs on commodity hardware
  - Takes advantage of open source software
  - Multiple user communities running on the same cluster
  - Application are Embarrassing Parallel (Seti@Home)
  - Fast ethernet and some gigabit interconnects

HEP

- HEP community
  - Large datasets (up to 1 PB in size)
  - Embarrassing Parallel problem (no need for fast interconnects between machines or multiple processors per machine)
  - Can exploit commodity hardware market
    - Dual processor instead of quad or larger
    - Not effected by limit of 32 bit architecture
    - Can run in under 4 GB of memory
    - Does not need checkpoint/restart capabilities
  - Experiments span multiple labs and countries (100's to 1000's researchers)

PDSF Layout



pdsfdv01 – pdsfdv07
400 MHz PII
138.5 GB
256 MB RAM
RedHat Linux 6.1

pdsfdv08 – pdsfdv10, pdsfdv14 – pdsfdv15
2x450 MHz PIII
1 TB
256 MB RAM
RedHat Linux 6.1

Gigabit

pdsfsu00
Sun E450
Quad 250 MHz
1.3 TB
3 GB RAM
Solaris 2.6

4*100 Mb

pdsfdv11 & pdsfdv12
450 MHz PIII
120.8 GB
256 MB RAM
RedHat Linux 6.1

pdsflx000
2x850 MHz PIII
475 GB
512 MB RAM
RedHat Linux 6.1

Gigabit

HPSS and Outside Resources

100 Mb

Cisco 5500

2x400 MhZ PII
13.3 GB
512 MB RAM
RedHat Linux 6.1
(compute nodes)
pdsflx015 – pdsflx020

400 MhZ PII
8.4 GB
256 MB RAM
RedHat Linux 6.1
(compute nodes)
pdsflx021 – pdsflx032
pdsflx147 – pdsflx150

2x650 MhZ PIII
11.9 GB
512 MB RAM
RedHat Linux 6.1
(compute nodes)
pdsflx033 – pdsflx120

2x333 MhZ PII
6.1 GB
512 MB RAM
RedHat Linux 6.1
(Interactive)
pdsflx001 – pdsflx008

2x450 MhZ PIII
8.4 GB
512 MB RAM
RedHat Linux 6.1
(compute nodes)
pdsflx009 – pdsflx014
pdsflx129 – pdsflx146

266 MhZ PII
3.3 GB
64 MB RAM
RedHat Linux 6.1
(compute nodes)
pdsflx151 – pdsflx159

Sun Ultra 60
360 MHz
128 MB RAM
Solaris 2.6
(afs gateway)
pdsfsu05

Total cluster disk space: 7.511 TB
Total number of compute nodes: 152
Total number of cpu's: 281

History

- Started at Superconducting Super-Collider
  - 1991 1000 MIPS and 40 GB disk (HP and Sun)
  - 1992 2000 MIPS and 80 GB disk
  - 1993 8000 MIPS and 240 GB disk
  - 1994 128 processors/12000 MIPS and 160 GB disk
- Moved to LBNL
  - 1997 128 processors and 160 GB disk
  - 1998 142 processors and 282 GB disk (Linux for disk vaults)
  - 1999 66 processors and 658 GB disk (Move total to Intel)
  - 2000 281 processors and 7.5 TB disk
  - 2001 ~431 processors and 22.5 TB disk

Problems and Solutions

- Networking
- Storage (Disk Space)
- Cluster Filesystem
- Administration
  - Configuration Management
  - Monitoring
- Hardware Density
- Users

Networking

- Everything is based on fast ethernet
- Network bottlenecked for the NFS servers on the fast ethernet since a user can have up to 280 jobs running at a time
  - Tom Davis wrote the kernel bonding driver to bond two ethernet ports together when the max jobs was 120
  - Now we are running copper gigabit for added throughput

Storage

- Datasets outgrew 40 GB disk vaults
  - Used ide drives and linux to create 64GB disk vaults
  - Then upgraded to Raidzone's 15 drives plus 75 GB drives to create a 1 TB RAID 5 filesystem
- 1 TB + Linux NFS seems to be unstable under our work conditions
  - Limit system filesystem to under 1 TB currently 600 GB with 3ware
  - Looking into a SANS solution for greater needs

Network Filesystem

- Userland NFS proved too slow
  - Knfsd was introduced to help performance
- NFSv2
  - NFSv3 patches added but still running in v2 mode. Performance increased over standard kernel v2.
  - Checking into NFSv3
- But even NFSv3 has problems scaling
  - Looking into GFS or other network filesystem

Administration

- Standalone configuration on each node had a problem with staying in sync
  - Installed with an NFS mounted /usr
- NFS mounted /usr has problems with RPM installs and local configuration files.
  - Planning on moving back to RPM since autorpm works better.
  - Cfengine to help maintain configuration files

Monitoring

- SNMP polling was timing out because the number of nodes was increasing.
  - Implemented MON
  - MRTG was added to monitor the network
- MON worked but its interface was not friendly for operations staff and users
  - Checked out Big Brother/Sister
  - Now using Netsaint

NIS

- Our central NIS server could not handle the load
  - Moving to our Sun box did not help
  - Setting up NIS broadcast between multiple servers only loaded the fastest responding server
  - Grouped several nodes to point to one server but this still has problems when a server goes down
  - Possible move to static files on compute nodes and NIS only for interactive nodes

Hardware Density

- Desktop mini-tower cases take up too much room in standard racks
  - Moved to 2U rack mount machines with dual cpus
  - Intel flip chips now allows 1U dual processor nodes
  - Care must be taken with cooling with high density
- Disk vaults where mini-towers with 4 ide drives
  - Moved to Raidzone hardware with 15 drives in 8U
  - New Raidzone are 15 drives 4U but restricted software at $22k
  - 3ware can provide 16 drives 6U at $15k

Networking Hardware

- Our Cisco Cat 5513 is full. 2 gigabit blades and 1024 ports of 10/100 blades
  - Moving to a distributed network of small switches at the top of each rack with links back to a main switch
  - This creates less spaghetti wiring
- 8 ports fiber gigabit blade density is not enough
  - Extreme Summit 7i is 28 copper + 4 fiber gigabit ports which can auto sense between 100/1000

Console Cabling

- KVM switches are expensive and do not offer remote administration
  - Moved to Rocketport cards with linux console software
  - Enabled linux serial console. This allows access from the lilo prompt but not BIOS level stuff.
  - Serial consoles are rack based and not centralized

Power Cabling

- Old machine room layout was 2 20 Amp circuits per rack
  - Since our density was increasing, when our new facility was being built we planned for 4 20 Amp circuits per rack. 8 nodes per circuit.
  - High bandwidth nodes are 5 per circuit
  - Power on flexible conduit under the floor so reconfiguration of power is easier
  - Key servers on UPS

User base

- Most clusters have a single application/user base to deal with.
- PDSF is a general cluster supporting several groups.
  - Configuration is kept simple and not driven by any group
  - Local setups provide users with same look and feel of other clusters they may work on
  - Some customisations can be done only if it does not impact the general cluster (Adding light MPI work for one group's test run.)

Software

- LSF
  - Main use is to provide fair sharing of compute nodes
    - Groups buy hardware and thus shares in the cluster
    - We provide support and maintenance of the cluster
  - Can provide some resource management (NFS servers)
- Group shared programs/code is placed into a 'group common' directory tree
- Extra system applications or applications shared by all group go into /usr/local

Future Projects

- Autorpm for installation
- Myrinet or other solution for increased MPI support
- SAN solutions involving fiber channel and/or gigabit (iSCSI)
- Journaling filesystem (xfs, ext3, reiser, jfs)
- Network filesystems (gfs, pvfs, afs, gpfs)
- LDAP for a replacement for NIS
- Remote power management
- Possible scheduling software replacement (GRD)

Conclusion

- Linux works
  - There are still problems but solutions are being worked upon
  - Large community of users and developers (Open source works)
  - Creating multiple clusters for different locations is cheaper for the our user base
  - Allows for better scaling of hardware since experiments will get bigger