High Performance Computing System Administrator

CENTRE FOR DEVELOPMENT OF ADVANCED COMPUTING PUNE

CASE STUDY

Submitted By:

Batch September 2022-23

AIM

Build a two node Disk-less HPC-Cluster using OpenHPC with warewulf, slurm, Nagios and do a HPL benchmark and document the result.

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TABLE OF CONTENT

REQUIREMENTS

Hardware reqirements:

- RAM : 32 GB
- PROCESSOR : i7 10 gen

- HDD : 200GB

Software reqirements:
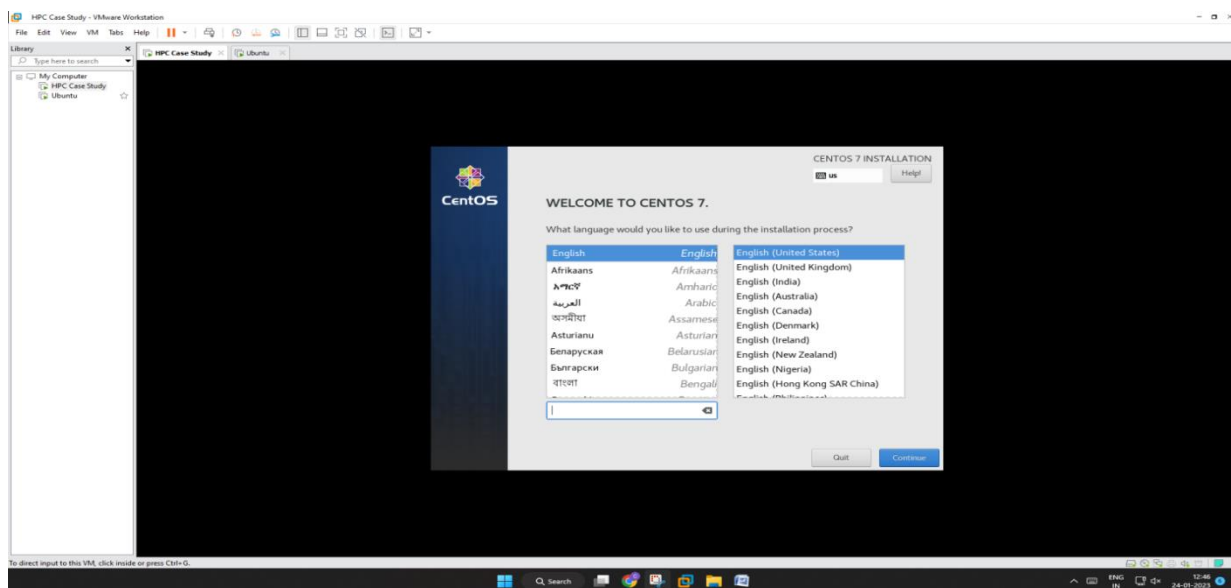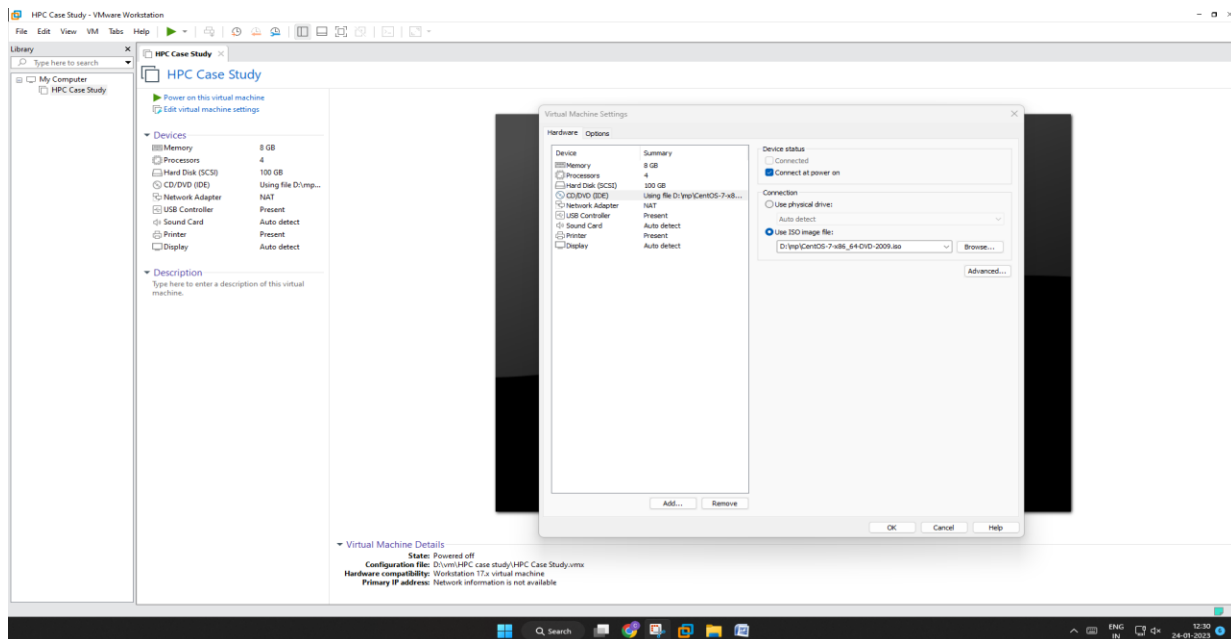
- Vmware workstation
- Centos 7 iso

*Internet connectivity

INSTALLATION

The head node is configured as the primary node in the cluster and is setup to manage and install all compute nodes.

Install the Base Operating System

Create new virtual machine and BootfromtheCentOS*installmedia(DVD).

Post-Install Configuration

After done to create virtual machine of Centos 7 with master configuration few must configuration are required

1) Setting hostname : master
2) Firewalld must be disabled
3) Selinux disable
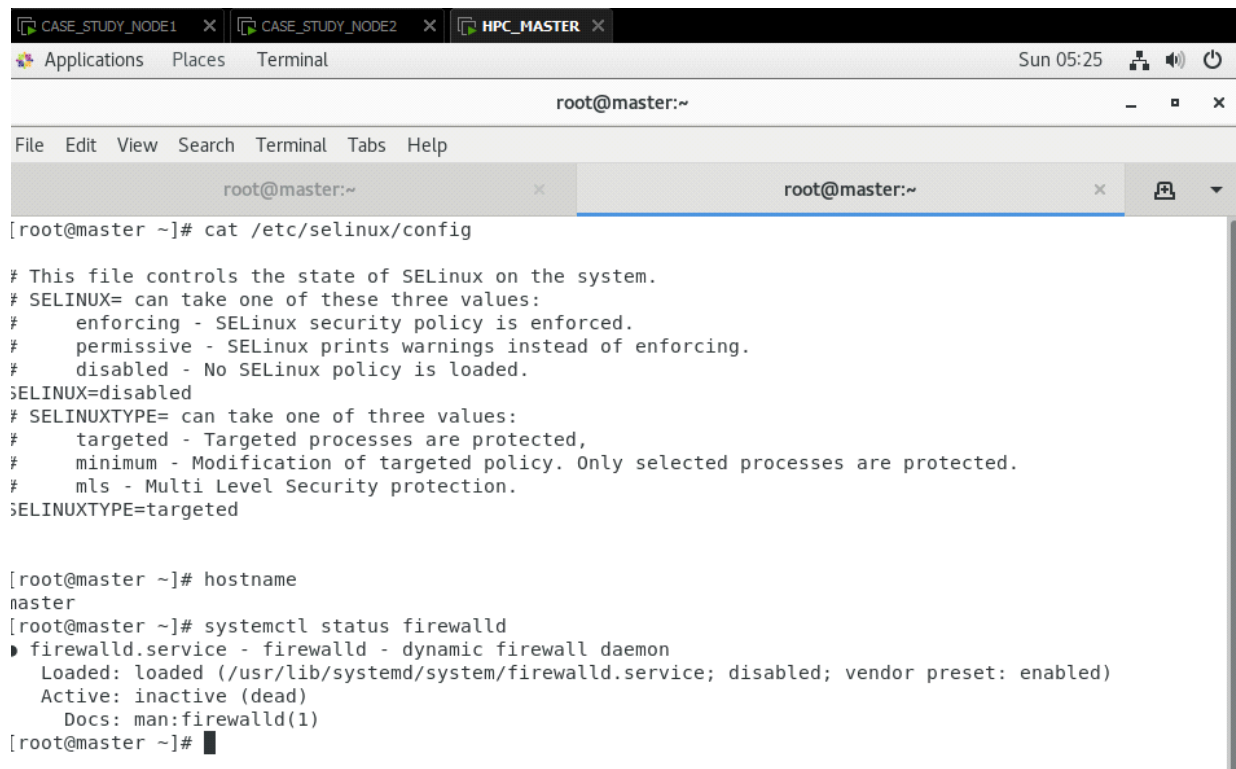4) Network configuration must be done

hostnamectl set-hostname master

 [root@master ~]#

systemctl stop firewalld

#systemctl disable firewalld

vi /etc/selinux/conf

→ Change enforcing to disabled

```
[root@master ~]# cat /etc/selinux/config

# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#     enforcing - SELinux security policy is enforced.
#     permissive - SELinux prints warnings instead of enforcing.
#     disabled - No SELinux policy is loaded.
SELINUX=disabled
# SELINUXTYPE= can take one of three values:
#     targeted - Targeted processes are protected,
#     minimum - Modification of targeted policy. Only selected processes are protected.
#     mls - Multi Level Security protection.
SELINUXTYPE=targeted


[root@master ~]# hostname
master
[root@master ~]# systemctl status firewalld
▶ firewalld.service - firewalld - dynamic firewall daemon
   Loaded: loaded (/usr/lib/systemd/system/firewalld.service; disabled; vendor preset: enabled)
   Active: inactive (dead)
     Docs: man:firewalld(1)
[root@master ~]# █
```
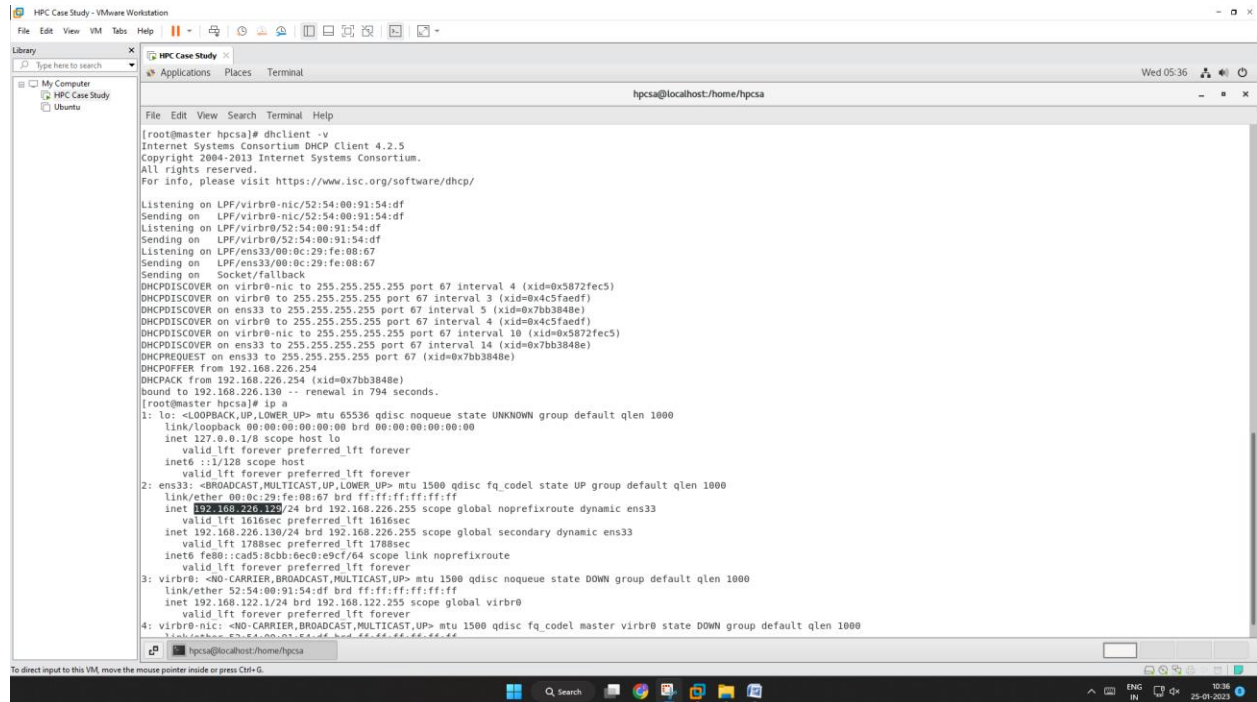
dhclient -v

ip a

nmcli -p connection show --active

openHPC with Warewulf

OpenHPC is a set of community-driven FOSS tools for Linux based HPC. OpenHPC does not have specific hardware requirements.

Warewulf is **a bare metal, stateless, cluster provisioning solution to facilitate the operating system deployment and management of large quantities of clustered hardware resources**. Extensible. Easy to change the default functionality, node images, and customize for any clustering use-case**.**
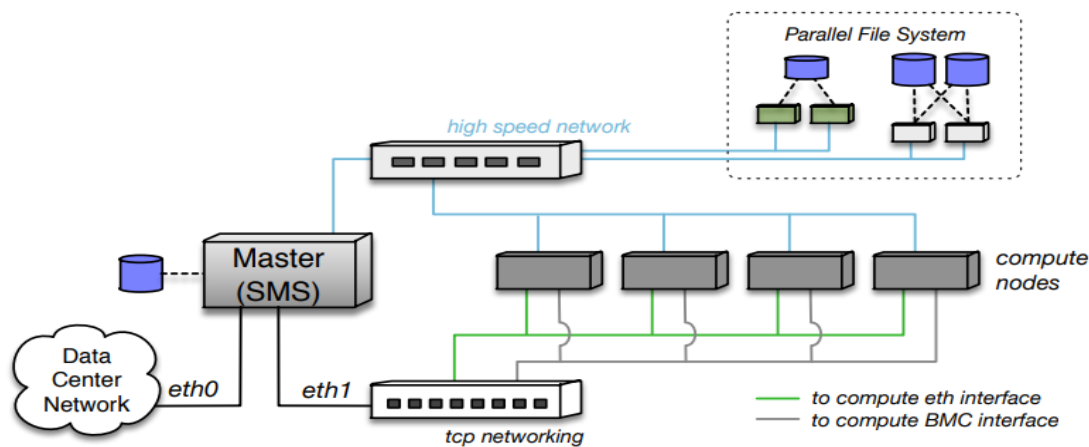
Figure 1: Overview of physical cluster architecture.

#Yum install http://build.openhpc.community/OpenHPC:/1.3/CentOS_7/aarch64/ohpc-release-1.3-1.el7.aarch64.rpm

yum -y install ohpc-base

```
[root@master ~]# yum install http://build.openhpc.community/OpenHPC:/1.3/CentOS_7/x86_64/ohpc-release-1.3-1.el7.x86_64.rpm
Loaded plugins: fastestmirror, langpacks
ohpc-release-1.3-1.el7.x86_64.rpm                                                                                        | 4.4 kB  00:00:00
Examining /var/tmp/yum-root-owrHtq/ohpc-release-1.3-1.el7.x86_64.rpm: ohpc-release-1.3-1.el7.x86_64
Marking /var/tmp/yum-root-owrHtq/ohpc-release-1.3-1.el7.x86_64.rpm to be installed
Resolving Dependencies
--> Running transaction check
---> Package ohpc-release.x86_64 0:1.3-1.el7 will be installed
--> Processing Dependency: epel-release for package: ohpc-release-1.3-1.el7.x86_64
Loading mirror speeds from cached hostfile
 * base: repo.extreme-ix.org
 * extras: repo.extreme-ix.org
 * updates: repo.extreme-ix.org
--> Running transaction check
---> Package epel-release.noarch 0:7-11 will be installed
--> Finished Dependency Resolution

Dependencies Resolved

================================================================================================================================================
 Package                        Arch                    Version                    Repository                              Size
================================================================================================================================================
Installing:
 ohpc-release                   x86_64                  1.3-1.el7                  /ohpc-release-1.3-1.el7.x86_64         1.4 k
Installing for dependencies:
 epel-release                   noarch                  7-11                       extras                                 15 k

Transaction Summary
================================================================================================================================================
Install  1 Package (+1 Dependent package)

Total size: 16 k
Total download size: 15 k
Installed size: 26 k
Is this ok [y/d/N]: y
Downloading packages:
epel-release-7-11.noarch.rpm                                                                                            | 15 kB  00:00:00
Running transaction check
Running transaction test
Transaction test succeeded
Running transaction
  Installing : epel-release-7-11.noarch                                                                                                  1/2
  Installing : ohpc-release-1.3-1.el7.x86_64                                                                                             2/2
  Verifying  : ohpc-release-1.3-1.el7.x86_64                                                                                             1/2
```

```
---> Package slurm-slurmctld-ohpc.x86_64 0:18.08.8-4.1.ohpc.1.3.8.1 will be installed
---> Package slurm-slurmdbd-ohpc.x86_64 0:18.08.8-4.1.ohpc.1.3.8.1 will be installed
--> Running transaction check
---> Package pmix-ohpc.x86_64 0:2.2.2-9.1.ohpc.1.3.7 will be installed
--> Finished Dependency Resolution

Dependencies Resolved

================================================================================
 Package                      Arch      Version                  Repository       Size
================================================================================
Installing:
 ohpc-slurm-server            x86_64    1.3.8-3.1.ohpc.1.3.8     OpenHPC-updates  2.4 k
Installing for dependencies:
 munge-devel-ohpc             x86_64    0.5.13-7.1.ohpc.1.3.7    OpenHPC-updates   34 k
 munge-libs-ohpc              x86_64    0.5.13-7.1.ohpc.1.3.7    OpenHPC-updates   50 k
 munge-ohpc                   x86_64    0.5.13-7.1.ohpc.1.3.7    OpenHPC-updates  115 k
 pdsh-mod-slurm-ohpc          x86_64    2.33-97.1.ohpc.1.3.7     OpenHPC-updates   15 k
 pmix-ohpc                    x86_64    2.2.2-9.1.ohpc.1.3.7     OpenHPC-updates  4.2 M
 slurm-devel-ohpc             x86_64    18.08.8-4.1.ohpc.1.3.8.1 OpenHPC-updates   77 k
 slurm-example-configs-ohpc   x86_64    18.08.8-4.1.ohpc.1.3.8.1 OpenHPC-updates  193 k
 slurm-ohpc                   x86_64    18.08.8-4.1.ohpc.1.3.8.1 OpenHPC-updates   13 M
 slurm-perlapi-ohpc           x86_64    18.08.8-4.1.ohpc.1.3.8.1 OpenHPC-updates  778 k
 slurm-slurmctld-ohpc         x86_64    18.08.8-4.1.ohpc.1.3.8.1 OpenHPC-updates  1.1 M
 slurm-slurmdbd-ohpc          x86_64    18.08.8-4.1.ohpc.1.3.8.1 OpenHPC-updates  656 k

Transaction Summary
================================================================================
Install  1 Package (+11 Dependent packages)

Total download size: 20 M
Installed size: 82 M
Downloading packages:
(1/12): munge-devel-ohpc-0.5.13-7.1.ohpc.1.3.7.x86_64.rpm              |  34 kB  00:00:00
(2/12): munge-libs-ohpc-0.5.13-7.1.ohpc.1.3.7.x86_64.rpm              |  50 kB  00:00:01
(3/12): ohpc-slurm-server-1.3.8-3.1.ohpc.1.3.8.x86_64.rpm             | 2.4 kB  00:00:00
(4/12): pdsh-mod-slurm-ohpc-2.33-97.1.ohpc.1.3.7.x86_64.rpm           |  15 kB  00:00:00
(5/12): munge-ohpc-0.5.13-7.1.ohpc.1.3.7.x86_64.rpm                   | 115 kB  00:00:01
(6/12): slurm-devel-ohpc-18.08.8-4.1.ohpc.1.3.8.1.x86_64.rpm          |  77 kB  00:00:01
(7/12): slurm-example-configs-ohpc-18.08.8-4.1.ohpc.1.3.8.1.x86_64.rpm | 193 kB  00:00:02
(9/12): slurm-ohpc-18.08.8-4.1.ohpc.1.3.8.1.x86_64.rpm    24% [===============-      ] 510 kB/s | 4.9 MB  00:00:30 ETA
```

wwinit database

wwinit ssh_keys


```
[root@master ~]# wwinit database
database:   Checking to see if RPM 'mysql-server' is installed          NO
database:   Checking to see if RPM 'mariadb-server' is installed        OK
database:   Activating Systemd unit: mariadb
database:   + /bin/systemctl -q enable mariadb.service                  OK
database:   + /bin/systemctl -q restart mariadb.service                 OK
database:   Database version: 1
database:   + mysql --defaults-extra-file=/tmp/0.iHbEuSARU8yA/my.cnf ware OK
database:   + mysql --defaults-extra-file=/tmp/0.iHbEuSARU8yA/my.cnf ware OK
database:   Checking binstore kind                                      SUCCESS
Done.
[root@master ~]# wwinit ssh_keys
ssh_keys:   Checking ssh keys for root                                  OK
ssh_keys:   Checking root's ssh config                                  OK
ssh_keys:   Checking for default RSA host key for nodes                 NO
ssh_keys:   Creating default node ssh_host_rsa_key:
ssh_keys:   + ssh-keygen -q -t rsa -f /etc/warewulf/vnfs/ssh/ssh_host_rsa OK
ssh_keys:   Checking for default DSA host key for nodes                 NO
ssh_keys:   Creating default node ssh_host_dsa_key:
ssh_keys:   + ssh-keygen -q -t dsa -f /etc/warewulf/vnfs/ssh/ssh_host_dsa OK
ssh_keys:   Checking for default ECDSA host key for nodes               NO
ssh_keys:   Creating default node ssh_host_ecdsa_key:
                                                                        OK
ssh_keys:   Checking for default Ed25519 host key for nodes             NO
ssh_keys:   Creating default node ssh_host_ed25519_key:
                                                                        OK
Done.
[root@master ~]#
```

df -hT | grep -v tmpfs

echo "master:/home /home nfs nfsvers=3,nodev,nosuid 0 0" >> $CHROOT/etc/fstab

echo "master:/opt/ohpc/pub /opt/ohpc/pub nfs nfsvers=3,nodev 0 0" >> $CHROOT/etc/fstab

cat ${CHROOT}/etc/fstab

cat /etc/exports

echo "/home *(rw,no_subtree_check,fsid=10,no_root_squash)" >> /etc/exports

echo "/opt/ohpc/pub *(ro,no_subtree_check,fsid=11)" >> /etc/exports

```
ssh_keys:      Checking for default Ed25519 host key for nodes           NO
ssh_keys:      Creating default node ssh_host_ed25519_key:
                                                                         OK
Done.
[root@master ~]# df -hT | grep -v tmpfs
Filesystem              Type     Size  Used Avail Use% Mounted on
/dev/mapper/centos-root xfs       50G  9.4G   41G  19% /
/dev/sda1               xfs     1014M  282M  733M  28% /boot
/dev/mapper/centos-home xfs       46G   33M   46G   1% /home
/dev/sr0                iso9660  4.4G  4.4G     0 100% /run/media/root/CentOS 7 x86_64
[root@master ~]# hostname
master
[root@master ~]# cat  ${CHROOT}/etc/fstab
#GENERATED_ENTRIES#
tmpfs /dev/shm tmpfs defaults 0 0
devpts /dev/pts devpts gid=5,mode=620 0 0
sysfs /sys sysfs defaults 0 0
proc /proc proc defaults 0 0
[root@master ~]# echo "master:/home /home nfs nfsvers=3,nodev,nosuid 0 0" >> $CHROOT/etc/fstab
[root@master ~]# echo "master:/opt/ohpc/pub /opt/ohpc/pub nfs nfsvers=3,nodev 0 0" >> $CHROOT/etc/fstab
[root@master ~]# cat  ${CHROOT}/etc/fstab
#GENERATED_ENTRIES#
tmpfs /dev/shm tmpfs defaults 0 0
devpts /dev/pts devpts gid=5,mode=620 0 0
sysfs /sys sysfs defaults 0 0
proc /proc proc defaults 0 0
master:/home /home nfs nfsvers=3,nodev,nosuid 0 0
master:/opt/ohpc/pub /opt/ohpc/pub nfs nfsvers=3,nodev 0 0
[root@master ~]# cat /etc/exports
[root@master ~]# echo "/home *(rw,no_subtree_check,fsid=10,no_root_squash)" >> /etc/exports
[root@master ~]# echo "/opt/ohpc/pub *(ro,no_subtree_check,fsid=11)" >> /etc/exports
[root@master ~]# cat /etc/exports
/home *(rw,no_subtree_check,fsid=10,no_root_squash)
/opt/ohpc/pub *(ro,no_subtree_check,fsid=11)
[root@master ~]# systemctl start nfs-server
[root@master ~]# systemctl enable nfs-server
Created symlink from /etc/systemd/system/multi-user.target.wants/nfs-server.service to /usr/lib/systemd/system/nfs-server.service.
[root@master ~]# exportfs -arv
exporting *:/opt/ohpc/pub
exporting *:/home
[root@master ~]#
```

systemctl start nfs-server

systemctl enable nfs-server

Booting Disk-less Node

ip a (Booted node)

```
CentOS Linux 7 (Core)
Kernel 3.10.0-1160.81.1.el7.x86_64 on an x86_64

node1 login: root
Password:
[root@node1 ~]# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group defaul
t qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP gr
oup default qlen 1000
    link/ether 00:0c:29:ec:16:c2 brd ff:ff:ff:ff:ff:ff
    inet 192.168.23.150/24 brd 192.168.23.255 scope global eth0
       valid_lft forever preferred_lft forever
    inet6 fe80::20c:29ff:feec:16c2/64 scope link
       valid_lft forever preferred_lft forever
[root@node1 ~]# _
```

SLURM

The Slurm Workload Manager, formerly known as Simple Linux Utility for Resource Management (SLURM), or simply Slurm, is a free and open-source job scheduler for Linux and Unix-like kernels, used by many of the world's supercomputers and computer clusters.
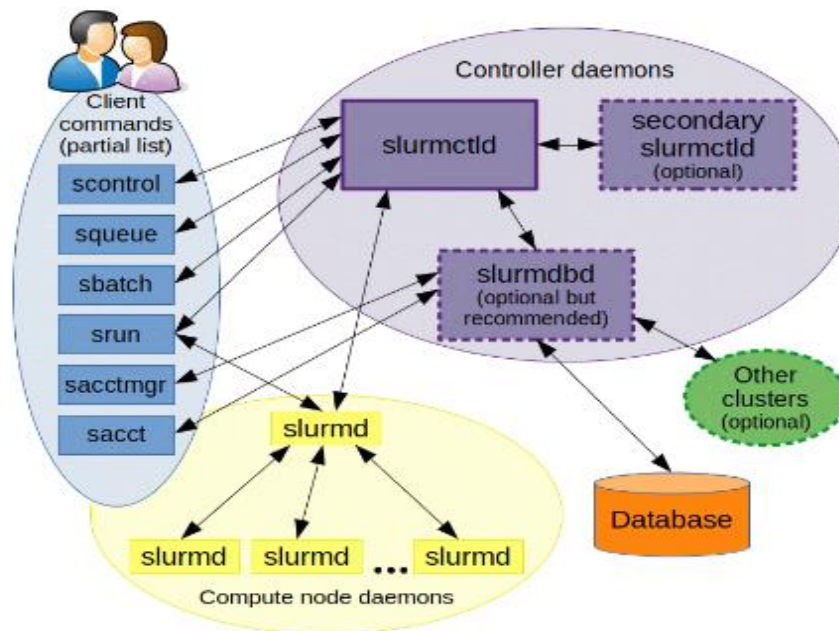
Figure 1. Slurm components

yum -y install ohpc-slurm-server

yum -y install slurm-sview-ohpc slurm-torque-ohpc

vi /etc/slurm/slurm.conf

    edit -> ClusterName=pearl

      -> ControlMachine=master

      -> NodeName=node[1-2]

export CHROOT=/opt/ohpc/admin/images/centos7.7

wwmkchroot centos-7 $CHROOT

chroot ${CHROOT} uname -r
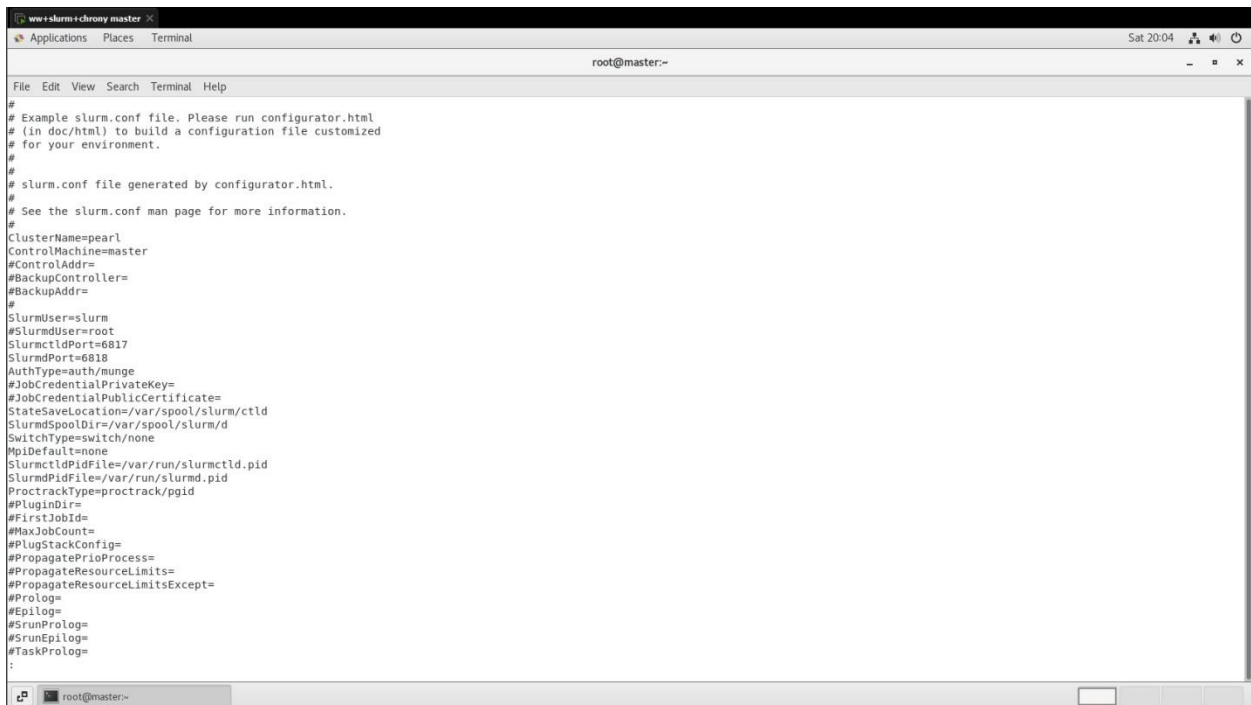
yum -y --installroot=${CHROOT} install \

 ohpc-base-compute kernel kernel-headers kernel-devel kernel-tools parted \

 xfsprogs python-devel yum htop ipmitool glibc* perl perl-CPAN perl-CPAN \
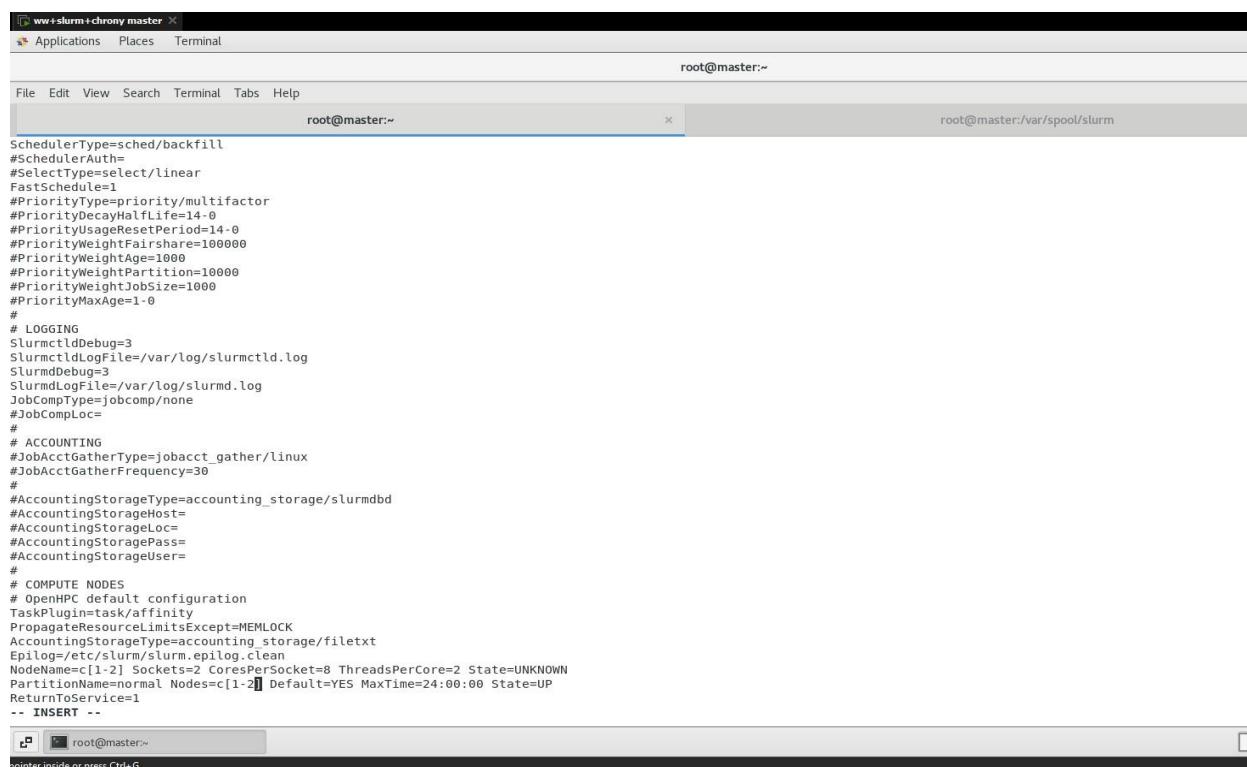
 sysstat gcc make xauth firefox squashfs-tools

Slurm Configuration

```
#
# Example slurm.conf file. Please run configurator.html
# (in doc/html) to build a configuration file customized
# for your environment.
#
#
# slurm.conf file generated by configurator.html.
#
# See the slurm.conf man page for more information.
#
ClusterName=pearl
ControlMachine=master
#ControlAddr=
#BackupController=
#BackupAddr=
#
SlurmUser=slurm
#SlurmdUser=root
SlurmctldPort=6817
SlurmdPort=6818
AuthType=auth/munge
#JobCredentialPrivateKey=
#JobCredentialPublicCertificate=
StateSaveLocation=/var/spool/slurm/ctld
SlurmdSpoolDir=/var/spool/slurm/d
SwitchType=switch/none
MpiDefault=none
SlurmctldPidFile=/var/run/slurmctld.pid
SlurmdPidFile=/var/run/slurmd.pid
ProctrackType=proctrack/pgid
#PluginDir=
#FirstJobId=
#MaxJobCount=
#PlugStackConfig=
#PropagatePrioProcess=
#PropagateResourceLimits=
#PropagateResourceLimitsExcept=
#Prolog=
#Epilog=
#SrunProlog=
#SrunEpilog=
#TaskProlog=
:
```

```
SchedulerType=sched/backfill
#SchedulerAuth=
#SelectType=select/linear
FastSchedule=1
#PriorityType=priority/multifactor
#PriorityDecayHalfLife=14-0
#PriorityUsageResetPeriod=14-0
#PriorityWeightFairshare=100000
#PriorityWeightAge=1000
#PriorityWeightPartition=10000
#PriorityWeightJobSize=1000
#PriorityMaxAge=1-0
#
# LOGGING
SlurmctldDebug=3
SlurmctldLogFile=/var/log/slurmctld.log
SlurmdDebug=3
SlurmdLogFile=/var/log/slurmd.log
JobCompType=jobcomp/none
#JobCompLoc=
#
# ACCOUNTING
#JobAcctGatherType=jobacct_gather/linux
#JobAcctGatherFrequency=30
#
#AccountingStorageType=accounting_storage/slurmdbd
#AccountingStorageHost=
#AccountingStorageLoc=
#AccountingStoragePass=
#AccountingStorageUser=
#
# COMPUTE NODES
# OpenHPC default configuration
TaskPlugin=task/affinity
PropagateResourceLimitsExcept=MEMLOCK
AccountingStorageType=accounting_storage/filetxt
Epilog=/etc/slurm/slurm.epilog.clean
NodeName=c[1-2] Sockets=2 CoresPerSocket=8 ThreadsPerCore=2 State=UNKNOWN
PartitionName=normal Nodes=c[1-2] Default=YES MaxTime=24:00:00 State=UP
ReturnToService=1
-- INSERT --
```
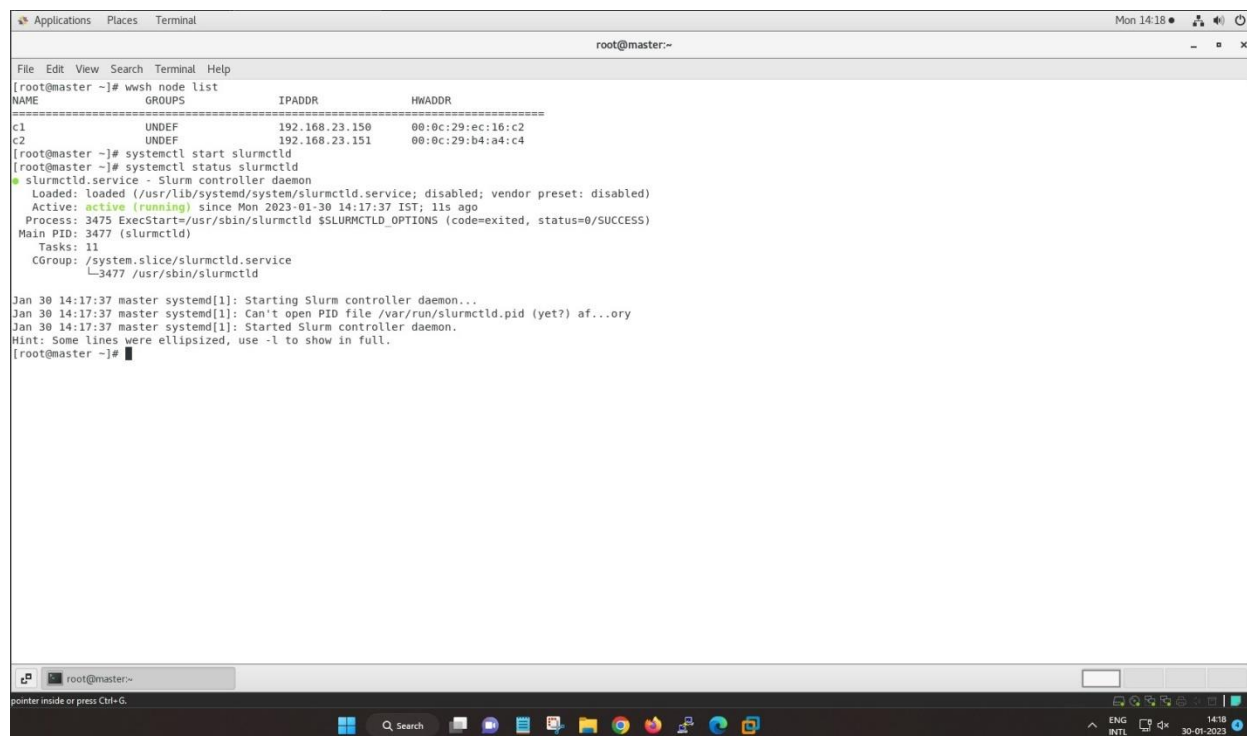
systemctl ststus slurmctld

Slurm status on master


```
[root@master ~]# wwsh node list
NAME            GROUPS          IPADDR          HWADDR
================================================================
c1              UNDEF           192.168.23.150  00:0c:29:ec:16:c2
c2              UNDEF           192.168.23.151  00:0c:29:b4:a4:c4
[root@master ~]# systemctl start slurmctld
[root@master ~]# systemctl status slurmctld
● slurmctld.service - Slurm controller daemon
   Loaded: loaded (/usr/lib/systemd/system/slurmctld.service; disabled; vendor preset: disabled)
   Active: active (running) since Mon 2023-01-30 14:17:37 IST; 11s ago
  Process: 3475 ExecStart=/usr/sbin/slurmctld $SLURMCTLD_OPTIONS (code=exited, status=0/SUCCESS)
 Main PID: 3477 (slurmctld)
    Tasks: 11
   CGroup: /system.slice/slurmctld.service
           └─3477 /usr/sbin/slurmctld

Jan 30 14:17:37 master systemd[1]: Starting Slurm controller daemon...
Jan 30 14:17:37 master systemd[1]: Can't open PID file /var/run/slurmctld.pid (yet?) af...ory
Jan 30 14:17:37 master systemd[1]: Started Slurm controller daemon.
Hint: Some lines were ellipsized, use -l to show in full.
[root@master ~]#
```

systemctl status slurmd

Slurm status on node

```
Kernel 3.10.0-1160.81.1.el7.x86_64 on an x86_64

c1 login: root
Password:
[root@c1 ~]# systemctl start slurmd
[root@c1 ~]# systemctl status slurmd
■ slurmd.service - Slurm node daemon
   Loaded: loaded (/usr/lib/systemd/system/slurmd.service; enabled; vendor prese
t: disabled)
   Active: active (running) since Mon 2023-01-30 14:17:19 IST; 42s ago
  Process: 1182 ExecStart=/usr/sbin/slurmd $SLURMD_OPTIONS (code=exited, status=
0/SUCCESS)
 Main PID: 1219 (slurmd)
    Tasks: 2
   Memory: 1.1M
   CGroup: /system.slice/slurmd.service
           └─1219 /usr/sbin/slurmd

Jan 30 14:16:59 c1 systemd[1]: Starting Slurm node daemon...
Jan 30 14:17:19 c1 systemd[1]: Can't open PID file /var/run/slurmd.pid (yet...ry
Jan 30 14:17:19 c1 systemd[1]: Started Slurm node daemon.
Hint: Some lines were ellipsized, use -l to show in full.
[root@c1 ~]# date
Mon Jan 30 14:20:13 IST 2023
[root@c1 ~]#
```

NAGIOS

Nagios is **an open source monitoring system for computer systems**. It was designed to run on the Linux operating system and can monitor devices running Linux, Windows and Unix operating systems (OSes). Nagios software runs periodic checks on critical parameters of application, network and server resources.
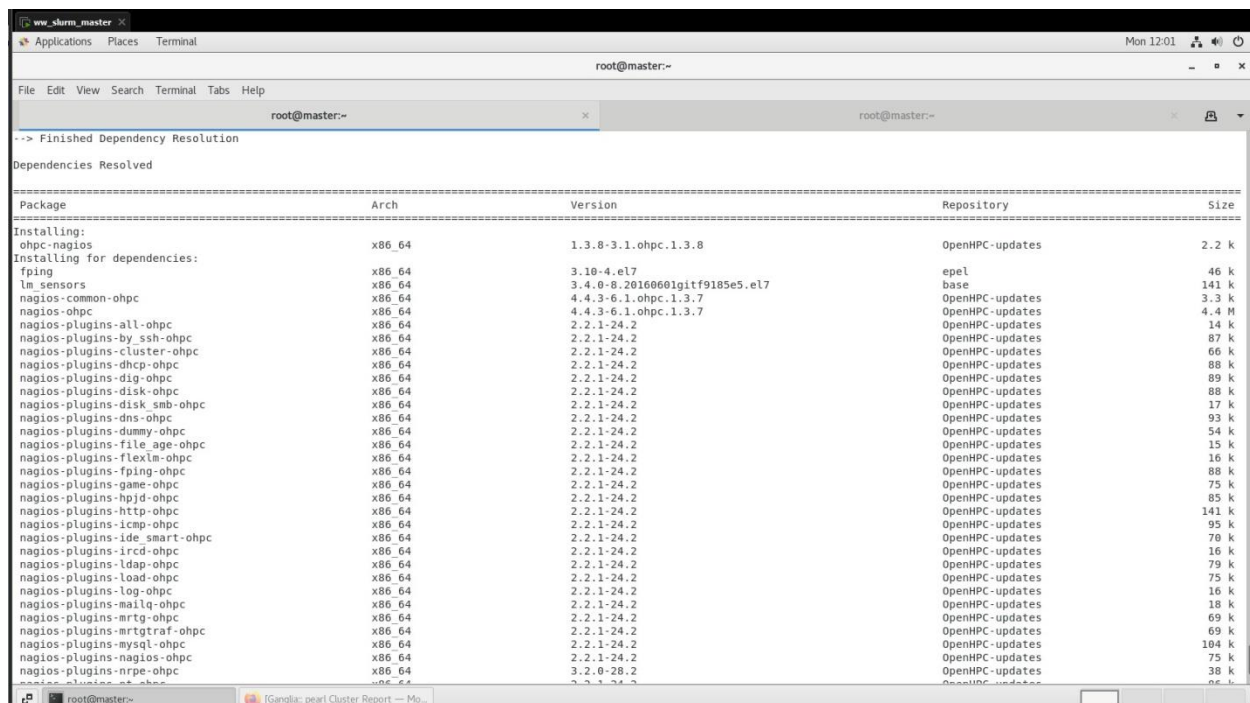
yum -y install ohpc-nagios   -> Install Nagios meta-package on master host

yum -y --installroot=$CHROOT install nagios-plugins-all-ohpc nrpe-ohpc

vi $CHROOT/etc/nagios/nrpe.cfg

vi $CHROOT/etc/hosts.allow

Nagios Packages:

Nagios Configuration file:

Nagios result on browser:

Node1 & Node2 showed

GANGLIA

Ganglia is **an open-source scalable distributed monitoring system for high-performance computing systems such as clusters and Grids**. It is carefully engineered to achieve very low per-node overheads and high concurrency.

yum -y install ohpc-ganglia

yum -y --installroot=${CHROOT} install ganglia-gmond-ohpc

cp /opt/ohpc/pub/examples/ganglia/gmond.conf /etc/ganglia/gmond.conf

sed -i "s/<sms>/master/" /etc/ganglia/gmond.conf

sed -i "s/OpenHPC/pearl/" /etc/ganglia/gmond.conf

cp /etc/ganglia/gmond.conf $CHROOT/etc/ganglia/gmond.conf

echo "gridname pearl" >> /etc/ganglia/gmetad.conf

echo "

systemctl enable gmond

systemctl enable gmetad

systemctl start gmond

systemctl start gmetad

chroot ${CHROOT} systemctl enable gmond

" > /tmp/start_ganglia_service.sh

bash /tmp/start_ganglia_service.sh

grep "^date.timezone =" /etc/php.ini

echo "date.timezone = Asia/Kolkata" >> /etc/php.ini

grep "^date.timezone =" /etc/php.ini

systemctl try-restart httpd

Go to browser : **http://master/ganglia**
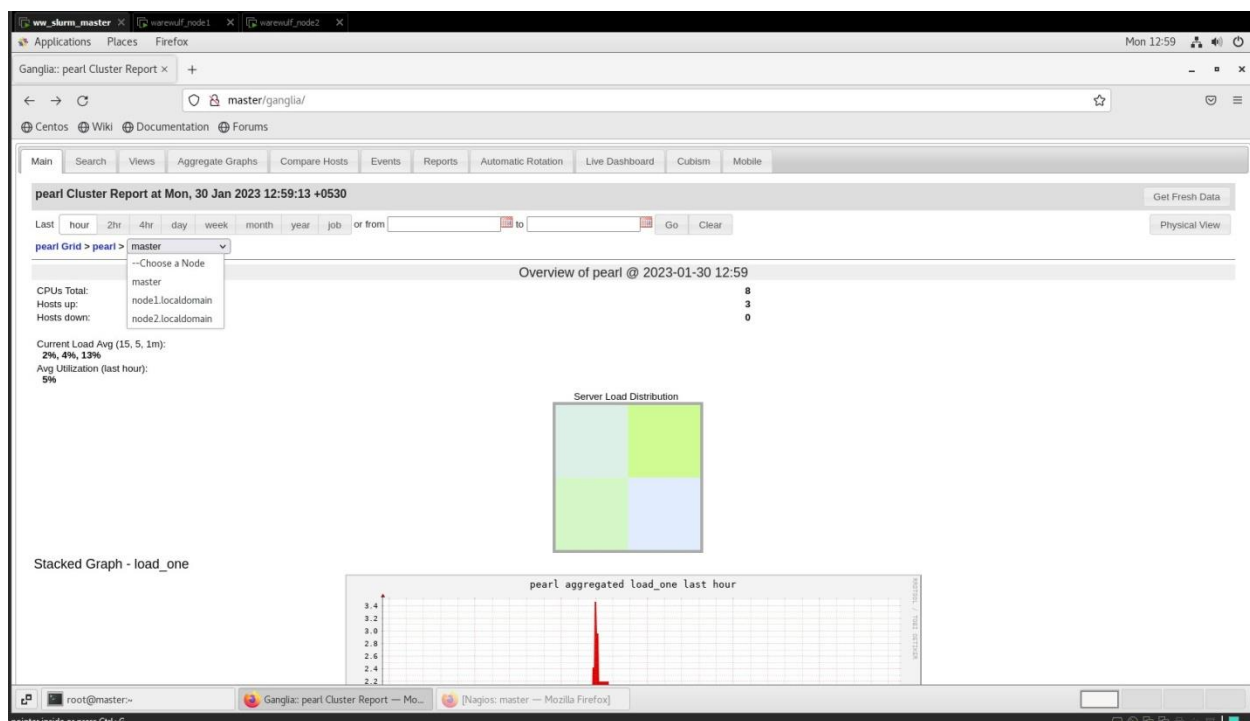
HPL Benchmarking

HPL is **a High-Performance Linpack benchmark implementation**. The code solves a uniformely random system of linear equations and reports time and floating-point execution rate using a standard formula for operation count.

yum install atlas -y

wget https://netlib.org/benchmark/hpl/hpl-2.3.tar.gz

wget https://download.open-mpi.org/release/open-mpi/v4.1/openmpi-4.1.4.tar.gz

```
fomit-frame-pointer -O3 -funroll-loops -o /root/Downloads/hpl-2.3/bin/Linux_PII_CBLA
t.o /root/Downloads/hpl-2.3/lib/Linux_PII_CBLAS/libhpl.a  /usr/lib64/atlas/libcblas.
mpi.so
gcc: error: /usr/lib64/atlas/libcblas.so.3: No such file or directory
gcc: error: /usr/lib64/atlas/libatlas.so.3: No such file or directory
make[2]: *** [dexe.grd] Error 1
make[2]: Leaving directory `/root/Downloads/hpl-2.3/testing/ptest/Linux_PII_CBLAS'
make[1]: *** [build_tst] Error 2
make[1]: Leaving directory `/root/Downloads/hpl-2.3'
make: *** [build] Error 2
[root@master hpl-2.3]# rpm -ql atlas
/etc/ld.so.conf.d/atlas-x86_64.conf
/usr/lib64/atlas
/usr/lib64/atlas/libsatlas.so.3
/usr/lib64/atlas/libsatlas.so.3.10
/usr/lib64/atlas/libtatlas.so.3
/usr/lib64/atlas/libtatlas.so.3.10
/usr/share/doc/atlas-3.10.1
/usr/share/doc/atlas-3.10.1/README.dist
[root@master hpl-2.3]#
```

vim Make.Linux_PII_CBLAS

```
>> edit    # --------------------------------------------------------------------
              # - HPL Directory Structure / HPL library -------------------------
              # --------------------------------------------------------------------
                   TOPdir     = /root/Downloads/hpl-2.
           # --------------------------------------------------------------------
              # - Message Passing library (MPI) -----------------------------------
              # --------------------------------------------------------------------
                   MPdir      = /opt/openmpi-4.1.
                   MPlib      = $(MPdir)/lib/libmpi.so
              # --------------------------------------------------------------------
                   # - Compilers / linkers - Optimization flags -----------
              # --------------------------------------------------------------------
              # CC         = /usr/bin/gcc
                   LINKER     = /usr/bin/gcc
              # --------------------------------------------------------------------
              # - Linear Algebra library (BLAS or VSIPL) ---------------------
              # --------------------------------------------------------------------
                   LAlib      = $(LAdir)/libsatlas.so.3
                   $(LAdir)/libtatlas.so.3
>> <Escape Key> : wq
```

cd /root/Downloads/hpl-2.3/bin/Linux_PII_CBLAS/

vi HPL.dat

```
HPLinpack benchmark input file
Innovative Computing Laboratory, University of Tennessee
HPL.out      output file name (if any)
6            device out (6=stdout,7=stderr,file)
4            # of problems sizes (N)
29 30 34 35  Ns
4            # of NBs
1 2 3 4      NBs
0            PMAP process mapping (0=Row-,1=Column-major)
3            # of process grids (P x Q)
2 1 4        Ps
2 4 1        Qs
16.0         threshold
3            # of panel fact
0 1 2        PFACTs (0=left, 1=Crout, 2=Right)
2            # of recursive stopping criterium
2 4          NBMINs (>= 1)
1            # of panels in recursion
2            NDIVs
3            # of recursive panel fact.
0 1 2        RFACTs (0=left, 1=Crout, 2=Right)
1            # of broadcast
0            BCASTs (0=1rg,1=1rM,2=2rg,3=2rM,4=Lng,5=LnM)
1            # of lookahead depth
0            DEPTHs (>=0)
2            SWAP (0=bin-exch,1=long,2=mix)
64           swapping threshold
0            L1 in (0=transposed,1=no-transposed) form
0            U  in (0=transposed,1=no-transposed) form
1            Equilibration (0=no,1=yes)
8            memory alignment in double (> 0)
~
~
~
~
~
~
~
~
"HPL.dat" 31L, 1133C
```

mpirun --allow-run-as-root -np 4 ./xhpl HPL.dat

```
root@master:~/Downloads/hpl-2.3/bin/Linux_PII_CBLAS
--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   1.81558863e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q               Time             Gflops
--------------------------------------------------------------------------------
WR00R2L4           30    1     4     1               0.00           3.0368e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   1.81558863e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q               Time             Gflops
--------------------------------------------------------------------------------
WR00R2C2           30    1     4     1               0.00           2.9527e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   1.81558863e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q               Time             Gflops
--------------------------------------------------------------------------------
WR00R2C4           30    1     4     1               0.00           3.0281e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   1.81558863e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q               Time             Gflops
--------------------------------------------------------------------------------
WR00R2R2           30    1     4     1               0.00           3.0077e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   1.81558863e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q               Time             Gflops
--------------------------------------------------------------------------------
WR00R2R4           30    1     4     1               0.00           2.7510e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   1.81558863e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q               Time             Gflops
--------------------------------------------------------------------------------
WR00L2L2           30    2     4     1               0.00           2.4171e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   2.65355261e-02 ...... PASSED
================================================================================
```

```
root@master:~/Downloads/hpl-2.3/bin/Linux_PII_CBLAS

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=  2.07165390e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q          Time           Gflops
--------------------------------------------------------------------------------
WR00L2L4           35    4     4     1          0.00           5.6846e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=  2.17523660e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q          Time           Gflops
--------------------------------------------------------------------------------
WR00L2C2           35    4     4     1          0.00           5.8055e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=  2.07165390e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q          Time           Gflops
--------------------------------------------------------------------------------
WR00L2C4           35    4     4     1          0.00           6.0286e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=  3.57360298e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q          Time           Gflops
--------------------------------------------------------------------------------
WR00L2R2           35    4     4     1          0.00           5.9891e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=  2.07165390e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q          Time           Gflops
--------------------------------------------------------------------------------
WR00L2R4           35    4     4     1          0.00           6.3178e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=  2.07165390e-02 ...... PASSED
================================================================================
T/V                N    NB     P     Q          Time           Gflops
--------------------------------------------------------------------------------
WR00C2L2           35    4     4     1          0.00           4.6802e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023

--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=  2.07165390e-02 ...... PASSED
================================================================================
```

root@master:~/Downloads/hpl-2.3/bin/Linux_PII_CBLAS

```
--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   2.07165390e-02 ...... PASSED
================================================================================
T/V                N    NB     P    Q               Time                 Gflops
--------------------------------------------------------------------------------
WR00R2C4          35     4     4    1               0.00              6.1972e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023


--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   3.57360298e-02 ...... PASSED
================================================================================
T/V                N    NB     P    Q               Time                 Gflops
--------------------------------------------------------------------------------
WR00R2R2          35     4     4    1               0.00              6.0979e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023


--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   2.07165390e-02 ...... PASSED
================================================================================
T/V                N    NB     P    Q               Time                 Gflops
--------------------------------------------------------------------------------
WR00R2R4          35     4     4    1               0.00              6.2135e-01
HPL_pdgesv() start time Sun Jan 29 19:32:49 2023

HPL_pdgesv() end time   Sun Jan 29 19:32:49 2023


--------------------------------------------------------------------------------
||Ax-b||_oo/(eps*(||A||_oo*||x||_oo+||b||_oo)*N)=   2.07165390e-02 ...... PASSED
================================================================================

Finished     864 tests with the following results:
          864 tests completed and passed residual checks,
            0 tests completed and failed residual checks,
            0 tests skipped because of illegal input values.
--------------------------------------------------------------------------------

End of Tests.
================================================================================
[root@master Linux_PII_CBLAS]# mpirun --allow-run-as-root -np 4 ./xhpl HPL.dat []
```

Cammands History

Work-Flow Commands:

Configuring Warewulf, Slurm, Nagios, Ganglia

Link1: ohpc-warewulf-slurm-nagios-ganglia.txt

Configuring HPL Benchmarking

Link2: hpl benchmarking.txt