Problem Statement-

Build a Two node Disk-less HPC-Cluster using OpenHPC with xCAT,OpenLDAP, Slurm, Ganglia, HPL benchmark and Document the result.

Introduction-

The master node serves as the overall system management server (SMS) and is provisioned with CentOS7.7 and is subsequently configured to provision the compute node with xCAT in a stateless configuration.

XCAT-

In VMWare Create 1 Machine namely-masterwith HDD 100GB, RAM 15GB, two Network 1.NAT 2. HostOnly.

Commands on master:

systemctl status firewalld

systemctl stop firewalld

systemctl disable firewalld

- Disabling Selinux

vi /etc/selinux/config

getenforce

setenforce 0

getenforce

vi /etc/selinux/config

syslinux=disabled

reboot

getenforce

- Enable use of the public xCAT repository by adding it to the local list of available package repositories. This also requires network access from your master server to the internet, or alternatively, that the repository be mirrored locally

yum install yum-utils

cat /etc/yum.conf

wget -P /etc/yum.repos.d https://xcat.org/files/xcat/repos/yum/latest/xcat-core/xcat-core.repo

yum install xCAT

yum update

ll /etc/profile.d/xcat.sh

```
[root@master ~]# ll /etc/profile.d/xcat.sh
-rwxr-xr-x 1 root root 174 Dec 23 08:24 /etc/profile.d/xcat.sh
```

. /etc/profile.d/xcat.sh

echo $PATH

lsxcatd -a

lsxcatd -d

lsxcatd –v

```
[root@master ~]# lsxcatd -a
Version 2.16.4 (git commit bb7a4bbbc8bde7e6613558d8d039fe43d49d2079, built Mon Jun 13 08:53:10 EDT 2022)
This is a Management Node
dbengine=SQLite
[root@master ~]# lsxcatd -d
dbengine=SQLite
[root@master ~]# lsxcatd -v
Version 2.16.4 (git commit bb7a4bbbc8bde7e6613558d8d039fe43d49d2079, built Mon Jun 13 08:53:10 EDT 2022)
```

tabdump site

chdef -t site dhcpinterfaces="ens36"

- Assigning host only IP to master

chdef -t site master="192.168.100.10”

tabdump site | grep master

tabdump site | grep dhcpinterfaces

```
[root@master ~]# tabdump site | grep master
"master","192.168.100.10",,
[root@master ~]# tabdump site | grep dhcpinterfaces
"dhcpinterfaces","ens36",,
```

lsblk

lsb_release

cat /etc/os-release

dd if=/dev/sr0 of=/root/Centos7.iso

ll –h

- Building a default image for use with xCAT. To begin, we will first need to have a local copy of the ISO image available for the underlying OS. The relevant ISO image is CentOS-7-x86 64-minimal.iso (available from the CentOS mirrors). We initialize the image creation process using the copycds command assuming that the necessary ISO image is available locally.

copycds /root/Centos7.iso

- Once completed, several OS images should be available for use within xCAT. These can be queried via:

lsdef -t osimage

- we leverage the stateless (netboot) image for compute nodes and proceed by using genimage to initialize a chroot-based install. Note that the previous query highlights the existence of other provisioning images as well.

genimage centos7.9-x86_64-netboot-compute

mkdir -p /install/custom/netboot/

lsdef -t osimage centos7.9-x86_64-netboot-compute

chdef -t osimage centos7.9-x86_64-netboot-compute synclists="/install/custom/netboot/compute.synclist"

- Syncing users, groups and passwords

echo "/etc/passwd -> /etc/passwd" >> /install/custom/netboot/compute.synclist

echo "/etc/group -> /etc/group" >> /install/custom/netboot/compute.synclist

echo "/etc/hosts -> /etc/hosts" >> /install/custom/netboot/compute.synclist

echo "/etc/shadow -> /etc/shadow" >> /install/custom/netboot/compute.synclist

- To finalize the xCAT provisioning configuration, this section first highlights packing of the stateless image from the chroot environment followed by the registration of desired compute nodes. To assemble the final compute image use packimage as follows:

packimage centos7.9-x86_64-netboot-compute

- Assigning IP in range of host only IP and mac address of newly created VM machine (compute node)

mkdef -t node cn00 groups=compute,all ip=192.168.100.115 mac=00:0C:29:0F:1F:93 netboot=xnba

- xnba-neworkboot loader

lsdef cn00

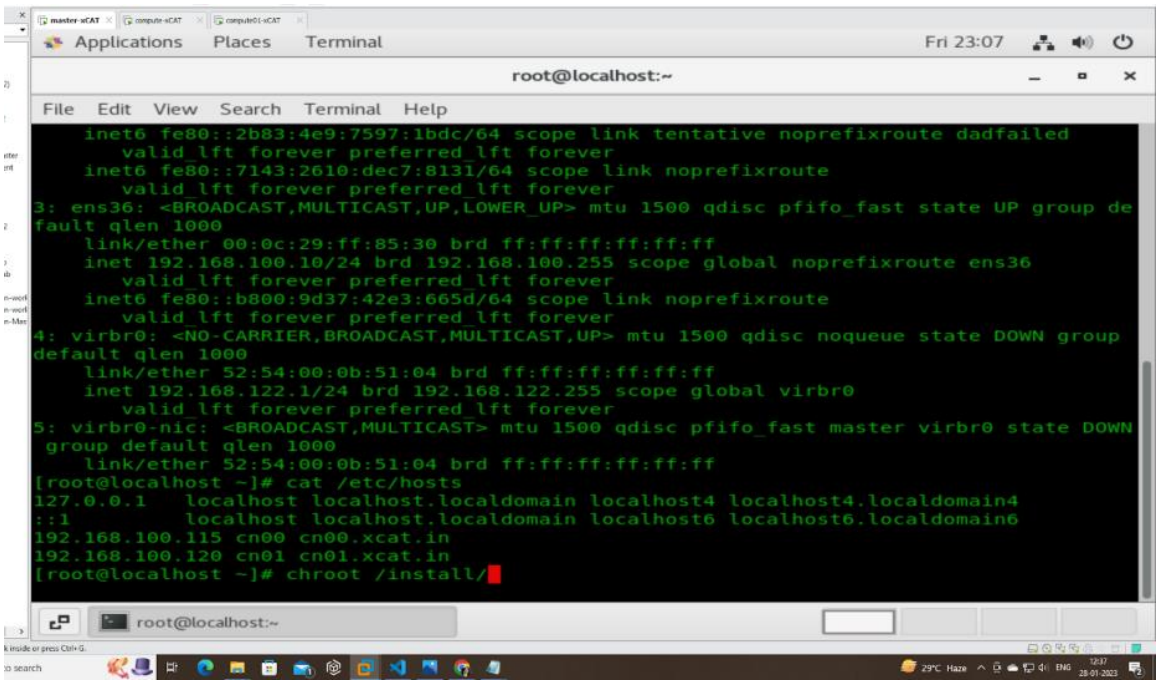
chdef -t node node1 provmethod=centos7.9-x86_64-netboot-compute

chdef -t group compute provmethod=centos7.9-x86_64-netboot-compute

lsdef node1

chdef -t site domain=xcat.in

cat /etc/hosts



makehosts

makenetworks

makedhcp -n

systemctl start dhcpd

makedns -n

yum install dhcp*

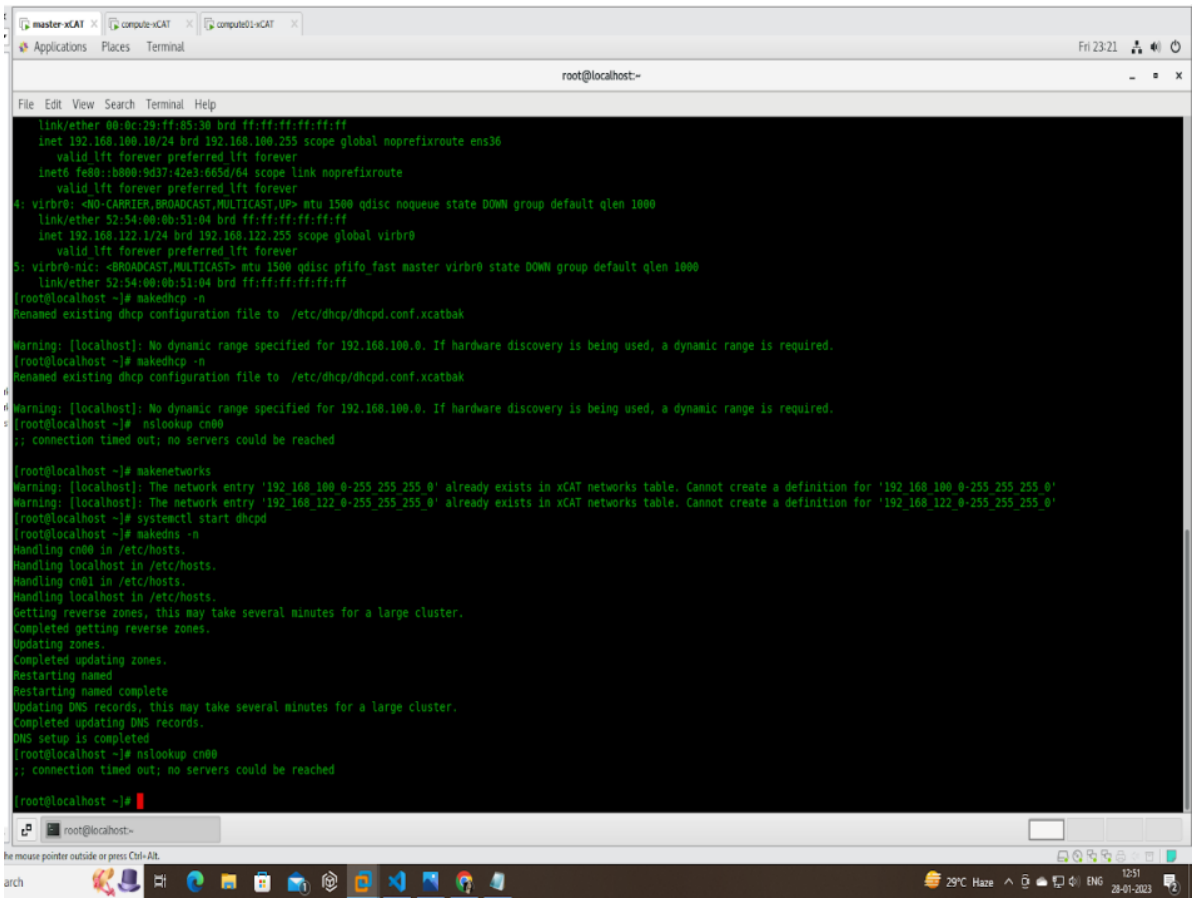
makedhcp -n

makedns

nslookup cn00

vi /etc/resolv.conf

nslookup cn00



vi /etc/resolv.conf

Generated by NetworkManager

search localdomain xcat.in

nameserver 192.168.100.10

nameserver 192.168.207.2

lsdef -t osimagewe

nodeset compute osimage=centos7.9-x86_64-netboot-compute

systemctl restart dhcpd

systemctl start dhcpd

makedhcp -n

nodeset compute osimage=centos7.9-x86_64-netboot-compute

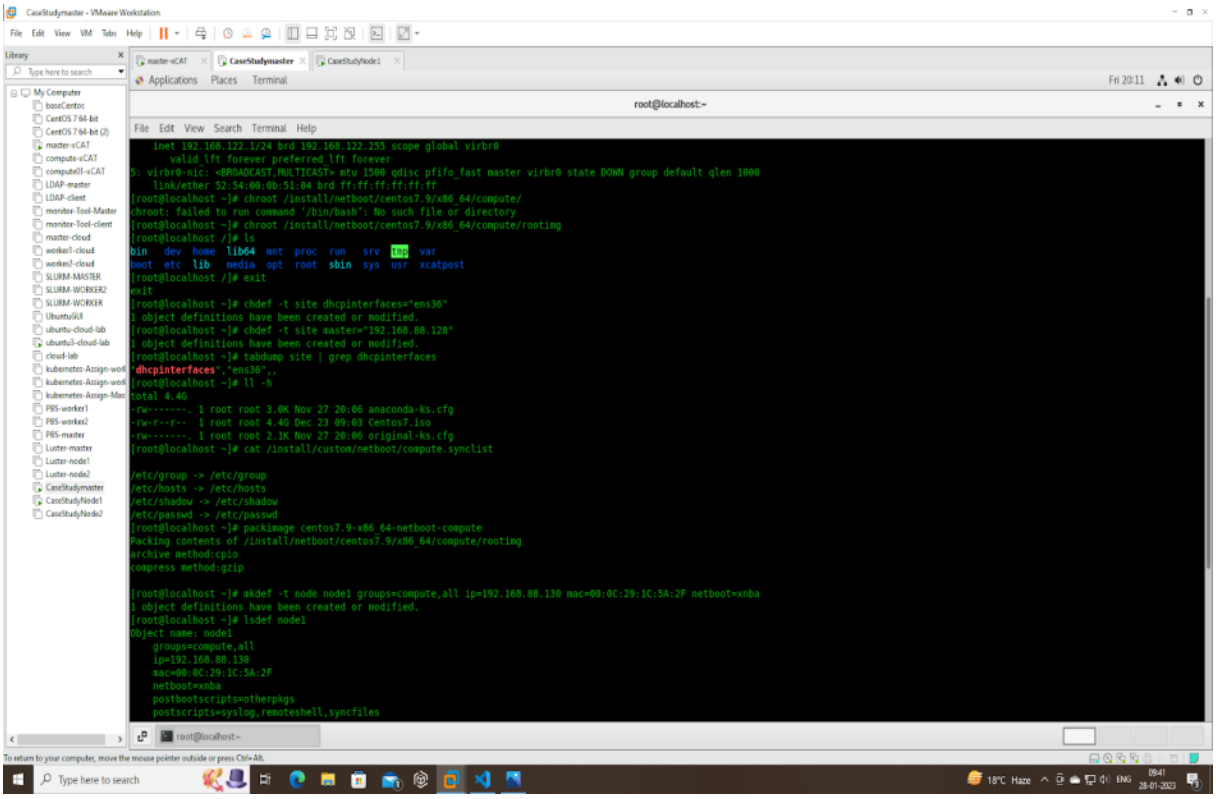
makedhcp cn00

systemctl status dhcpd

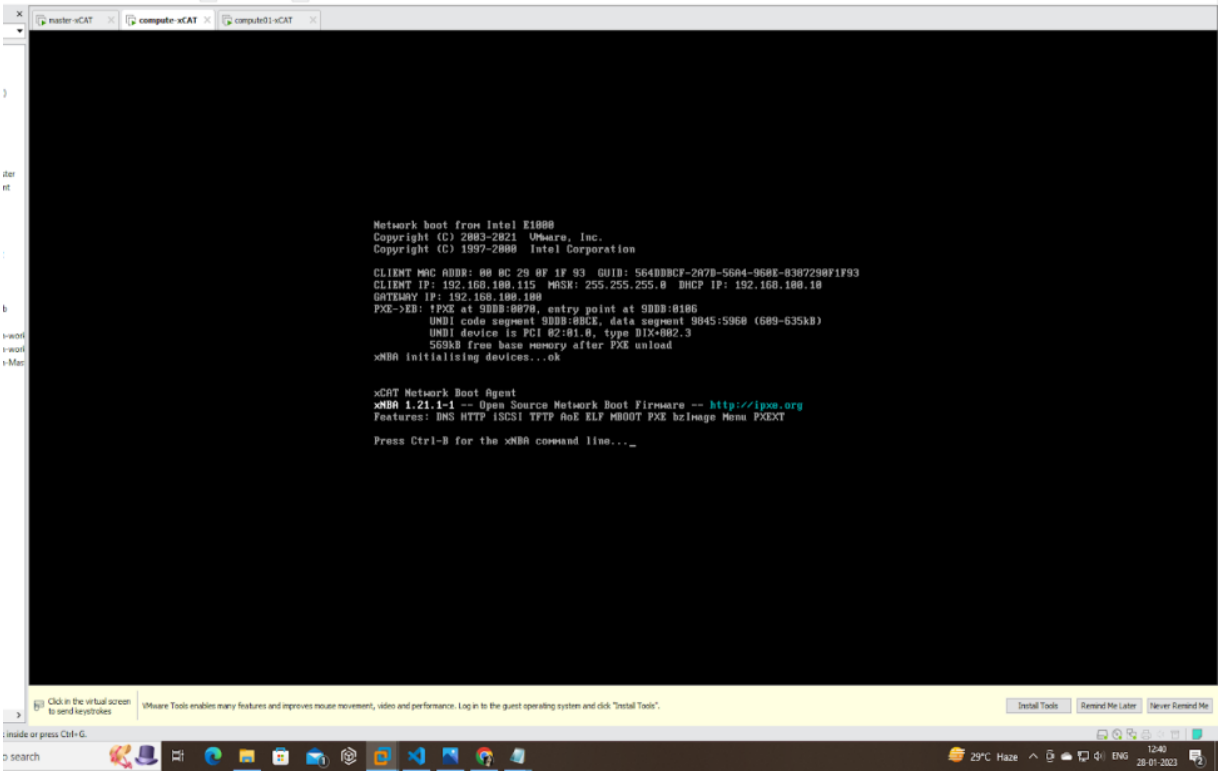
systemctl restart dhcpd

systemctl status dhcpd

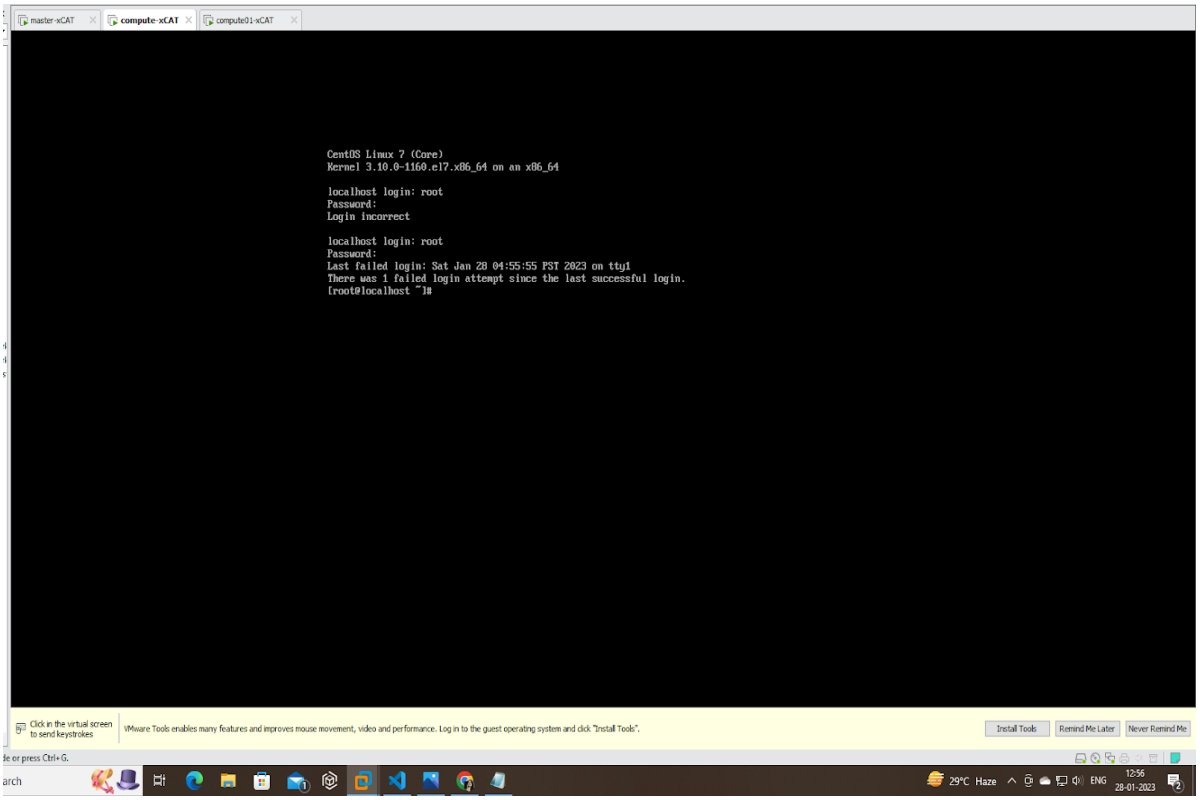
chdef -t osimage -o centos7.9-x86_64-netboot-compute synclists="/install/custom/netboot/compute.synclist"



- Booting Compute node through XCAT-



- Successfully booted via XCAT on node1



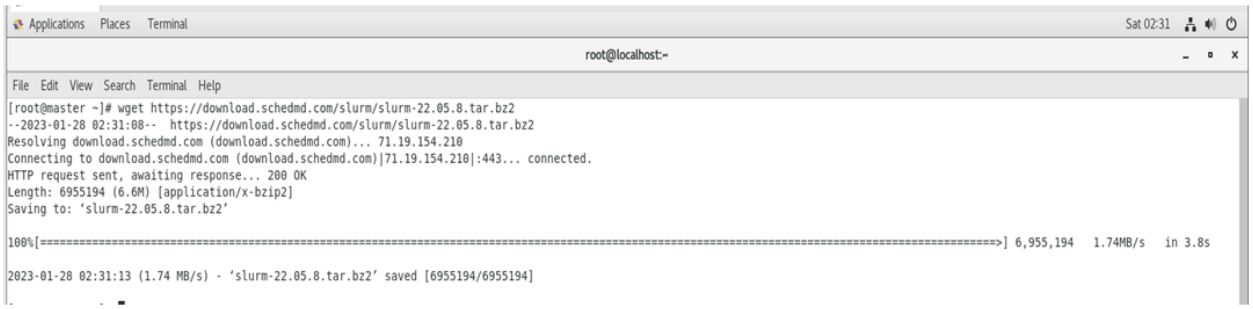
SLURM-

Installing Slurm via XCAT is a process of configuring the Slurm workload manager to run on a cluster managed by XCAT. It involves setting up XCAT as the frontend node and the compute nodes, configuring the Slurm daemons (such as slurmd and slurmctld), and defining the Slurm partition and nodes.

Commands for master

export CHROOT=/install/netboot/centos7.9/x86_64/compute/rootimg/

wgethttps://download.schedmd.com/slurm/slurm-22.05.8.tar.bz2



#yum install mariadb-server mariadb-devel –y

#yum install epel-release

#yum --installroot=$CHROOT install epel-release

yum install munge munge-libs munge-devel –y

yum --installroot=$CHROOT install munge munge-libs munge-devel –y

yum install rpm-build

yum install python3 readline-devel pam-devel

rpmbuild -ta slurm-22.05.8.tar.bz2

yum install gcc

- Creating munge key

/usr/sbin/create-munge-key –r

```
[root@master ~]# /usr/sbin/create-munge-key -r
Please type on the keyboard, echo move your mouse,
utilize the disks. This gives the random number generator
a better chance to gain enough entropy.
Generating a pseudo-random key using /dev/random completed.
[root@master ~]#
```

- Copying munge.key to node

scp /etc/munge/munge.key $CHROOT/etc/munge

#ls -l

```
[root@master munge]# ls -l
total 4
-r-------- 1 munge munge 1024 Jan 28 02:44 munge.key
[root@master munge]#
```

- Changing permission and ownership of the munge.key on both nodes

chown -R munge:munge /etc/munge/

chroot $CHROOT chown -R munge:munge /etc/munge/

chroot $CHROOT chmod 400 /etc/munge/munge.key

systemctl start munge

systemctl enable munge

systemctl status munge

```
[root@master munge]# systemctl start munge
[root@master munge]# systemctl enable munge
Created symlink from /etc/systemd/system/multi-user.target.wants/munge.service to /usr/lib/systemd/system/munge.service.
[root@master munge]# systemctl status munge
● munge.service - MUNGE authentication service
   Loaded: loaded (/usr/lib/systemd/system/munge.service; enabled; vendor preset: disabled)
   Active: active (running) since Sat 2023-01-28 02:52:58 PST; 32s ago
     Docs: man:munged(8)
 Main PID: 61391 (munged)
   CGroup: /system.slice/munge.service
           └─61391 /usr/sbin/munged

Jan 28 02:52:48 master systemd[1]: Starting MUNGE authentication service...
Jan 28 02:52:58 master systemd[1]: Started MUNGE authentication service.
```

- On master

scp -r /root/rpmbuild/RPMS/x86_64/ $CHROOT/home

chroot $CHROOT

cd /home/x86_64

- Removing Slurmctld service from compute node

rm –rf slurm-slurmctld-22.05.8-1.el7.x86_64.rpm

yum --installroot=$CHROOT install slurm*

- On both nodes-

export SLURMUSER=1500

groupadd -g $SLURMUSER slurm

useradd -m -c "SLURM workload manager" -d /var/lib/slurm -u $SLURMUSER -g slurm -s /bin/bash slurm

cp /etc/slurm/slurm.conf.example /etc/slurm.conf

vi /etc/slurm/slurm.conf

```
# 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.
# Put this file on all nodes of your cluster.
# See the slurm.conf man page for more information.
#
ClusterName=Diamond
SlurmctldHost=master
```

```
#RebootProgram=
ReturnToService=1
SlurmctldPidFile=/var/run/slurmctld.pid
SlurmctldPort=6817
SlurmdPidFile=/var/run/slurmd.pid
SlurmdPort=6818
SlurmdSpoolDir=/var/share/slurm/d
SlurmUser=slurm
#SlurmdUser=root
#SrunEpilog=
#SrunProlog=
StateSaveLocation=/var/share/slurm/ctld
SwitchType=switch/none
#TaskEpilog=

#
#
# COMPUTE NODES
#NodeName=linux[1-32] CPUs=1 State=UNKNOWN
NodeName=localhost CPUs=12 Boards=1 SocketsPerBoard=4 CoresPerSocket=3 ThreadsPerCore=1 RealMemory=7802

PartitionName=debug Nodes=ALL Default=YES MaxTime=INFINITE State=UP
```

mkdir -p /var/share/slurm/ctld

chown -R slurm:slurm /var/share/slurm

touch /var/log/slurmctld.log

systemctl start slurmd

systemctl enable slurmd

systemctl start slurmctld

systemctl enable slurmctld

chroot $CHROOT mkdir –p /var/share/slurm/d

chroot $CHROOT chown –R slurm:slurm /var/share/slurm

chroot $CHROOT touch /var/log/slurmd.log

cp /etc/slurm/cgroup.conf.example /etc/slurm/cgroup.conf

scp /etc/slurm/cgroup.conf $CHROOT/etc/slurm

systemctl start slurmctld

systemctl enable slurmctld

systemctl start munge

systemctl enable munge

chroot $CHROOT systemctl enable slurmctld

chroot $CHROOT systemctl enable munge

Slurm configuration done successfully-

Packaging the image –

packimage centos7.9-x86_64-netboot-compute

```
[root@master ~]# packimage centos7.9-x86_64-netboot-compute
Packing contents of /install/netboot/centos7.9/x86_64/compute/rootimg
archive method:cpio
compress method:gzip
```

LDAP

- Install OpenLDAP on master

yum -y install openldap-servers openldap-clients

cp /usr/share/openldap-servers/DB_CONFIG.example /var/lib/ldap/DB_CONFIG

chown ldap. /var/lib/ldap/DB_CONFIG

systemctl start slapd

systemctl enable slapd

generate encrypted password

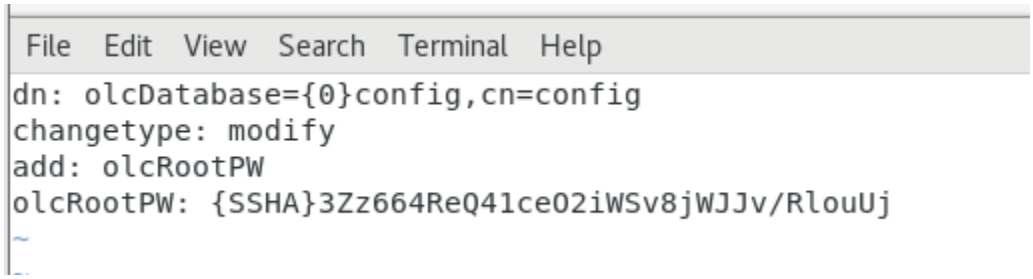
- Saving the password from below command for further authentication

slappasswd

{SSHA}3Zz664ReQ41ceO2iWSv8jWJJv/RlouUj

vi chrootpw.ldif

- Adding the above generated password in below file



ldapadd -Y EXTERNAL -H ldapi:/// -f chrootpw.ldif

ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/cosine.ldif

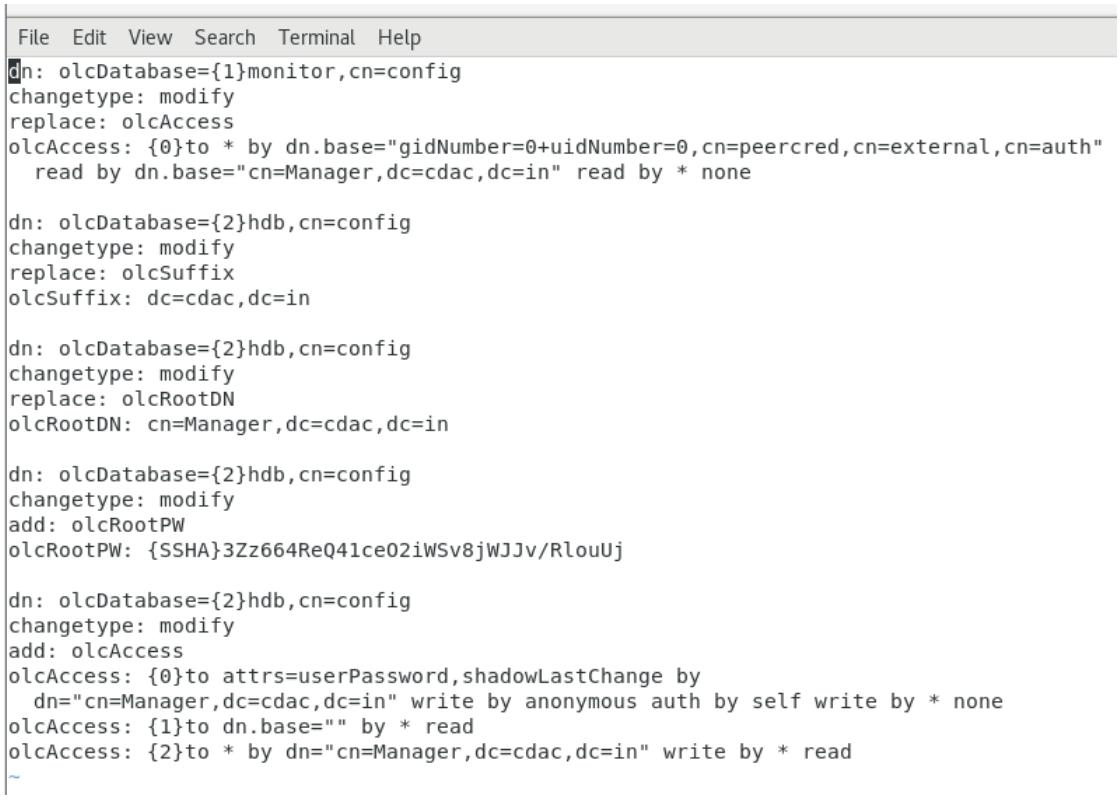
ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/nis.ldif

ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/inetorgperson.ldif

- Generate directory manager's password

vi chdomain.ldif

- replace to your own domain name for "dc=***,dc=***" section
- specify the password generated above for "olcRootPW" section



```
File  Edit  View  Search  Terminal  Help
dn: olcDatabase={1}monitor,cn=config
changetype: modify
replace: olcAccess
olcAccess: {0}to * by dn.base="gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth"
  read by dn.base="cn=Manager,dc=cdac,dc=in" read by * none

dn: olcDatabase={2}hdb,cn=config
changetype: modify
replace: olcSuffix
olcSuffix: dc=cdac,dc=in

dn: olcDatabase={2}hdb,cn=config
changetype: modify
replace: olcRootDN
olcRootDN: cn=Manager,dc=cdac,dc=in

dn: olcDatabase={2}hdb,cn=config
changetype: modify
add: olcRootPW
olcRootPW: {SSHA}3Zz664ReQ41ceO2iWSv8jWJJv/RlouUj

dn: olcDatabase={2}hdb,cn=config
changetype: modify
add: olcAccess
olcAccess: {0}to attrs=userPassword,shadowLastChange by
  dn="cn=Manager,dc=cdac,dc=in" write by anonymous auth by self write by * none
olcAccess: {1}to dn.base="" by * read
olcAccess: {2}to * by dn="cn=Manager,dc=cdac,dc=in" write by * read
~
```

ldapmodify -Y EXTERNAL -H ldapi:/// -f chdomain.ldif

vi basedomain.ldif

- replace to your own domain name for "dc=***,dc=***" section

```
File  Edit  View  Search  Terminal  Help
dn: dc=cdac,dc=in
objectClass: top
objectClass: dcObject
objectclass: organization
o: cdac in
dc: cdac

dn: cn=Manager,dc=cdac,dc=in
objectClass: organizationalRole
cn: Manager
description: Directory Manager

dn: ou=People,dc=cdac,dc=in
objectClass: organizationalUnit
ou: People

dn: ou=Group,dc=cdac,dc=in
objectClass: organizationalUnit
ou: Group
```

ldapadd -x -D cn=Manager,dc=cdac,dc=in -W -f basedomain.ldif

- Adding user account

vi ldapuser.ldif

- create new
- replace to your own domain name for "dc=***,dc=***" section

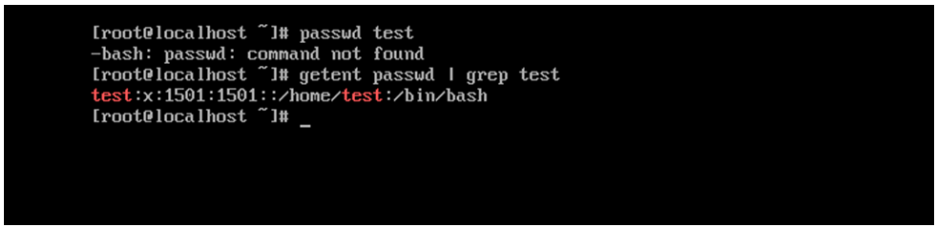
```
File  Edit  View  Search  Terminal  Help
dn: uid=test1,ou=People,dc=cdac,dc=in
objectClass: inetOrgPerson
objectClass: posixAccount
objectClass: shadowAccount
cn: test1
sn: Linux
userPassword: {SSHA}3Zz664ReQ41ceO2iWSv8jWJJv/RlouUj
loginShell: /bin/bash
uidNumber: 1501
gidNumber: 1501
homeDirectory: /home/test1

dn: cn=test1,ou=Group,dc=cdac,dc=in
objectClass: posixGroup
cn: test1
gidNumber: 1501
memberUid: test1
```

ldapadd -x -D cn=Manager,dc=cdac,dc=in -W -f ldapuser.ldif

- If you'd like to delete LDAP User or Group, Do as below.

ldapdelete -x -W -D 'cn=Manager,dc=cdac,dc=in' "uid=test,ou=People,dc=cdac,dc=in"



- Install OpenLDAP Client.

yum --installroot=/install/netboot/centos7.9/x86_64/compute/rootimg install openldap-clients

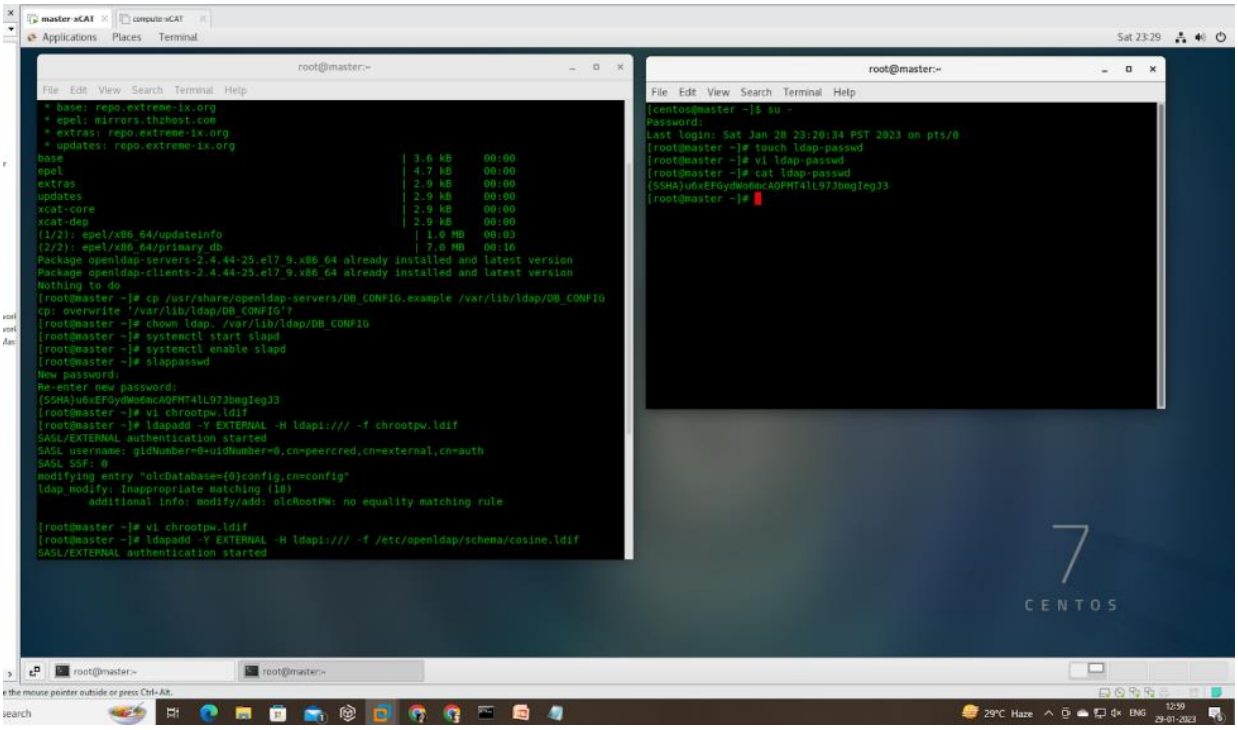
exports CHROOT=/install/netboot/centos7.9/x86_64/compute/rootimg

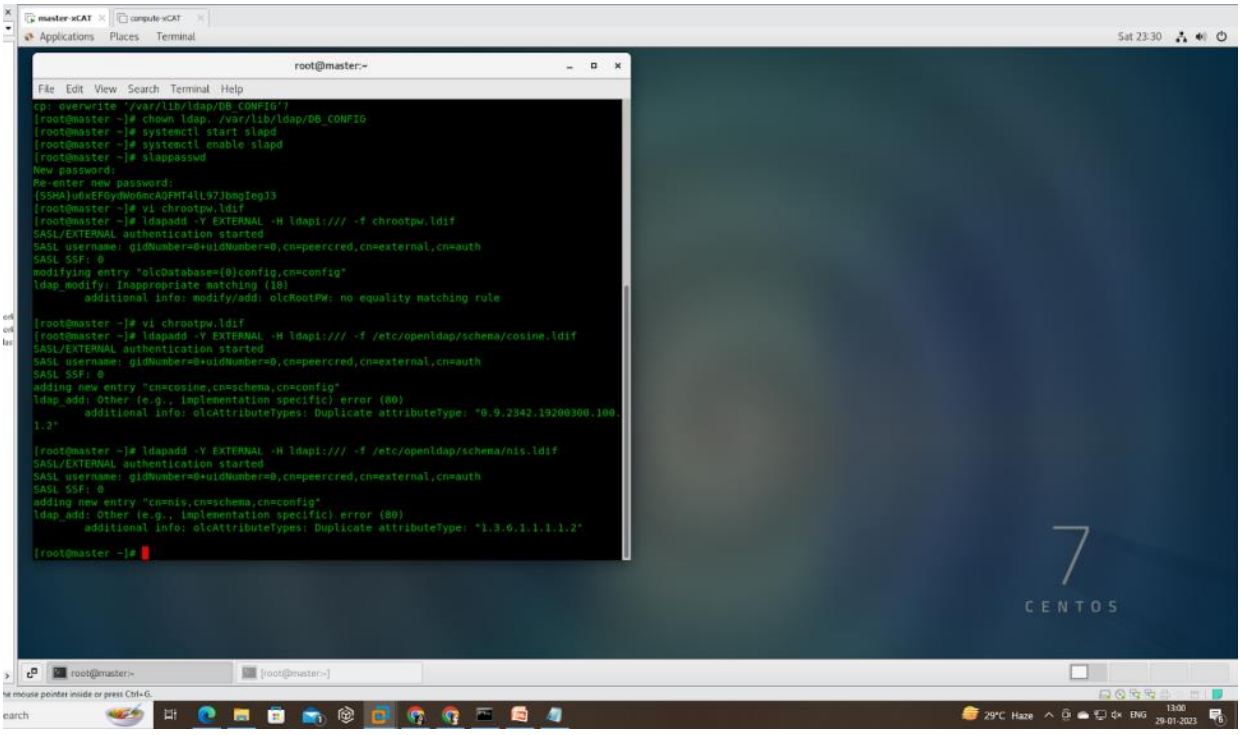
chroot $CHROOT

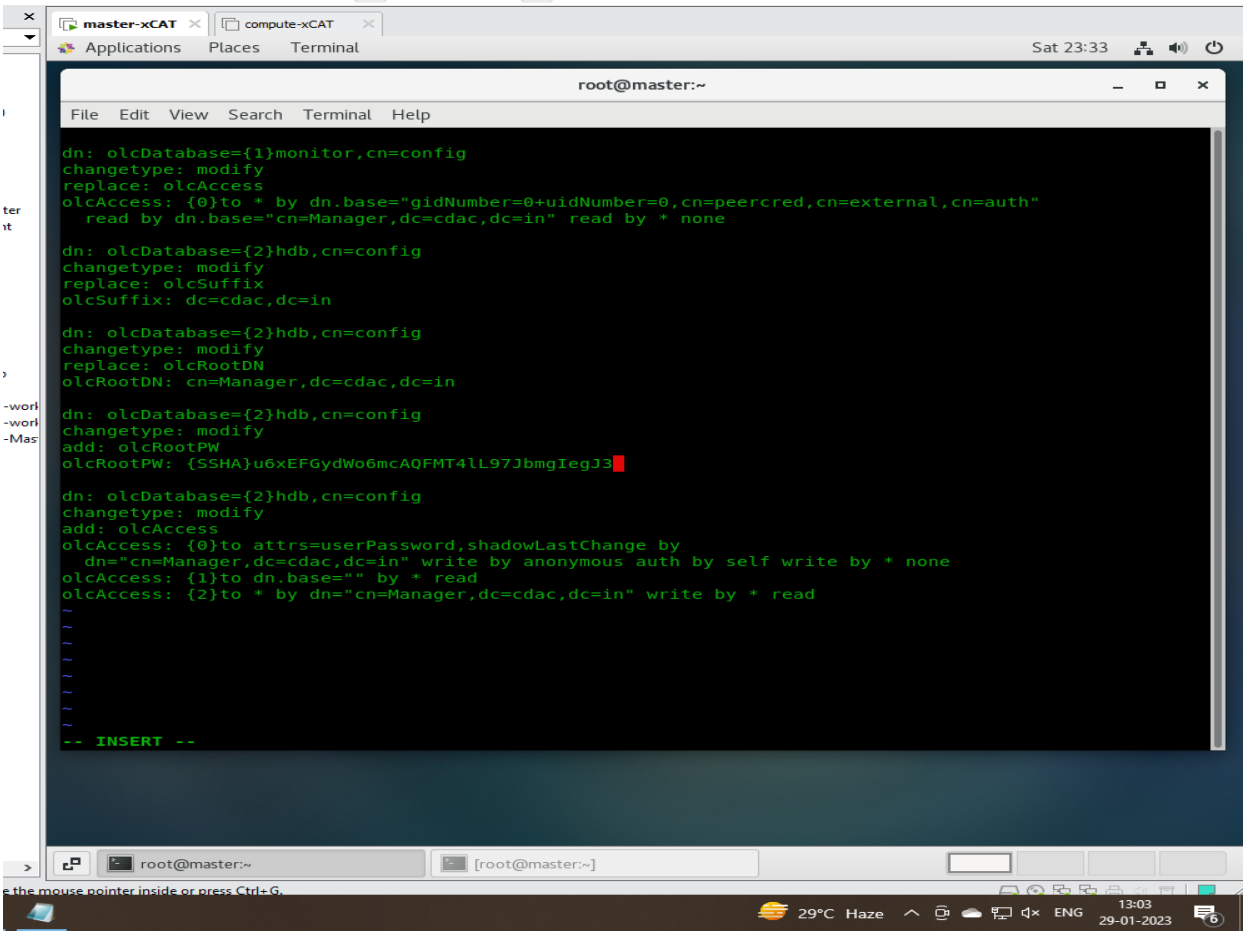
authconfig --enableldap --enableldapauth --ldapserver=master --ldapbasedn="dc=cdac,dc=in" --enablemkhomedir --update

systemctl restart nslcd

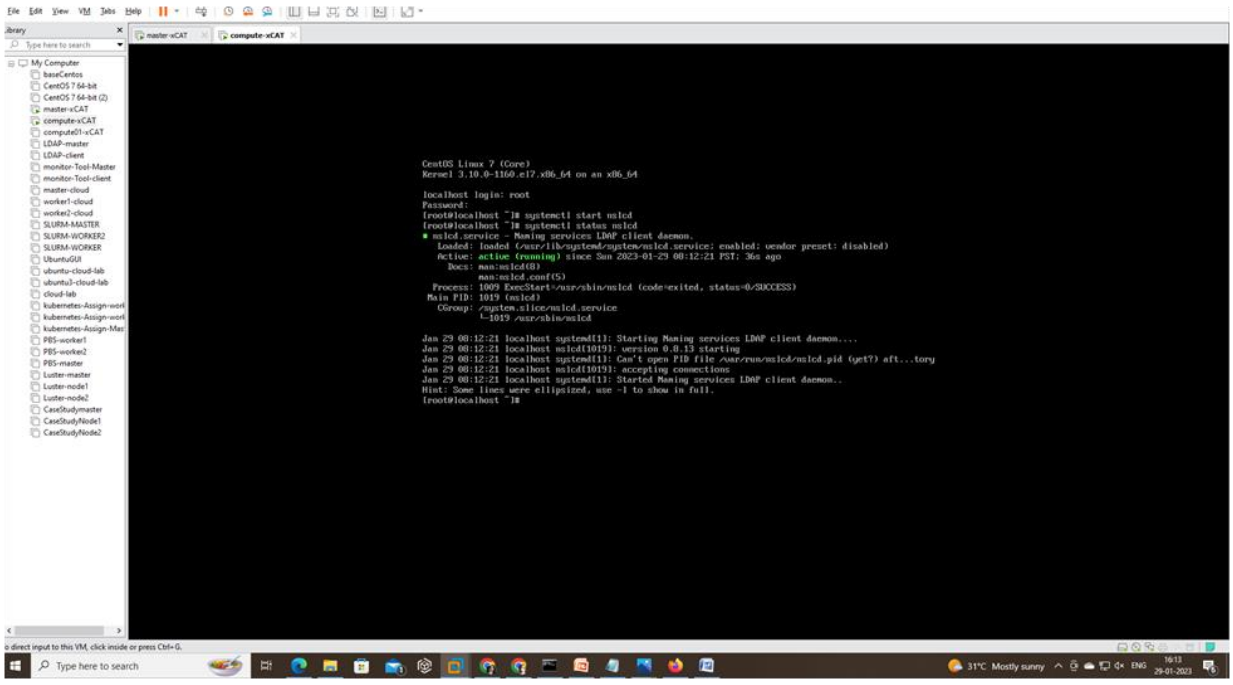
ldapsearch -x


master-xCAT
compute-xCAT
Applications Places Terminal
Sat 23:29
root@master:~
File Edit View Search Terminal Help
* base: repo.extreme-ix.org
* epel: mirrors.thzhost.com
* extras: repo.extreme-ix.org
* updates: repo.extreme-ix.org
base | 3.6 kB 00:00
epel | 4.7 kB 00:00
extras | 2.9 kB 00:00
updates | 2.9 kB 00:00
xcat-core | 2.9 kB 00:00
xcat-dep | 2.9 kB 00:00
(1/2): epel/x86_64/updateinfo | 1.0 MB 00:03
(2/2): epel/x86_64/primary_db | 7.0 MB 00:16
Package openldap-servers-2.4.44-25.el7_9.x86_64 already installed and latest version
Package openldap-clients-2.4.44-25.el7_9.x86_64 already installed and latest version
Nothing to do
[root@master ~]# cp /usr/share/openldap-servers/DB_CONFIG.example /var/lib/ldap/DB_CONFIG
cp: overwrite '/var/lib/ldap/DB_CONFIG'?
[root@master ~]# chown ldap. /var/lib/ldap/DB_CONFIG
[root@master ~]# systemctl start slapd
[root@master ~]# systemctl enable slapd
[root@master ~]# slappasswd
New password:
Re-enter new password:
{SSHA}u6xEFGydWo6mcAQFMT4lL97JbngIegJ3
[root@master ~]# vi chrootpw.ldif
[root@master ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f chrootpw.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
modifying entry "olcDatabase={0}config,cn=config"
ldap_modify: Inappropriate matching (18)
additional info: modify/add: olcRootPW: no equality matching rule
[root@master ~]# vi chrootpw.ldif
[root@master ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/cosine.ldif
SASL/EXTERNAL authentication started
root@master:~
File Edit View Search Terminal Help
[centos@master ~]$ su -
Password:
Last login: Sat Jan 28 23:20:34 PST 2023 on pts/0
[root@master ~]# touch ldap-passwd
[root@master ~]# vi ldap-passwd
[root@master ~]# cat ldap-passwd
{SSHA}u6xEFGydWo6mcAQFMT4lL97JbngIegJ3
[root@master ~]#
7
CENTOS
root@master:~
root@master:~
29°C Haze
ENG
12:59
29-01-2023


master-xCAT
compute-xCAT
Applications Places Terminal
Sat 23:30
root@master:~
File Edit View Search Terminal Help
cp: overwrite '/var/lib/ldap/DB_CONFIG'?
[root@master ~]# chown ldap. /var/lib/ldap/DB_CONFIG
[root@master ~]# systemctl start slapd
[root@master ~]# systemctl enable slapd
[root@master ~]# slappasswd
New password:
Re-enter new password:
{SSHA}u6xEFGydWo6mcAQFMT4lL97JbngIegJ3
[root@master ~]# vi chrootpw.ldif
[root@master ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f chrootpw.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
modifying entry "olcDatabase={0}config,cn=config"
ldap_modify: Inappropriate matching (18)
additional info: modify/add: olcRootPW: no equality matching rule
[root@master ~]# vi chrootpw.ldif
[root@master ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/cosine.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
adding new entry "cn=cosine,cn=schema,cn=config"
ldap_add: Other (e.g., implementation specific) error (80)
additional info: olcAttributeTypes: Duplicate attributeType: "0.9.2342.19200300.100.
1.2"
[root@master ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/nis.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
adding new entry "cn=nis,cn=schema,cn=config"
ldap_add: Other (e.g., implementation specific) error (80)
additional info: olcAttributeTypes: Duplicate attributeType: "1.3.6.1.1.1.1.2"
[root@master ~]#
7
CENTOS
root@master:~
[root@master:~]
29°C Haze
ENG
13:00
29-01-2023



Service started successfully on node —



GANGLIA

yum install ganglia rrdtool ganglia-gmetad ganglia-gmond ganglia-web

htpasswd -c /etc/httpd/auth.basic adminganglia

vi /etc/httpd/conf.d/ganglia.conf

```
File  Edit  View  Search  Terminal  Help
#
# Ganglia monitoring system php web frontend
#

Alias /ganglia /usr/share/ganglia

<Location /ganglia>
          AuthType basic
          AuthName "Ganglia web UI"
          AuthBasicProvider file
          AuthUserFile "/etc/httpd/auth.basic"
          Require user adminganglia
</Location>
```

vi /etc/ganglia/gmetad.conf

```
data_source "my cluster" localhost
gridname "MyGrid"


data_source "Labs" 60 192.168.100.10 # Master node
data_source "Labs" 60 192.168.100.115 # Monitored node
```

vi /etc/ganglia/gmond.conf

```
/*
 * The cluster attributes specified will be used as part of the <CLUSTER>
 * tag that will wrap all hosts collected by this instance.
 */
cluster {
  name = "Labs"
  owner = "unspecified"
  latlong = "unspecified"
  url = "unspecified"
}

/* The host section describes attributes of the host, like the location */
host {
  location = "unspecified"
}

/* Feel free to specify as many udp_send_channels as you like.  Gmond
   used to only support having a single channel */
udp_send_channel {
  #bind_hostname = yes # Highly recommended, soon to be default.
                       # This option tells gmond to use a source address
                       # that resolves to the machine's hostname.  Without
                       # this, the metrics may appear to come from any
                       # interface and the DNS names associated with
                       # those IPs will be used to create the RRDs.
  #mcast_join = 239.2.11.71
  host = node
  port = 8649
  ttl = 1
}

/* You can specify as many udp_recv_channels as you like as well. */
udp_recv_channel {
#  mcast_join = 239.2.11.71
  port = 8649
  bind = 239.2.11.71
  #retry_bind = true
   #Size of the UDP buffer. If you are handling lots of metrics you really
   #should bump it up to e.g. 10MB or even higher.
   #buffer = 10485760
}
```

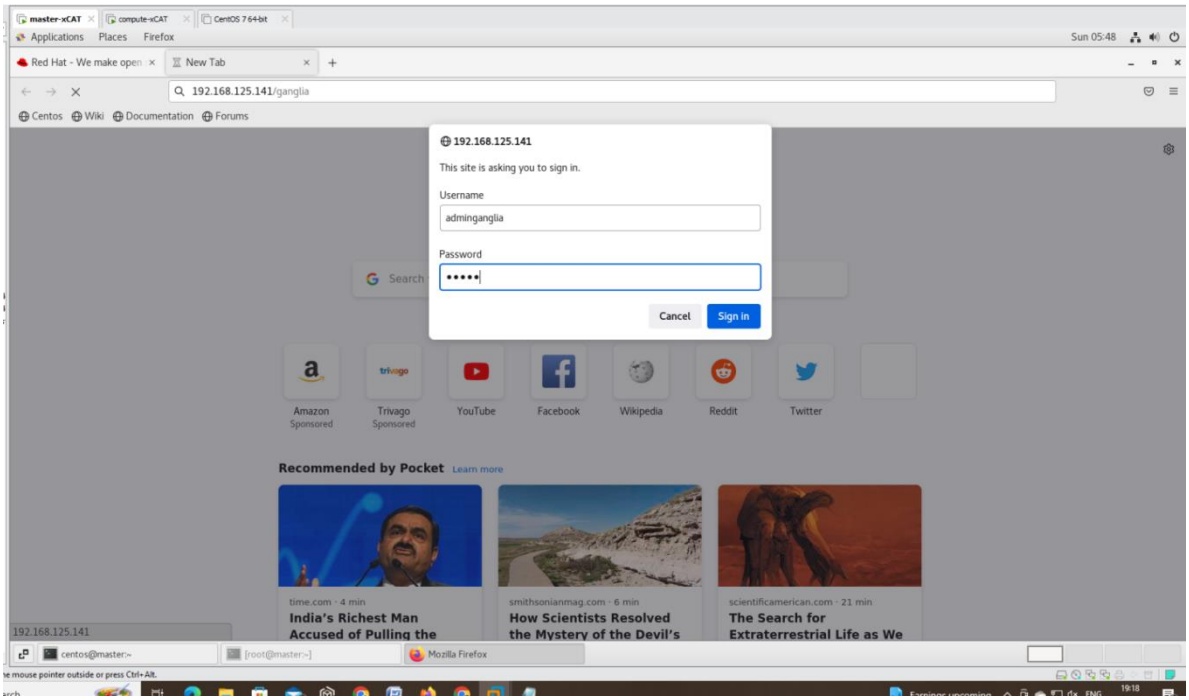
setsebool -P httpd_can_network_connect 1

systemctl restart httpd gmetad gmond

systemctl enable httpd gmetad httpd

ip a

- Browser-----> http://<ganglia_master_ip>/ganglia



yum --installroot=$CHROOT install ganglia rrdtool ganglia-gmetad ganglia-gmond ganglia-web

vi /etc/ganglia/gmond.conf

```
 */
cluster {
  name = "Labs"
  owner = "unspecified"
  latlong = "unspecified"
  url = "unspecified"
}

/* The host section describes attributes of the host, like the location */
host {
  location = "unspecified"
}

/* Feel free to specify as many udp_send_channels as you like.  Gmond
   used to only support having a single channel */
udp_send_channel {
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                       # interface and the DNS names associated with
                       # those IPs will be used to create the RRDs.
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  host = localhost
  port = 8649
  ttl = 1
}

/* You can specify as many udp_recv_channels as you like as well. */
udp_recv_channel {
  mcast_join = 239.2.11.71
  port = 8649
  bind = 239.2.11.71
  # retry_bind = true
  # Size of the UDP buffer. If you are handling lots of metrics you really
  # should bump it up to e.g. 10MB or even higher.
  # buffer = 10485760
}
```

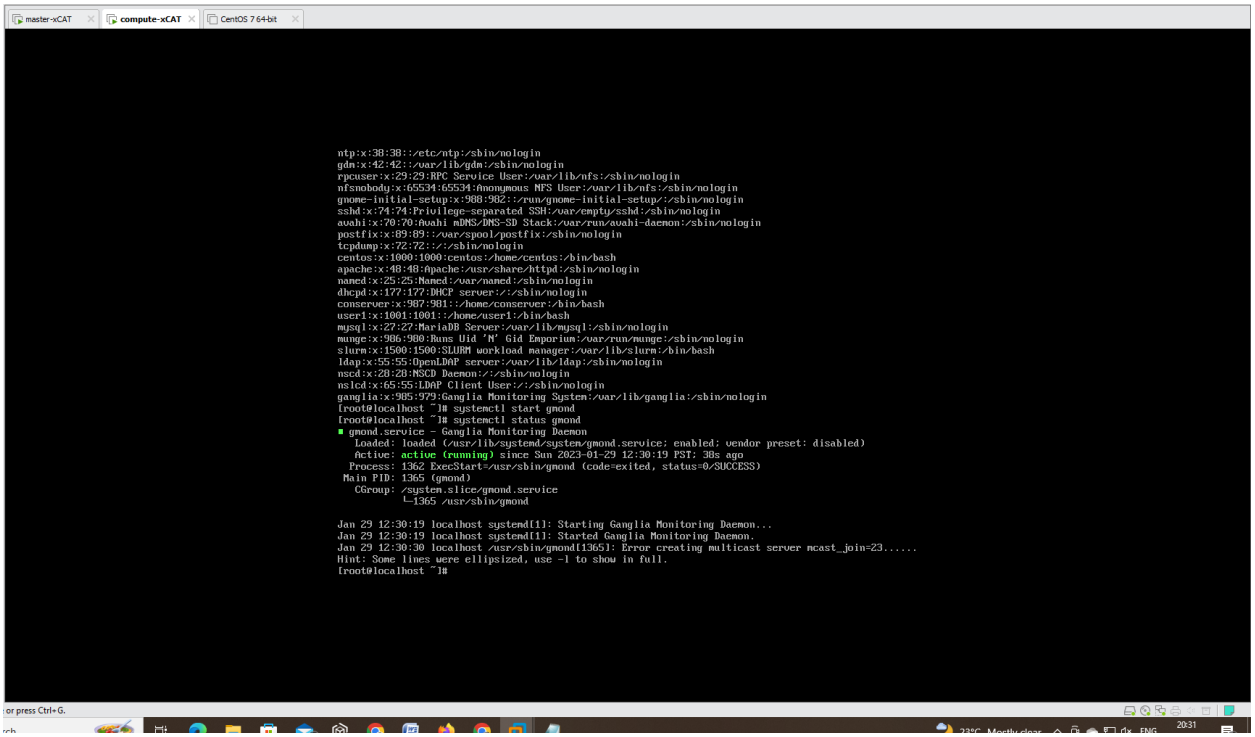
chroot $CHROOT

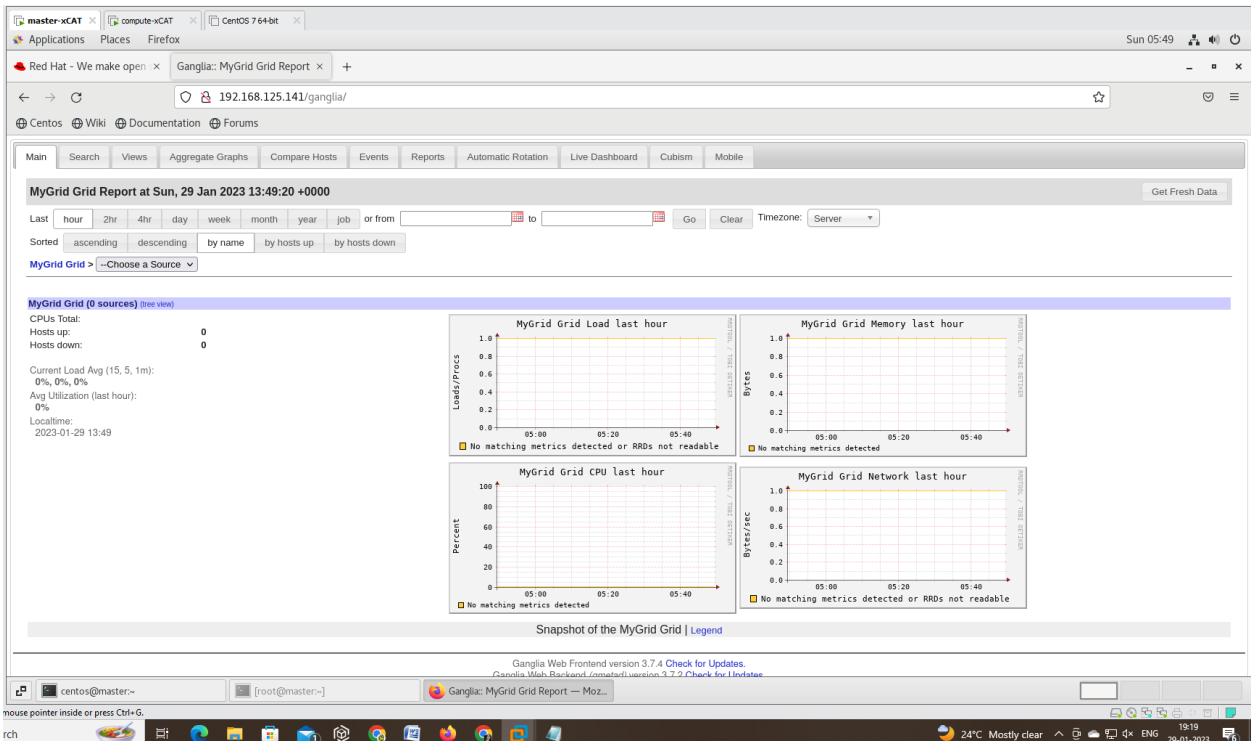
systemctl enable gmond

systemctl restart httpd gmetad gmond

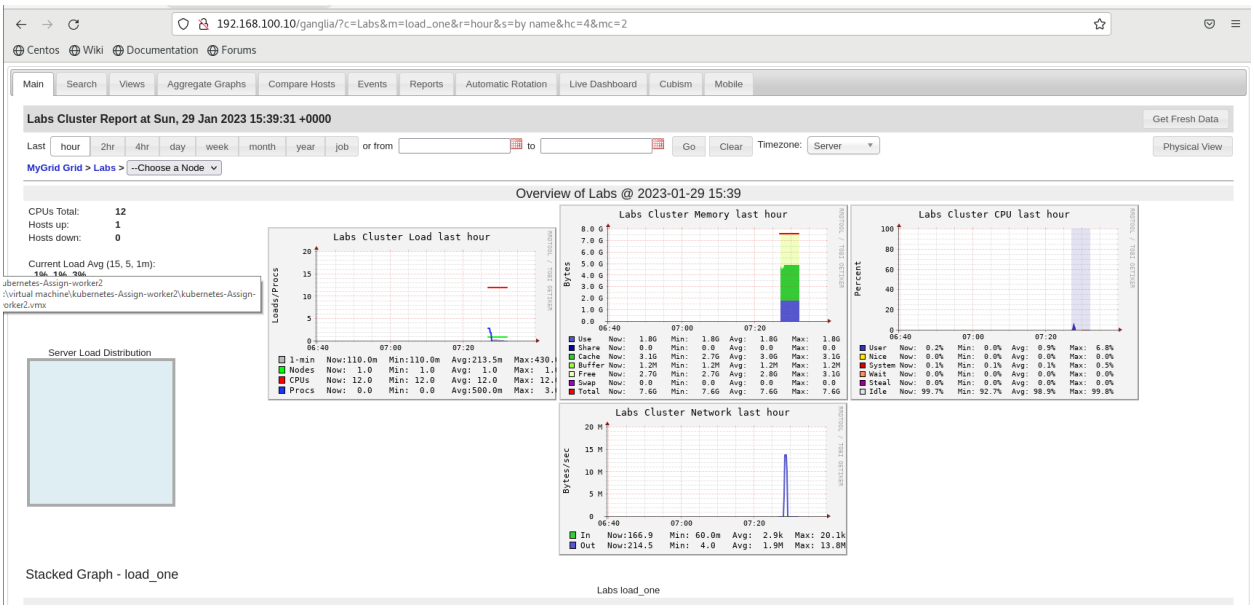
systemctl enable httpd gmetad httpd

packimage centos7.9-x86_64-netboot-compute

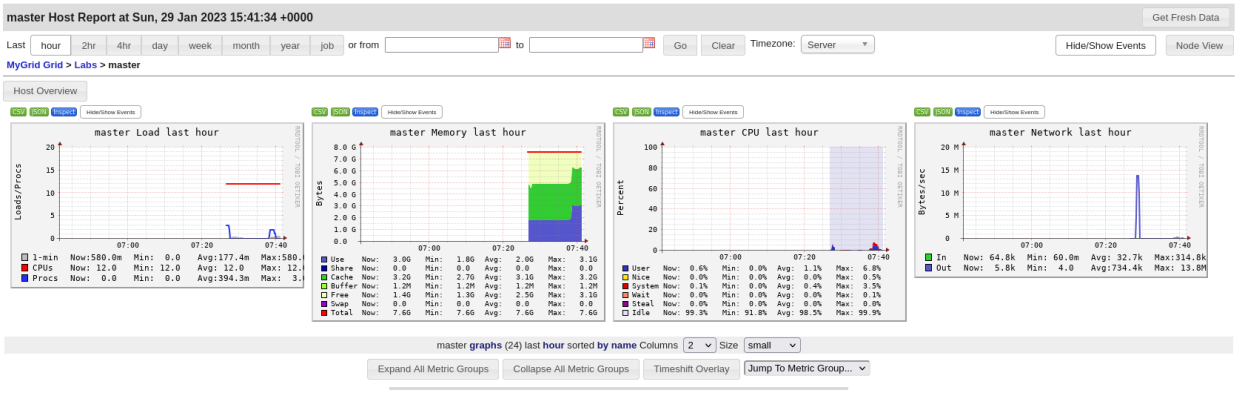




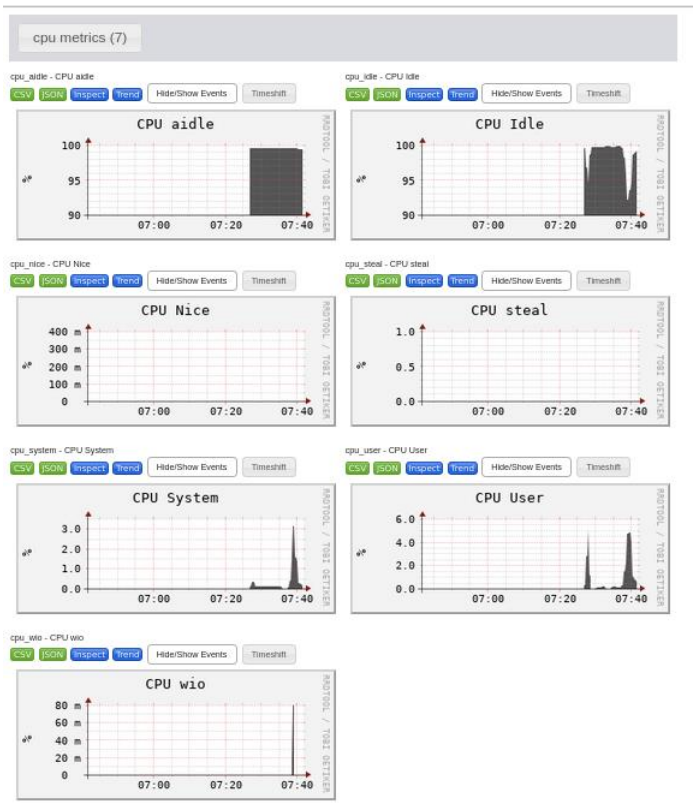
- Cluster labs-



- Master-



- CPU metrics of master-



- Disk and Load metrics of master

- Memory and network metrics of the master-

HPL BENCHMARKING

yum install epel-release

yum install atlas

- Download below file from ->google->hpl netlib->hpl-2.3.tar.gz save in /etc/yum.repos.d

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

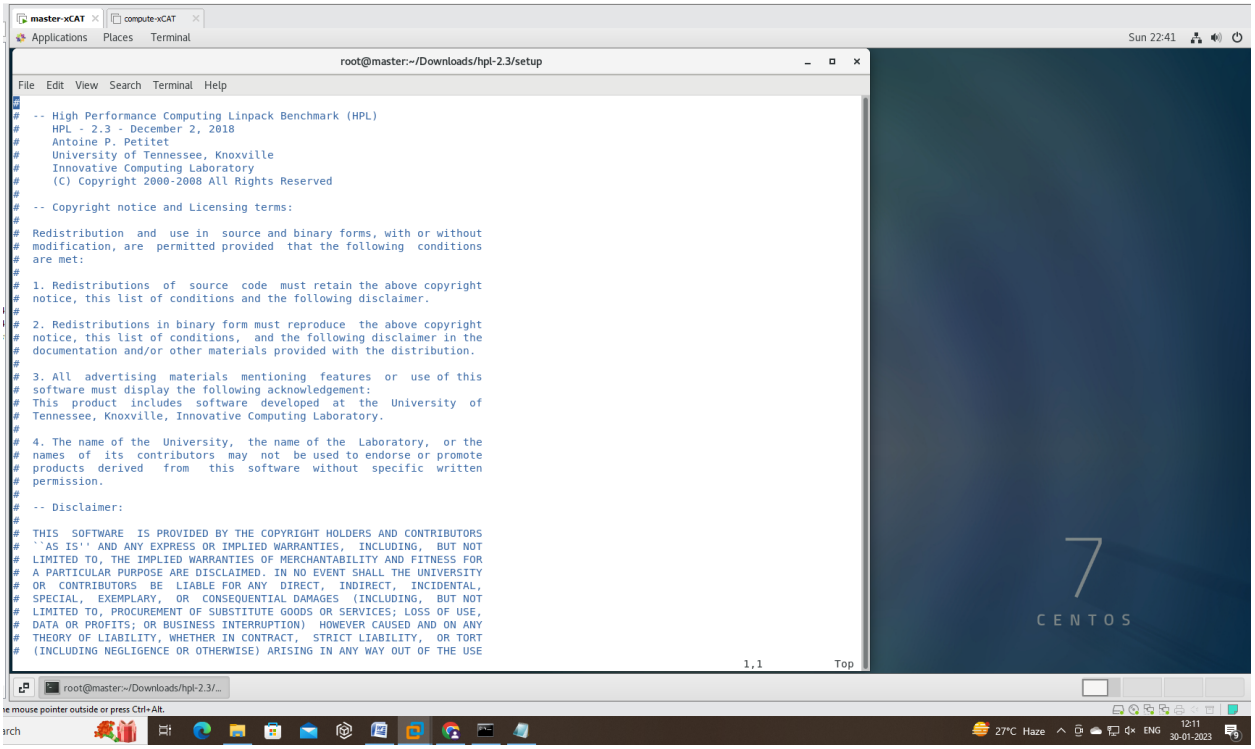
tar -xf /hpl-2.3.tar.gz

ls /hpl-2.3

cd /hpl-2.3/setup/

ls

cat Make.Linux_Intel64



cp /root/Downloads/hpl-2.3/setup/Make.Linux_Intel64 /root/Downloads/hpl-2.3

rpm -ql

rpm -ql atlas

- Download below file from ->google->Open MPI: Version 4.1 -> openmpi-4.1.4.tar.gz save in /etc/yum.repos.d

tar -xf openmpi-4.1.4.tar.gz

ls

- if not execute install gcc yum install gcc

yum install gcc-c++

./configure --prefix=/opt/openmpi4.1.4 --enable-orterun-prefix-by-default

make –43j 8

make install

echo $PATH

export PATH=/opt/openmpi-4.1.4/bin/:$PATH

```
[root@master openmpi-4.1.4]# export PATH=/opt/openmpi-4.1.4/bin/:$PATH
[root@master openmpi-4.1.4]# mp
mpartition    mpic++        mpicxx        mpif90        mpls_dump
mpathconf     mpicc         mpiexec       mpifort       mpris-proxy
mpathpersist  mpiCC         mpif77        mpirun        mpstat
[root@master openmpi-4.1.4]# mp
aclocal.m4          Doxyfile            ompi/
AUTHORS             examples/           opal/
autogen.pl          INSTALL             orte/
config/             libtool             oshmem/
config.log          LICENSE             README
config.lt           Makefile            README.JAVA.txt
config.status       Makefile.am         test/
configure           Makefile.in         VERSION
configure.ac        Makefile.ompi-rules
contrib/            NEWS
```

export LD_LIBRARY_PATH=/opt/openmpi-4.1.4/bin:$LD_LIBRARY_PATH

```
[root@master hpl-2.3]# ls
acinclude.m4  config.guess  depcomp     Makefile.am           missing  THANKS
aclocal.m4    config.sub    HISTORY     Makefile.in           NEWS     TODO
AUTHORS       configure     include     Make.Linux_PII_CBLAS  README   TUNING
BUGS          configure.ac  INSTALL     makes                 setup    www
ChangeLog     COPYING       install-sh  Make.top              src
compile       COPYRIGHT     Makefile    man                   testing
```

```
[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
```

#vi Make.Linux_PII_CBLAS

```
# ----------------------------------------------------------------------
# - shell --------------------------------------------------------------
# ----------------------------------------------------------------------
#
SHELL        = /bin/bash
# ----------------------------------------------------------------------
# - HPL Directory Structure / HPL library ------------------------------
# ----------------------------------------------------------------------
#
TOPdir       = /root/Downloads/hpl-2.3
# ----------------------------------------------------------------------
# - Message Passing library (MPI) --------------------------------------
# ----------------------------------------------------------------------
#
MPdir        = /opt/openmpi4.1.4
MPlib        = $(MPdir)/lib/libmpi.so.40
#
# ----------------------------------------------------------------------
# - Compilers / linkers - Optimization flags ---------------------------
# ----------------------------------------------------------------------
#
CC           = /usr/bin/gcc
#
LINKER       = /usr/bin/gcc
#
# ----------------------------------------------------------------------
# - Linear Algebra library (BLAS or VSIPL) -----------------------------
```

```
# ----------------------------------------------------------------------
#
LAdir        = /usr/lib64/atlas
LAlib        = $(LAdir)/libsatlas.so.3 $(LAdir)/libtatlas.so.3.10
#
```

make arch=Linux_PII_CBLAS

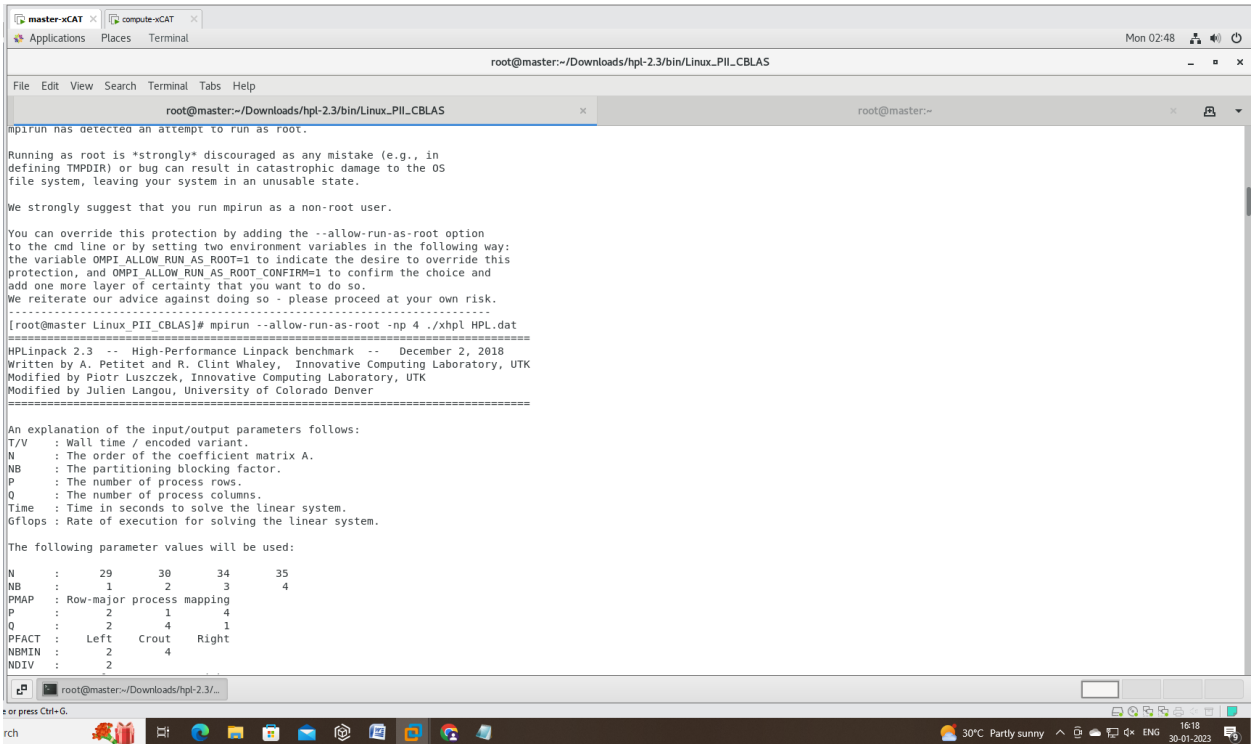
#cd /root/Downloads/hpl-2.3/bin/Linux_PII_CBLAS/

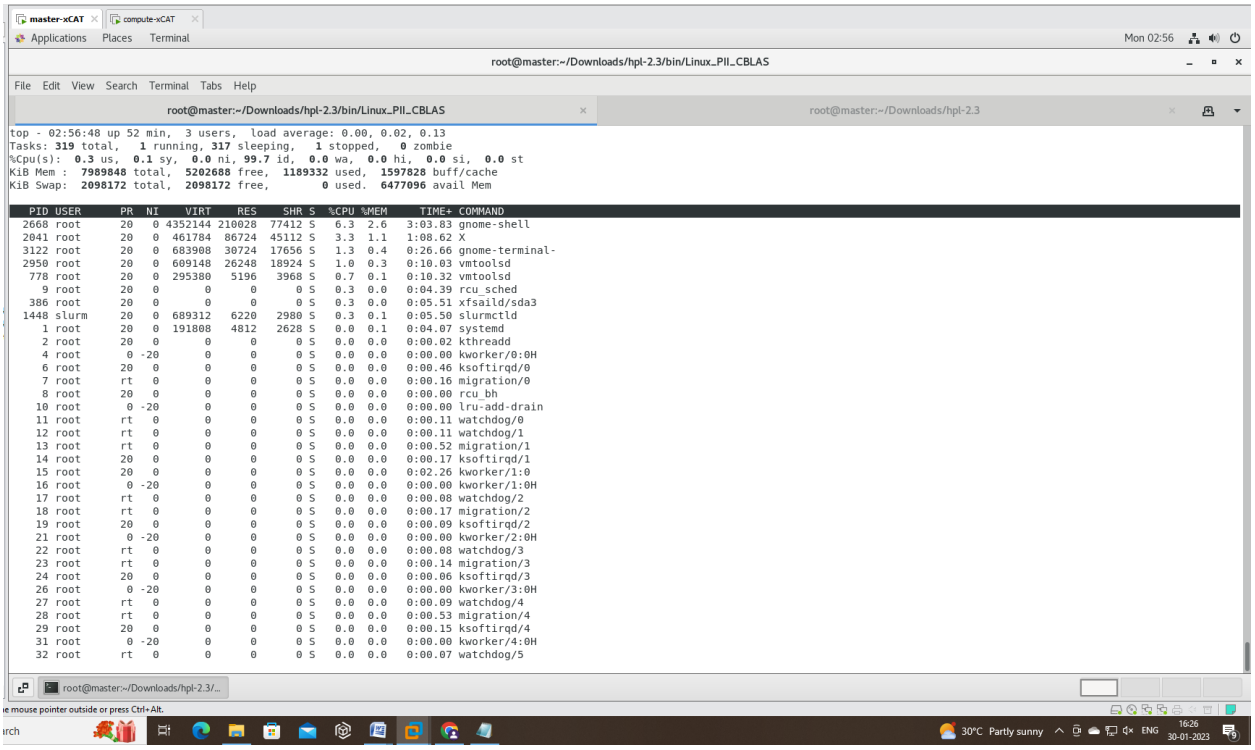
```
[root@master hpl-2.3]# cd /root/Downloads/hpl-2.3/bin/Linux_PII_CBLAS/
[root@master Linux_PII_CBLAS]# ls
HPL.dat  xhpl
[root@master Linux_PII_CBLAS]#
```

#vi HPL.dat

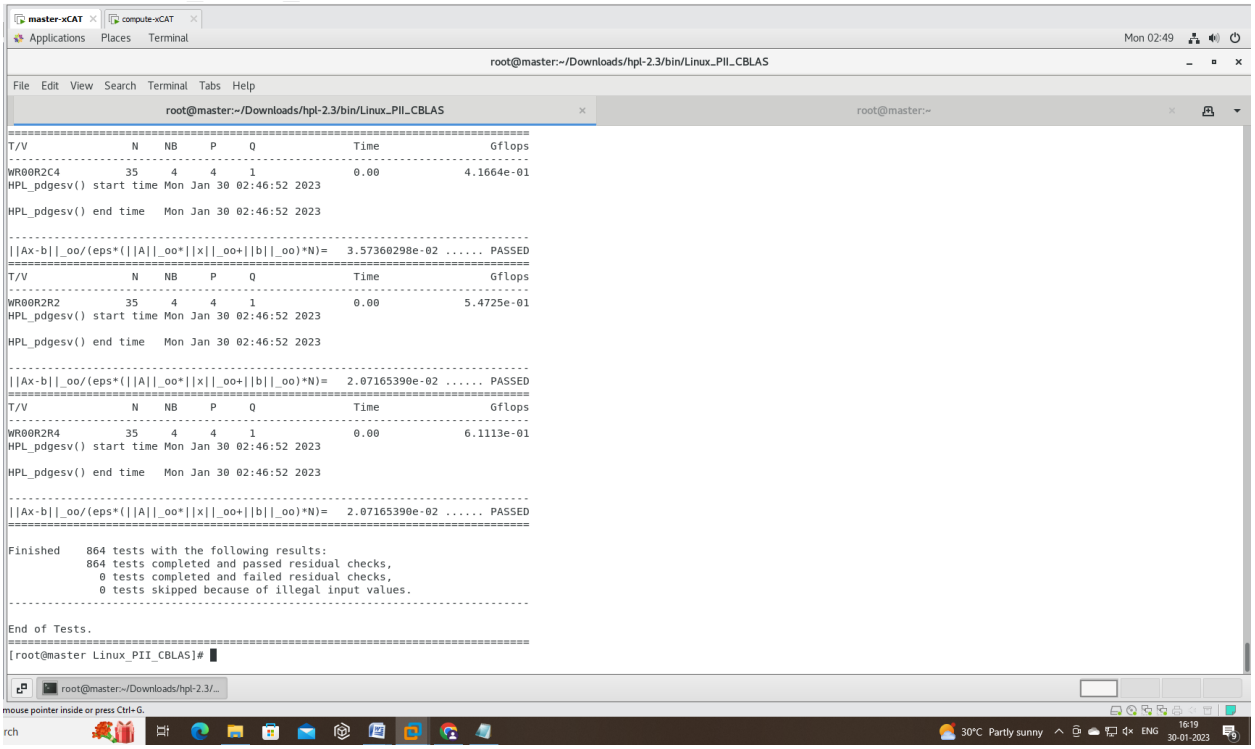
```
HPLinpack benchmark input file
Innovative Computing Laboratory, University of Tennessee
HPL.out      output file name (if any)
6            device out (6=stdout,7=stderr,file)
4            # of problems sizes (N)
29 30 34 35  Ns
4            # of NBs
1 2 3 4      NBs
0            PMAP process mapping (0=Row-,1=Column-major)
3            # of process grids (P x Q)
4 2          Ps
2 4          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)
~
~
```

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





- Final Result of Benchmarking



Conclusion-

We have successfully booted our Compute node via network using XCAT. We further, configured LDAP for user authentication supported by creation of a new user. Furthermore, added Slurm in our cluster for performing job scheduling. Added, Ganglia for monitoring of both the nodes. And finally, checked the efficiency of our cluster through HPL Benchmarking.