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OpenHPC: Beyond the Install Guide

OpenHPC: Beyond the Install Guide
for PEARC24

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OpenHPC: Beyond the Install Guide

└─ Introduction

└─ Acknowledgments and shameless plugs

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Acknowledgments and shameless plugs

[OpenHPC](#) especially Tim Middelkoop (Internet2) and Chris Simmons (Massachusetts Green High Performance Computing Center). They have a BOF at 1:30 Wednesday. You should go to it.

[Jetstream2](#) especially Jeremy Fischer, Mike Lowe, and Julian Pistorius. Jetstream2 has a tutorial at the same time as this one. Please stay here.

[NSF CC*](#) for the equipment that led to some of the lessons we're sharing today (award #2127188).

[ACCESS](#) current maintainers of the project formerly known as the XSEDE Compatible Basic Cluster.

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OpenHPC: Beyond the Install Guide

└ Introduction

└┐ Where we're starting from

└┐┐ Where we're starting from

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Where we're starting from



Figure 1: Two example HPC networks for the tutorial

You:

- ▶ have installed OpenHPC before
- ▶ have been issued a (basically) out-of-the-box OpenHPC cluster for this tutorial

Cluster details:

- ▶ Rocky Linux 9 (x86_64)
- ▶ OpenHPC 3.1, Warewulf 3, Slurm 23.11.6
- ▶ 2 non-GPU nodes
- ▶ 2 GPU nodes (currently without GPU drivers, so: expensive non-GPU nodes)
- ▶ 1 management node (SMS)
- ▶ 1 unprovisioned login node

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Where we're starting from

We used the OpenHPC automatic installation script from Appendix A with a few variations:

1. Installed `a-mail` to have a valid `MailProg` for `slurm.conf`.
2. Created `user1` and `user2` accounts with password-less `sudo` privileges.
3. Changed `CHROOT` from `/opt/ohpc/admin/images/rocky9.3` to `/opt/ohpc/admin/images/rocky9.4`.
4. Enabled `slurds` and `nmap` in `CHROOT`.
5. Added `nano` and `yum` to `CHROOT`.
6. Removed a redundant `ReturnToService` line from `/etc/slurm/slurm.conf`.
7. Stored all compute/GPU nodes' SSH host keys in `/etc/ssh/ssh_known_hosts`.

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└─ Introduction

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└─ Where we're going

Where we're going

1. A login node that's practically identical to a compute node (except for where it needs to be different)
2. A slightly more secured SMS and login node
3. GPU drivers on the GPU nodes
4. Using node-local storage for the OS and/or scratch
5. De-coupling the SMS and the compute nodes (e.g., independent kernel versions)
6. Easier management of node differences (GPU or not, diskless/single-disk/multi-disk, Infiniband or not, etc.)
7. Slurm configuration to match some common policy goals (fair share, resource limits, etc.)

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└─ Making better infrastructure nodes

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└─ Assumptions

Assumptions

1. We have a VM named `login`, with no operating system installed.
2. The `eth0` network interface for `login` is attached to the internal network, and `eth1` is attached to the external network.
3. The `eth0` MAC address for `login` is known—check the **Login server** section of your handout for that. It's of the format `aa:bb:cc:dd:ee:ff`.
4. We're logged into the SMS as `user1` or `user2` that has `sudo` privileges.

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 - └─ Creating a new login node

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Creating a new login node

Working from section 3.9.3 of the install guide:

```
[user@node-0 ~]$ sudo wvsh -y node new login --netdev with0 \
--ipaddr=172.16.0.2 --hwaddr=__:__:__:__:__:__
[user@node-0 ~]$ sudo wvsh -y provision set login \
--pulp=rckey9.4 --bootstrap=uname -r \
--files=dynamic_hosts,passwords,group,shadow,munge.key,network
```

Make sure to replace the __ with the characters from your login node's MAC address!

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- └─ What'd we just do?

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What'd we just do?

Ever since login was powered on, it's been stuck in a loop trying to PXE boot. What's the usual PXE boot process for a client in an OpenHPC environment?

1. The client network card tries to get an IP address from a DHCP server (the SMS) by broadcasting its MAC address.

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What'd we just do?

Ever since login was powered on, it's been stuck in a loop trying to PXE boot. What's the usual PXE boot process for a client in an OpenHPC environment?

1. The client network card tries to get an IP address from a DHCP server (the SMS) by broadcasting its MAC address.
2. The SMS responds with the client's IP and network info, a next-server IP (the SMS again), and a filename option (a bootloader from the iPXE project).

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What'd we just do?

Ever since login was powered on, it's been stuck in a loop trying to PXE boot. What's the usual PXE boot process for a client in an OpenHPC environment?

1. The client network card tries to get an IP address from a DHCP server (the SMS) by broadcasting its MAC address.
2. The SMS responds with the client's IP and network info, a next-server IP (the SMS again), and a filename option (a bootloader from the iPXE project).
3. The network card gets the bootloader over TFTP and executes it.

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What'd we just do?

Ever since login was powered on, it's been stuck in a loop trying to PXE boot. What's the usual PXE boot process for a client in an OpenHPC environment?

1. The client network card tries to get an IP address from a DHCP server (the SMS) by broadcasting its MAC address.
2. The SMS responds with the client's IP and network info, a next-server IP (the SMS again), and a filename option (a bootloader from the iPXE project).
3. The network card gets the bootloader over TFTP and executes it.
4. iPXE makes a second DHCP request and this time, it gets a URL (by default, [http://SMS_IP/Win/pxen/cfg/\\$\({client_mac}\)](http://SMS_IP/Win/pxen/cfg/$({client_mac}))) for an iPXE config file.

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What'd we just do?

Ever since login was powered on, it's been stuck in a loop trying to PXE boot. What's the usual PXE boot process for a client in an OpenHPC environment?

1. The client network card tries to get an IP address from a DHCP server (the SMS) by broadcasting its MAC address.
2. The SMS responds with the client's IP and network info, a next-server IP (the SMS again), and a `tftpname` option (a bootloader from the iPXE project).
3. The network card gets the bootloader over TFTP and executes it.
4. iPXE makes a second DHCP request and this time, it gets a URL (by default, `http://SMS_IP/VA/tftp/cfg/${client_mac}`) for an iPXE config file.
5. The config file contains the URL of a Linux kernel and initial ramdisk, plus multiple kernel parameters available after initial bootup for getting the node's full operating system contents.

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What'd we just do?

1. The node name, `--baddr`, and `--ipaddr` parameters go into the SMS DHCP server settings.

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What'd we just do?

1. The node name, `--baddr`, and `--ipaddr` parameters go into the SMS DHCP server settings.
2. The `--bootstrap` parameter defines the kernel and ramdisk for the IPXE configuration.

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What'd we just do?

1. The node name, `--baddr`, and `--ipaddr` parameters go into the SMS DHCP server settings.
2. The `--bootstrap` parameter defines the kernel and ramdisk for the PXE configuration.
3. The node name, `--swdev`, `--ipaddr`, `--baddr` parameters all go into kernel parameters accessible from the provisioning software.

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What'd we just do?

1. The node name, `--baddr`, and `--ipaddr` parameters go into the SMS DHCP server settings.
2. The `--bootstrap` parameter defines the kernel and ramdisk for the IPXE configuration.
3. The node name, `--swdev`, `--ipaddr`, `--baddr` parameters all go into kernel parameters accessible from the provisioning software.
4. During the initial bootup, the `--baddr` parameter is passed to a CGI script on the SMS to identify the correct VNFS for the provisioning software to download (set by the `--vzfs` parameter).

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What'd we just do?

1. The node name, `--baddr`, and `--ipaddr` parameters go into the SMS DHCP server settings.
2. The `--bootstrap` parameter defines the kernel and ramdisk for the PXE configuration.
3. The node name, `--rootdir`, `--ipaddr`, `--baddr` parameters all go into kernel parameters accessible from the provisioning software.
4. During the initial bootup, the `--baddr` parameter is passed to a CGI script on the SMS to identify the correct VNFS for the provisioning software to download (set by the `--vzfs` parameter).
5. After downloading the VNFS, the provisioning software will also download files from the SMS set by the `--files` parameter.

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 - └─ Did it work? So far, so good.

Did it work? So far, so good.

```
[user@node-0 ~]$ sudo ssh login
[root@login ~]# df -h
Filesystem
...
172.16.0.1:/home
172.16.0.1:/opt/ohpc/pub
```

x

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- └─ Making better infrastructure nodes

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- └─ Did it work? Not entirely.

Did it work? Not entirely.

```
[root@login ~]# sinfo
sinfo: error: resolve_ctls_from_dns_srv: res_nsearch error:
Unknown host
sinfo: error: fetch_config: DNS SRV lookup failed
sinfo: error: _establish_config_source: failed to fetch config
sinfo: fatal: Could not establish a configuration source
```

systemctl status slurm is more helpful, with
fatal: Unable to determine this slurm's NodeName. So how do we fix this one?

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Option 1: take the error message literally

x

Option 1: take the error message literally

So there's no entry for login in the `SMS alurm.conf`. To fix that:

1. Run `alurm -C` on the login node to capture its correct CPU specifications. Copy that line to your laptop's clipboard.

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└─ Making better infrastructure nodes

└─ A dedicated login node

└─ Option 1: take the error message literally

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Option 1: take the error message literally

So there's no entry for login in the SMS `slurm.conf`. To fix that:

1. Run `slurm -C` on the login node to capture its correct CPU specifications. Copy that line to your laptop's clipboard.
2. On the SMS, run `nano /etc/slurm/slurm/slurm.conf` and make a new line of all the `slurm -C` output from the previous step (pasted from your laptop clipboard).

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└─ Option 1: take the error message literally

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Option 1: take the error message literally

So there's no entry for login in the SMS `slurm.conf`. To fix that:

1. Run `slurm -C` on the login node to capture its correct CPU specifications. Copy that line to your laptop's clipboard.
2. On the SMS, run `nano /etc/slurm/slurm/slurm.conf` and make a new line of all the `slurm -C` output from the previous step (pasted from your laptop clipboard).
3. Save and exit nano by pressing `Ctrl-X` and then `Enter`.

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└─ Option 1: take the error message literally

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Option 1: take the error message literally

So there's no entry for login in the SMS `slurm.conf`. To fix that:

1. Run `slurm -C` on the login node to capture its correct CPU specifications. Copy that line to your laptop's clipboard.
2. On the SMS, run `nano /etc/slurm/slurm/slurm.conf` and make a new line of all the `slurm -C` output from the previous step (pasted from your laptop clipboard).
3. Save and exit nano by pressing `Ctrl-X` and then `Enter`.
4. Reload the new Slurm configuration everywhere (well, everywhere functional) with `sudo scontrol reconfigure` on the SMS.

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└─ Option 1: take the error message literally

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Option 1: take the error message literally

So there's no entry for login in the SMS `slurm.conf`. To fix that:

1. Run `slurm -C` on the login node to capture its correct CPU specifications. Copy that line to your laptop's clipboard.
2. On the SMS, run `nano /etc/slurm/slurm/slurm.conf` and make a new line of all the `slurm -C` output from the previous step (pasted from your laptop clipboard).
3. Save and exit nano by pressing `Ctrl-X` and then `Enter`.
4. Reload the new Slurm configuration everywhere (well, everywhere functional) with `sudo scontrol reconfigure` on the SMS.
5. `ssh` back to the login node and restart `slurmd`, since it wasn't able to respond to the `scontrol reconfigure` from the previous step (`sudo ssh login ssystemctl restart slurmd` on the SMS).

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 - └─ A dedicated login node
 - └─ Option 1: take the error message literally

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Option 1: take the error message literally

Now an `info` should work on the login node:

```
[root@login ~]# info
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
normal*    up 1-00:00:00      1  idle c1
```

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- └─ Option 2: why are we running slurmd anyway?

Option 2: why are we running `slurmd` anyway?

The `slurmd` service is really only needed on systems that will be running computational jobs, and the login node is not in that category.

Running `slurmd` like the other nodes means the login node can get all its information from the SMS, but we can do the same thing with a very short customized `slurm.conf` with two lines from the SMS' `slurm.conf`:

```
ClusterName=cluster  
SlurmctldHost=zma-0
```

(where `zma-0` should be **your** SMS hostname from your handout) and stopping/disabling the `slurmd` service.

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└─ Making better infrastructure nodes

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└─ Interactive testing

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Interactive testing

1. On the login node as root, temporarily stop the slurm service with `systemctl stop slurm`
2. On the login node as root, edit `/etc/slurm/slurm.conf` with `nano /etc/slurm/slurm.conf`
3. Add the two lines to the right.
4. Save and exit nano by pressing `Ctrl-X` and then `Enter`.

Verify that `sinfo` still works without `slurm` and with the custom `/etc/slurm/slurm.conf`.

```
[root@login ~]# sinfo
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
normal*   up  1-00:00:00      1  idle  c1
```

```
/etc/slurm/slurm.conf on login
node
```

```
ClusterName=cluster
SlurmctldHost=ams-0
```

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Making permanent changes from the SMS

Making permanent changes from the SMS

Let's reproduce the changes we made interactively on the login node in the Warewulf settings on the SMS.

For the customized `s1urm.conf` file, we can keep a copy of it on the SMS and add it to the Warewulf file store.

We've done that previously for files like the shared `munge.key` for all cluster nodes (see section 3.8.5 of the OpenHPC install guide).

We also need to make sure that file is part of the login node's provisioning settings.

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- └─ Making permanent changes from the SMS

Making permanent changes from the SMS

On the SMS:

```
[user@smc-0 ~]$ sudo scp login:/etc/slurm/slurm.conf \
/etc/slurm/slurm.conf.login
slurm.conf                                100% 40    87.7KB/s   00:00
[user@smc-0 ~]$ sudo wvsh -y file import \
/etc/slurm/slurm.conf.login --name=slurm.conf.login \
--path=/etc/slurm/slurm.conf
```

Now the file is available, but we need to ensure the login node gets it. That's handled with wvsh provision.

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 - └─ A dedicated login node
 - └─ A quick look at wvsh provision

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A quick look at wvsh provision

What are the provisioning settings for compute node c1?

```
[username@0 ~]$ wvsh provision print c1
#### c1 #####
ci: MASTER           = UNDEF
ci: BOOTSTRAP        = c1.96-1.el9.elrepo.x86_64
ci: VMFS              = rocky9.4
ci: VALIDATE         = FALSE
ci: FILES             = dynamic_hosts.group.range.key.network,
                        passwd.shadow
...
ci: KARGO             = "net.ifnames=0 biosdevname=0 quiet"
ci: BOOTLOCAL        = FALSE
```

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 - └─ A quick look at wvsh provision

x

A quick look at wvsh provision

What are the provisioning settings for node login?

```
[username=0 ~]$ wvsh provision print login
### login #####
login: MASTER      = UNDEF
login: BOOTSTRAP    = 0.1.50-1.el9.elrepo.x86_64
login: VNF2         = rocky9.4
login: VALIDATE     = FALSE
login: FILES        = dynamic_hosts.group.range.key.network,
                    passwd.shadow
...
login: XARGS        = "set.ifnames=0 biosdevname=0 quiet"
login: BOOTLOCAL    = FALSE
```

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 - └─ A dedicated login node
 - └─ A quick look at `wwsh` provision

x

A quick look at `wwsh` provision

The provisioning settings for `c1` and `login` are identical, but there's a lot to read in there to be certain about it.

We could run the two outputs through `diff`, but every line contains the node name, so **no lines are literally identical**.

Let's simplify and filter the `wwsh` provision output to make it easier to compare.

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- └─ Filtering `wwsh provision` output

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Filtering `wwsh provision` output

► I only care about the lines containing `= signs`, so

```
wwsh provision print cl | grep "="
```

is a start.

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Filtering `wwsh provision` output

x

Filtering `wwsh provision` output

► I only care about the lines containing `= signs`, so

```
wwsh provision print cl | grep "="
```

is a start.

► Now all the lines are prefixed with `cl::`, and I want to keep everything after that, so

```
wwsh provision print cl | grep "=" | cut -d: -f2-
```

will take care of that.

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└─ Making better infrastructure nodes

└─ A dedicated login node

└─ Filtered result

Filtered result

```
vvah provision print cl | grep = | cut -d: -f2-
MASTER          = UNDEF
BOOTSTRAP        = 6.1.06-1.el9.elrepo.x86_64
YNFS              = rocky9.4
VALIDATE         = FALSE
FILES            = dynamic_hosts.group.manage.key.network,
                  passwd,shadow
...
KARGES           = "net.ifnames=0 biosdevname=0 quiet"
BOOTLOCAL        = FALSE
```

Much more useful.

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- └─ Making better infrastructure nodes
 - └─ A dedicated login node
 - └─ Making a function for this

x

Making a function for this

We may be typing that command pipeline a lot, so let's make a shell function to cut down on typing:

```
[user@node-0 ~]$ function preprint() { \
  vssh provision print $@ | grep -i cut -d: -f2- ; }
[user@node-0 ~]$ preprint ci
MASTER                = OMPI
BOOTSTRAP               = 6.1.96-1.el9.elrepo.x86_64
...

```

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- └─ Making better infrastructure nodes
 - └─ A dedicated login node
 - └─ diff-ing the outputs

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diff-ing the outputs

We could redirect a `proprint ci` and a `proprint login` to files and `diff` the resulting files, or we can use the shell's `<()` operator to treat command output as a file:

```
[user@node-0 ~]$ diff -u <$(proprint ci) <$(proprint login)
[user@node-0 ~]$
```

Either of those shows there are zero provisioning differences between a compute node and the login node.

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- └─ A dedicated login node

- └─ Adding the custom `slurm.conf` to the login node

Adding the custom `slurm.conf` to the login node

Add a file to login's FILES property with:

```
[user@node-0 ~]$ sudo bash -y provision set login \
--fileadd=slurm.conf.login
```

(refer to section 3.9.3 of the install guide for previous examples of `--fileadd`).

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- └─ Making better infrastructure nodes
 - └─ A dedicated login node
 - └─ Checking for provisioning differences

Checking for provisioning differences

Run the previous diff command to easily see what's changed:

```
[user@node-0 ~]$ diff -u <$(proprint c1) <$(proprint login)
--- /dev/fd/63  2024-07-06 11:11:07.682959677 -0400
+++ /dev/fd/62  2024-07-06 11:11:07.683959681 -0400
@@ -2,7 +2,7 @@
@@ BOOTSTRAP      = 6.1.96-1.el9.elrepo.x86_64
@@ YRFS           = rocky9.4
@@ VALIDATE       = FALSE
-@@ FILES          = dynamic_hosts,group,munge.key,network,
+@@ FILES          = dynamic_hosts,group,munge.key,network,
+ password,shadow,
+ password,shadow,slurm.conf,login
@@ PRESHELL       = FALSE
@@ POSTSHELL      = FALSE
@@ POSTHUTDOWN    = FALSE
```

x

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Ensuring slurmd doesn't run on the login node

Ensuring `slurmd` doesn't run on the login node

To disable the `slurmd` service on just the login node, we can take advantage of conditions in the `systemd` service file. Back on the login node as root:

```
[user@bmc-0 ~]$ sudo nsh login
[root@login ~]# systemctl edit slurmd
```

Insert these lines between the lines of `## Anything between here... and`
`## Lines below this comment...:`

```
[Unit]
ConditionHost=!c*
ConditionHost=!g*
```

This will only run the service on nodes whose hostnames start with `c` or `g`.

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- └─ Ensuring slurmd doesn't run on the login node

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Ensuring `slurmd` doesn't run on the login node

Once that file is saved, try to start the `slurmd` service with `systemctl start slurmd` and check its status with `systemctl status slurmd`.

```
s slurmd.service - Slurm node daemon
..
Condition: start condition failed at Sat 2024-07-06 18:12:17
EDT; 4min 22s ago
..
Jul 06 17:14:16 login systemd[1]: Stopped Slurm node daemon.
Jul 06 18:12:17 login systemd[1]: Slurm node daemon was skipped
because of an unset condition check (ConditionNot=+).
```

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- └─ Making better infrastructure nodes
 - └─ A dedicated login node
 - └─ Making the changes permanent

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Making the changes permanent

The `systemctl edit` command resulted in a file
`/etc/systemd/system/slurmd.service.d/override.conf`. Let's:

- make a place for it in the chroot on the SMS, and
- copy the file over from the login node.

```
[user@node-0 ~]$ export CHROOT=/opt/ohpc/admin/images/rocky9.4
[user@node-0 ~]$ sudo mkdir -p \
$(CHROOT)/etc/systemd/system/slurmd.service.d/
[user@node-0 ~]$ sudo scp \
login:/etc/systemd/system/slurmd.service.d/override.conf \
$(CHROOT)/etc/systemd/system/slurmd.service.d/
override.conf      100% 23   36.7KB/s   00:00
```

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- └─ Making better infrastructure nodes
 - └─ A dedicated login node
 - └─ Making the changes permanent

x

Making the changes permanent

Finally, we'll:

- rebuild the VNFs, and
- reboot both the login node and a compute node to test the changes.

```
[user@ana-0 ~]$ sudo vvvvfa --chroot=${CHROOT}
Using 'rocky9.4' as the VNFs name
...
Total elapsed time
: 24.42 s
[user@ana-0 ~]$ sudo ssh login reboot
[user@ana-0 ~]$ sudo ssh ci reboot
```

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Verifying the changes on the login node

Verifying the changes on the login node

Verify that the login node doesn't start slurm, but can still run sinfo without any error messages.

```
[user@node-0 ~]$ sudo ssh login systemctl status slurm  
s slurm.service - Slurm node daemon  
...  
Jul 06 18:26:23 login systemd[1]: Slurm node daemon was  
skipped because of an unset condition check  
(ConditionHost=c*).  
[user@node-0 ~]$ sudo ssh login sinfo  
PARTITION AVAIL TIMELIMIT NODES STATE NODELIST  
normal* up 1-00:00:00 1 idle c1
```

x

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OpenHPC: Beyond the Install Guide

└─ Making better infrastructure nodes

└─ A dedicated login node

└─ Verifying the changes on a compute node

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Verifying the changes on a compute node

Verify that the compute node still starts slurmd (it can also run sinfo).

```
[user@node-0 ~]$ sudo bash c1 systemctl status slurmd
● slurmd.service - Slurm node daemon
...
Jul 06 19:03:22 c1 systemd[1]: Started Slurm node daemon.
Jul 06 19:03:22 c1 slurmd[1082]: slurmd: CPUs=2 Boards=1
  Sockets=2 Cores=1 Threads=1 Memory=8913 TopDisk=25966
  Optime=28 CPUSpecList=(null) FeaturesAvail=(null)
  FeaturesActive=(null)
[user@node-0 ~]$ sudo bash c1 sinfo
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
normal*    up 1:00:00:00      1    down c1
```

(Yes, c1 is marked down—we'll fix that shortly.)

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Problem: the login node doesn't let users log in

x

Problem: the login node doesn't let users log in

What if we ssh to the login node as someone other than root?

```
[user@bmc-0 ~]$ ssh login
Access denied: user user1 (uid=1001) has no active jobs on this node.
Connection closed by 172.16.0.2 port 22
```

which makes this the exact opposite of a login node for normal users. Let's fix that.

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Making the login node function as a login node

x

Making the login node function as a login node

- ▶ The Access denied is caused by the `pan_sshd.no` entry at the end of `/etc/pan.d/ssh`, which is invaluable on a normal compute node, but not on a login node.
- ▶ On the SMS, you can also do a `diff -u /etc/pan.d/ssh $(CWD007)/etc/pan.d/ssh`
- ▶ You'll see that the `pan_sshd.no` line is the only difference between the two files.

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└─ Making better infrastructure nodes

└─ A dedicated login node

└─ Testing a PAM change to the login node

Testing a PAM change to the login node

- ▶ Temporarily comment out the last line of the login node's `/etc/pam.d/ssh` and see if you can ssh into the login node as a normal user (i.e., `ssh user1@login`).
- ▶ Your user should be able to log in now.
- ▶ In case the PAM configuration won't let root log in, **don't panic!** Instructors can reboot your login node from its console to put it back to its original state.

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- └─ Making better infrastructure nodes
 - └─ A dedicated login node
 - └─ Making the change permanent

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Making the change permanent

- We want to ensure that the login node gets the same `/etc/pam.d/sahd` that the SMS uses.
- We'll follow the same method we used to give the login node a custom `slurm.conf`:

```
[user@name-0 ~]$ sudo wvash -y file import /etc/pam.d/sahd \
--name=sahd.login
[user@name-0 ~]$ wvash file list
...
sahd.login : rw-r--r-- 1 root root 727 /etc/pam.d/sahd
```

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- └─ Making better infrastructure nodes
 - └─ A dedicated login node
 - └─ Making the change permanent

x

Making the change permanent

```
[user@node-0 ~]$ sudo wvash -y provision set login \
--fileadd=sashd.login
[user@node-0 ~]$ diff -u <{(proprint ci)} <{(proprint login)}
...
- VALIDATE          = FALSE
+ FILES             = dynamic_hosts.group,munge.key,network,
+ password,shadow   = dynamic_hosts.group,munge.key,network,
+ FILES             = dynamic_hosts.conf.login,sashd.login
+ ...
```

(refer to section 3.9.3 of the install guide for previous examples of --fileadd).

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- └─ Making better infrastructure nodes

- └─ A dedicated login node

- └─ Testing the change

x

Testing the change

Reboot the login node and let's see if we can log in as a regular user.

```
[user@node-0 ~]$ sudo bash login reboot
[user@node-0 ~]$ bash login
[user@login ~]$
```

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OpenHPC: Beyond the Install Guide

- └─ Making better infrastructure nodes
 - └─ A bit more security for the SMS and login nodes
 - └─ A bit more security for the SMS and login nodes

x

A bit more security for the SMS and login nodes

TODO: narrative about checking `/var/log/secure` on the SMS, seeing lots of brute-force SSH attempts for both it and login

TODO: Verify if this will work on the SMS with a simple
`sudo yum install fail2ban ; sudo systemctl enable fail2ban firewalld`, but we'll also have to ensure that we don't disrupt NFS or other services to the internal network

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- └─ Making better compute nodes

- └─ More seamless reboots of compute nodes

- └─ Why was c1 marked as down?

x

Why was c1 marked as down?

You can return c1 to an idle state by running
sudo scontrol update node=c1 state=resume on the SMS:

```
[user@msm-0 ~]$ sudo scontrol update node=c1 state=resume
[user@msm-0 ~]$ sinfo
PARTITION AVAIL  TIMELIMIT  NODES  STATE MODELIST
normal*   up  1-00:00:00      1    idle  c1
```

We should configure things so that we don't have to manually resume nodes every time we reboot them.

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OpenHPC: Beyond the Install Guide

- └─ Making better compute nodes

- └─ More seamless reboots of compute nodes

- └─ More seamless reboots of compute nodes

More seamless reboots of compute nodes

- ▶ Slurm doesn't like it when a node gets rebooted without its knowledge.
- ▶ There's an `scontrol reboot` option that's handy to have nodes reboot when system updates occur, but it requires a valid setting for `RebootProgram` in `/etc/slurm/slurm.conf`.
- ▶ By default, Slurm and OpenHPC don't ship with a default `RebootProgram`, so let's make one.

x

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OpenHPC: Beyond the Install Guide

- └─ Making better compute nodes
 - └─ More seamless reboots of compute nodes
 - └─ Adding a valid RebootProgram

x

Adding a valid RebootProgram

```
[user@node-0 ~]$ grep -i reboot /etc/slurm/slurm.conf
#RebootProgram=""
[user@node-0 ~]$ echo 'RebootProgram="/sbin/shutdown -r now' \
| sudo tee -a /etc/slurm/slurm.conf
[user@node-0 ~]$ grep -i reboot /etc/slurm/slurm.conf
#RebootProgram=""
RebootProgram="/sbin/shutdown -r now"
```

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OpenHPC: Beyond the Install Guide

└─ Making better compute nodes

└─ More seamless reboots of compute nodes

└─ Informing all nodes of the changes and testing it out

x

Informing all nodes of the changes and testing it out

```
user@bms-0 ~]$ sudo scontrol reconfigure
user@bms-0 ~]$ sudo scontrol reboot ASAP nextstate=RESUME c1
```

- ▶ scontrol reboot will wait for all jobs on a group of nodes to finish before rebooting the nodes.
- ▶ scontrol reboot ASAP will immediately put the nodes in a DRAIN state, routing all pending jobs to other nodes until the rebooted nodes are returned to service.
- ▶ scontrol reboot ASAP nextstate=RESUME will set the nodes to accept jobs after the reboot. nextstate=DRAIN will leave the nodes in a DRAIN state if you need to do more work on them before returning them to service.

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OpenHPC: Beyond the Install Guide

- └─ Making better compute nodes
 - └─ More seamless reboots of compute nodes
 - └─ Did it work?

x

Did it work?

TODO: verify what a successful "return to idle" looks like here, including an uptime of seconds to minutes rather than days.

```
[user@node-0 ~]$ sudo cat /etc/hosts
08:44:31 up 66 days, 17:24, 2 users, load average: 0.00, 0.04, 0.05
[user@node-0 ~]$ cat /etc/hosts
PARTITION AVAIL  TIMELIMIT  NODES  STATE NODELIST
normal*    up 1-00:00:00      1   idle  c1
```

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OpenHPC: Beyond the Install Guide

- └─ Making better compute nodes

- └─ Decoupling kernels from the SMS

- └─ Decoupling kernels from the SMS

[Decoupling kernels from the SMS](#)

How to install kernels into the chroot and bootstrap from the chroot.

x

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OpenHPC: Beyond the Install Guide

- └─ Making better compute nodes

- └─ Semi-stateful node provisioning

- └─ Semi-stateful node provisioning

[Semi-stateful node provisioning](#)

(talking about the parted and filesystem-related pieces here.)

x

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OpenHPC: Beyond the Install Guide

- └─ Making better compute nodes

- └─ Management of GPU drivers

- └─ Management of GPU drivers

Management of GPU drivers

(installing GPU drivers – mostly rsync'ing a least-common-denominator chroot into a GPU-named chroot, copying the NVIDIA installer into the chroot, mounting /proc and /sys, running the installer, umounting /proc and /sys, and building a second VNFs)

x

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OpenHPC: Beyond the Install Guide

- └─ Managing system complexity
 - └─ Configuration settings for different node types
 - └─ Configuration settings for different node types

Configuration settings for different node types

(have been leading into this a bit with the `wwsh` file entries, `systemd` conditions, etc.
But here we can also talk about nodes with two drives instead of one, nodes with and without Infiniband, nodes with different provisioning interfaces, etc.)

x

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OpenHPC: Beyond the Install Guide

- └─ Managing system complexity
 - └─ Automation for Warewulf3 provisioning
 - └─ Automation for Warewulf3 provisioning

Automation for Warewulf3 provisioning

(here we can show some sample Python scripts where we can store node attributes and logic for managing the different VNFSees)

x

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OpenHPC: Beyond the Install Guide

- └─ Configuring Slurm policies

- └─ Configuring Slurm policies

[Configuring Slurm policies](#)

Can adapt a lot of Mike's CaRCC Emerging Centers talk from a couple years ago for this. Fair share, hard limits on resource consumption, QOSes for limiting number of GPU jobs or similar.

x

OpenHPC: Beyond the Install Guide

└─ Configuring Slurm policies

└─ Sample slide

This is my note.

- It can contain Markdown
- like this list

Left column

This slide has two columns. They don't always have to have columns. It also has a titled block of content in the left column. Make sure you've always got a `::: notes` block after the slide content, even if it has no content.

Use `#` and `##` headers in the Markdown file to make level-1 and level-2 headings. `###` headers to make slide titles, and `####` to make block titles.