

Bright Cluster Manager 8.2

# Installation Manual

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# 1

## Quickstart Installation Guide

This chapter describes a basic and quick installation of Bright Cluster Manager on “bare metal” cluster hardware as a step-by-step process, and gives very little explanation of the steps. Following these steps should allow a moderately experienced cluster administrator to get a cluster up and running in a fairly standard configuration as quickly as possible. This would be without even having to read the introductory Chapter 2 of this manual, let alone the entire manual. References to chapters and sections are provided where appropriate.

Some asides, before getting on with the steps themselves:

- If the cluster has already been installed, tested, and configured, but only needs to be configured now for a new network, then the administrator should only need to look at Chapter 6. Chapter 6 lays out how to carry out the most common configuration changes that usually need to be done to make the cluster work in the new network.
- For administrators that are very unfamiliar with clusters, reading the introduction (Chapter 2) and then the more detailed installation walkthrough for a bare metal installation (Chapter 3, sections 3.1, 3.2, and 3.3) is recommended. Having carried out the head node installation, the administrator can then return to this quickstart chapter (Chapter 1), and continue onward with the quickstart process of regular node installation (section 1.3).
- The configuration and administration of the cluster after it has been installed is covered in the Bright Cluster Manager *Administrator Manual*. The *Administrator Manual* should be consulted for further background information as well as guidance on cluster administration tasks, after the introduction (Chapter 2) of the *Installation Manual* has been read.
- If all else fails, administrator-level support is available via <https://support.brightcomputing.com>. Section 13.2 of the *Administrator Manual* has further details on how to brief the support team, so that the issue can be resolved as quickly as possible.

The quickstart steps now follow:

### 1.1 Installing The Head Node

The head node does not need to be connected to the regular nodes at this point, though it helps to have the wiring done beforehand so that how things are connected is known.

1. The BIOS of the head node should have the local time set.
2. The head node should be booted from the Bright Cluster Manager DVD.
3. The option: `Install Bright Cluster Manager (Graphical)`, or `Install Bright Cluster Manager (Text mode)`, should be selected in the text boot menu. The Graphical installation is

recommended, and brings up the GUI installation Welcome screen. Only the Text mode installation is possible for ARMv8, and provides a minimal version of the GUI installation.

Only the GUI installation is discussed in the rest of this quickstart for convenience.

4. At the Welcome screen, Continue should be clicked. By default, this continues with a Normal (recommended) installation mode.
5. At the License screens:
  - At the Bright Computing Software License screen, the acceptance checkbox should be ticked. Continue should then be ticked.
  - At the Linux base distribution screen, the acceptance checkbox should be ticked. Continue should then be clicked.
6. At the Kernel Modules screen, Continue should be clicked.
7. At the Hardware Information screen, the detected hardware should be reviewed. If additional kernel modules are required, then the administrator should go back to the Kernel Modules screen. Once all the relevant hardware (Ethernet interfaces, hard drive and DVD drive) is detected, Continue should be clicked.
8. At the Nodes screen:
  - The number of racks and regular nodes are specified
  - The base name for the regular nodes is set. Accepting the default of node means nodes names are prefixed with node, for example: node001, node002...
  - The number of digits to append to the base name is set. For example, accepting the default of 3 means nodes from node001 to node999 are possible names.
  - The correct hardware manufacturer is selected

Continue is then clicked.

9. At the Network Topology screen, a network layout is chosen. The default layout, private internal network, is the most commonly used layout. The rest of this chapter assumes the default layout was chosen. Click Continue
10. At the Additional Network Configuration screen, it is possible to:
  - add an InfiniBand and/or 10 Gig-E network, and
  - configure the use of IPMI/iLO/DRAC/CIMC/Redfish BMCs on the nodes. Adding an IPMI/iLO/DRAC/CIMC/Redfish network is needed to configure IPMI/iLO/DRAC/CIMC/Redfish interfaces in a different IP subnet, and is recommended.

When done, Continue should be clicked.

11. At the Networks screen, the network parameters for the head node should be entered for the interface facing the network named externalnet:
  - If using DHCP on that interface, the OK button should be clicked to accept the parameters for IP Address, Netmask and Gateway as suggested by the DHCP server on the external network.
  - If not using DHCP on that interface, the Use DHCP checkbox should be unchecked, and static values put in instead. Then the OK button should be clicked.

The network parameters for externalnet can then be reviewed. These are the:



- base address (also called the *network address*)
- netmask
- domain name
- default gateway

The network `externalnet` corresponds to the site network that the cluster resides in (for example, a corporate or campus network). The IP address details are therefore the details of the head node for a type 1 `externalnet` network (figure 3.12). A domain name should be entered to suit the local requirements.

- At the `Nameservers` screen, additional DNS search domains and additional external DNS name servers, if required, can be added or removed. For the default network topology (see item 9, page 2), if the external network has a DHCP lease with DNS configuration information, then nothing needs to be added to resolve external hosts. `Continue` should be clicked.
- At the `Network Interfaces` screen:
  - The IP addresses assigned to the network interfaces should be reviewed. All networks besides the `externalnet` network use private IP ranges by default and normally do not have to be changed.
  - If necessary, the node interface properties should be modified. When IPMI/iLO/DRAC/CIMC/Redfish interfaces reside in the same IP subnet, an IP Offset is set for the `ipmi0` interface.

`Continue` should be clicked.

- The `Subnet Managers` screen is displayed if an InfiniBand network was enabled. At this screen, nodes (if any) that are to run the subnet manager for the InfiniBand network should be selected. `Continue` should then be clicked.
- At the `Installation sources` screen, the DVD drive containing the Bright Cluster Manager DVD should be selected, then `Continue` clicked.
- At the `Workload Management` screen, a workload manager should be selected. `Continue` should then be clicked.
- At the `Disk Partitioning and Layouts` screen, a drive should be selected on the head node. The installation will be done onto this drive, overwriting all its previous content.

The administrator can modify the disk layout for the head node by selecting a pre-defined layout. For hard drives that have less than about 500GB space, the XML file `master-one-big-partition.xml` is used by default:

Partition	Space	Mounted At	Filesystem Type
1	512M	/boot	ext2
0	100M	/boot/efi	fat
2	16G	-	swap
3	rest	/	xfs (RHEL7, SLES12, Ubuntu), ext4 (RHEL6)

Default layout for up to 500GB: One big partition.

For hard drives that have about 500GB or more of space, the XML file `master-standard.xml` is used by default:

Partition	Space	Mounted At	Filesystem Type
1	512M	/boot	ext2
0	100M	/boot/efi	fat
2	16G	-	swap
3	20G	/tmp	xfs (RHEL7, SLES12, Ubuntu), ext4 (RHEL6)
4	180G	/var	xfs (RHEL7, SLES12, Ubuntu), ext4 (RHEL6)
5	rest	/	xfs (RHEL7, SLES12, Ubuntu), ext4 (RHEL6)

Default layout for more than 500GB: Several partitions.

The layouts indicated by these tables may be fine-tuned by editing the XML partitioning definition during this stage. The “max” setting in the XML file corresponds to the “rest” entry in these tables, and means the rest of the drive space is used up for the associated partition, whatever the leftover space is.

There are also other layout templates available from a menu.

Continue is clicked, and then the administrator must confirm that the data on the listed drive(s) may be erased by clicking Yes.

18. At the Time Configuration screen, a time-zone should be selected, and optionally, NTP time-servers should be added. Continue should be clicked.
19. At the Cluster Access screen, some network restrictions can be set. By default there are no network-specific restrictions on access to the cluster (e.g. using ssh or Bright View<sup>1</sup>). To accept the defaults, Continue should be clicked.
20. At the Authentication screen, a hostname should be entered for the head node. Also a password should be entered, twice, for use in system administration. Continue should then be clicked.
21. At the Console screen, a text or graphical console can be configured for the nodes in the cluster. It should be noted that Bright View can still be used remotely even if the console of the head node is set to text mode. Continue should then be clicked.
22. At the Summary screen, the network summary should be reviewed. The Start button then starts the installation. Yes should be clicked to confirm that the data on the listed drive(s) may be erased.
23. The Installation Progress screen should eventually complete. Clicking on Reboot and then clicking Yes to confirm, reboots the head node.

## 1.2 First Boot

1. The DVD should be removed or the boot-order altered in the BIOS to ensure that the head node boots from the first hard drive.
2. Once the machine is fully booted, a log in should be done as root with the password that was entered during installation.
3. A check should be done to confirm that the machine is visible on the external network. Also, it should be checked that the second NIC (i.e. eth1) is physically connected to the external network.

<sup>1</sup>A web browser-based GUI front end provided by Bright Cluster Manager to manage the cluster. It uses port 8081 by default.

4. If the parent distribution for Bright Cluster Manager is RHEL and SUSE then registration (Chapter 5) should usually be done.
5. The license parameters should be verified to be correct:  

```
cmsh -c "main licenseinfo"
```

If the license being used is a temporary license (see End Time value), a new license should be requested well before the temporary license expires. The procedure for requesting and installing a new license is described in Chapter 4.

## 1.3 Booting Regular Nodes

1. A check should be done to make sure the first NIC (i.e. `eth0`) on the head node is physically connected to the internal cluster network.
2. The BIOS of regular nodes should be configured to boot from the network. The regular nodes should then be booted. No operating system is expected to be on the regular nodes already. If there is an operating system there already, then by default, it is overwritten by a default image provided by the head node during the next stages.
3. If everything goes well, the node-installer component starts on each regular node and a certificate request is sent to the head node.

If a regular node does not make it to the node-installer stage, then it is possible that additional kernel modules are needed. Section 5.8 of the *Administrator Manual* contains more information on how to diagnose problems during the regular node booting process.

4. To identify the regular nodes (that is, to assign a host name to each physical node), several options are available. Which option is most convenient depends mostly on the number of regular nodes and whether a (configured) managed Ethernet switch is present.

Rather than identifying nodes based on their MAC address, it is often beneficial (especially in larger clusters) to identify nodes based on the Ethernet switch port that they are connected to. To allow nodes to be identified based on Ethernet switch ports, section 3.8 of the *Administrator Manual* should be consulted.

If a node is unidentified, then its node console displays an Ncurses message to indicate it is an unknown node, and the net boot keeps retrying its identification attempts. Any one of the following methods may be used to assign node identities when nodes start up as unidentified nodes:

- a. **Identifying each node on the node console:** To manually identify each node, the “Manually select node” option is selected for each node. The node is then identified manually by selecting a node-entry from the list, choosing the Accept option. This option is easiest when there are not many nodes. It requires being able to view the console of each node and keyboard entry to the console.
- b. **Identifying nodes using `cmsh`:** In `cmsh` the `newnodes` command in device mode (page 173, section 5.4.2 of the *Administrator Manual*) can be used to assign identities to nodes from the command line. When called without parameters, the `newnodes` command can be used to verify that all nodes have booted into the node-installer and are all waiting to be assigned an identity.
- c. **Identifying nodes using Bright View:** The node identification resource (page 177, section 5.4.2 of the *Administrator Manual*) in Bright View automates the process of assigning identities so that manual identification of nodes at the console is not required.

### Example

To verify that all regular nodes have booted into the node-installer:

```
[root@mycluster ~]# cmsh
[mycluster]% device newnodes
MAC                First appeared          Detected on switch port
-----
00:0C:29:D2:68:8D  05 Sep 2011 13:43:13 PDT [no port detected]
00:0C:29:54:F5:94  05 Sep 2011 13:49:41 PDT [no port detected]
..
[mycluster]% device newnodes | wc -l
MAC                First appeared          Detected on switch port
-----
32
[mycluster]% exit
[root@mycluster ~]#
```

### Example

Once all regular nodes have been booted in the proper order, the order of their appearance on the network can be used to assign node identities. To assign identities node001 through node032 to the first 32 nodes that were booted, the following commands may be used:

```
[root@mycluster ~]# cmsh
[mycluster]% device newnodes -s -n node001..node032
MAC                First appeared          Hostname
-----
00:0C:29:D2:68:8D  Mon, 05 Sep 2011 13:43:13 PDT node001
00:0C:29:54:F5:94  Mon, 05 Sep 2011 13:49:41 PDT node002
..
[mycluster]% exit
[root@mycluster ~]#
```

5. Each regular node is now provisioned and eventually fully boots. In case of problems, section 5.8 of the *Administrator Manual* should be consulted.
6. *Optional:* To configure power management, Chapter 4 of the *Administrator Manual* should be consulted.

## 1.4 Quickstart For GPUs

This assumes that the head nodes and regular nodes are up and running. Getting GPUs set up right can be done as follows for a typical installation:

### 1. GPU Hardware And Sanity Check

If the hardware is not detected, then that must first be fixed. Checking for the hardware can be done as follows:

- (a) NVIDIA GPUs hardware should be detected on the nodes that use it. This is true for NVIDIA GPU units (separate from the nodes) as well as for on-board NVIDIA GPUs. The `lspci` command can be used for detection. For example, for a GPU used by node001:

#### Example

```
[root@bright82 ~]# ssh node001 lspci | grep NVIDIA
00:07.0 3D controller: NVIDIA Corporation GK110BGL [Tesla K40c] (rev a1)
```

- (b) AMD CPUs, which have a GPU integrated with the CPU, the CPU chip, can similarly be identified with `lscpu`:

#### Example

```
[root@bright82 ~]# ssh node001 lscpu | grep "Model name:"
Model name:          AMD Ryzen 5 2500U with Radeon Vega Mobile Gfx
```

The AMD chips can then be checked against the list of AMD chips with AMD GPUs, as listed at <https://www.amd.com/en/support/kb/release-notes/rn-prorad-lin-18-20>

## 2. Installing The Software

- (a) Details of AMD GPU software installation are given in section 7.5.
- (b) For NVIDIA GPUs, assuming the GPU is on the regular node `node001`, and that the hardware can handle CUDA 10.1, then software installation is carried out at the head node as follows:
- the software components are installed for the head node itself with:
 

```
[root@bright82 ~]# yum install cuda10.1-toolkit cuda10.1-sdk
```
  - Components are installed into the image, for example the image `default-image`, with:
 

```
[root@bright82 ~]# yum --installroot=/cm/images/default-image install cuda-driver cuda-dcgm
```
  - The nodes with GPUs can then simply be rebooted to compile the CUDA drivers as the node boots, and to start the CUDA driver up:
 

```
[root@bright82 ~]# cmsh -c 'device; reboot -n node001..node015'
```

Further details on the basic installation of CUDA for GPUs are given in section 7.4

## 3. Configuring GPUs For The Cluster Manager

After the GPU software has been installed, the `gpusettings` submode becomes available. This submode allows the cluster administrator to modify GPU values. Keeping the default settings in the submode should be fine, which means configuration of GPU settings can simply be skipped.

However, if needed, then the settings can be modified as described in section 3.13.3 of the *Administrator Manual*,

- on page 119 for NVIDIA GPUs
- on page 121 for AMD GPUs.

## 4. Configuring GPUs For The Workload Manager

Slurm workload manager can be set up from the head node by running:

```
[root@bright82 ~]# wlm-setup -w slurm -s
...
Enabling job metrics ..... [ OK ]
```

```
-----
Please note that the changes in the software image(s) have not
been propagated to the running nodes. This will happen when
the node(s) is/are rebooted.
-----
```

The regular nodes can then be rebooted to get the workload manager running:

```
[root@bright82 ~]# cmsh -c 'device; reboot -n node001..node015'
```

If the nodes with GPUs are in the default category, then the attributes for generic resources of the Slurm clients running on the nodes can be set as follows:

### Example

```
[root@bright82 ~]# cmsh
[bright82]% category use default
[bright82->category[default]]% roles
[bright82->category[default]->roles]% use slurmclient
[...[slurmclient]]% genericresources
[...[slurmclient]->genericresources]% add gpu0
[...[slurmclient*]->genericresources*[gpu0*]]% set name gpu
[...[slurmclient*]->genericresources*[gpu0*]]% set file /dev/nvidia0
[...[slurmclient*]->genericresources*[gpu0*]]% set cores 0-7
[...[slurmclient*]->genericresources*[gpu0*]]% set type k20xm
[...[slurmclient*]->genericresources*[gpu0*]]% add gpu1
[...[slurmclient*]->genericresources*[gpu1*]]% set name gpu
[...[slurmclient*]->genericresources*[gpu1*]]% set file /dev/nvidia1
[...[slurmclient*]->genericresources*[gpu1*]]% set cores 8-15
[...[slurmclient*]->genericresources*[gpu1*]]% set type k20xm
[...[slurmclient*]->genericresources*[gpu1*]]% commit
[...[slurmclient]->genericresources[gpu2]]% list
Alias (key) Name      Type      Count      File
-----
gpu0          gpu        k20xm           /dev/nvidia0
gpu1          gpu        k20xm           /dev/nvidia1
[...[slurmclient]->genericresources[gpu2]]%
```

In the preceding cmsh session, when setting the attributes for genericresources:

- The lines `add gpu0`, `add gpu1` and so on are to set up the aliases (`gpu0`, `gpu1`...). The aliases set here are arbitrary names provided by the cluster administrator, for labels to be used by the Bright Cluster Manager front ends.
- The `set name gpu` lines, on the other hand, set the value of the name attribute for each alias. The value for name is not arbitrary, and should match the output of:

```
[root@bright82 ~]# cmsh -c "device use master; roles; get slurmserver grestypes"
gpu
```

The other attributes should be allocated according to the resources the kernel has detected on the node hardware:

- Thus, the `set file` lines are based on a kernel having set device paths of `/dev/nvidia0` and `/dev/nvidia1` for two GPUs placed in a node, when the driver was installed. These paths are viewed by the administrators as being resources in the resource pool, and it is from that pool that a file path is allocated to the alias.
- Similarly, the `set cores` lines are allocated from the resource pool of all CPU cores available on the host node.
- The `set type` line takes an arbitrary identifier string that is defined by the administrator. This value is set for the convenience of users. Typically it would indicate the type of GPU that is associated with the device in the device path and that is being made available.

More on these attributes can be found in the man pages (`man 5 gres.conf`).

NVIDIA configuration for Slurm and other workload managers is described in further detail in section 7.5 of the *Administrator Manual*

## 5. Running A GPU Slurm Job

A user can be created with, for example, an unimaginative name such as `auser`:

```
[root@bright82 ~]# cmlsh
[bright82]% user add auser
[bright82->user*[auser*]]% set password
enter new password:
retype new password:
[bright82->user*[auser*]]% commit
```

The “Hello World” `helloworld.cu` script from section 8.5.4 of the *User Manual* can be saved in `auser`’s directory, and then compiled for the GPU with `nvcc`:

```
[auser@bright82 ~]$ module load shared cuda10.1/toolkit
[auser@bright82 ~]$ nvcc helloworld.cu -o helloworld
```

A `slurmgpuhello.sh` batch script can be built as follows:

```
[auser@bright82 ~]$ cat slurmgpuhello.sh
#!/bin/sh
#SBATCH -o my.stdout
#SBATCH --time=30      #time limit to batch job
#SBATCH --ntasks-per-node=1
#SBATCH -p defq #assuming gpu is in defq
#SBATCH --gpus=1
echo -n "hostname is "; hostname
module clear -f
./helloworld
```

It can be submitted as a batch job from the head node:

```
[auser@bright82 ~]$ sbatch slurmgpuhello.sh
Submitted batch job 35
```

The output can then be seen:

```
[auser@bright82 ~]$ cat my.stdout
hostname is node001
String for encode/decode: Hello World!
String encoded on CPU as: Uryy|-dlyq.
String decoded on GPU as: Hello World!
[auser@bright82 ~]$
```

More about Slurm batch scripts and GPU compilation can be found in Chapter 8 of the *User Manual*.

## 1.5 Optional: Upgrading Python

The version of Python provided by the Linux-based OS distributors typically lags significantly behind the latest upstream version. This is normally a good thing, since the distributors provide integration, and carry out testing to make sure it works well with the rest of the OS. The version of Python that the distributors provide is also the version which Bright Cluster Manager tools expect and rely on. However, some administrators would like to have the latest Python versions available on their cluster, for the OS, or for the applications. One reason may be that later versions have some nicer features.

Installing Python outside of the distribution will normally break Bright Cluster Manager and is therefore not recommended. For administrators that would like to carry out this out-of-distribution upgrade anyway, there are knowledge base articles #1226 (<http://kb.brightcomputing.com/faq/index.php?action=artikel&cat=23&id=226>) and #1197 (<http://kb.brightcomputing.com/faq/index.php?action=artikel&cat=18&id=198>) that explain how to do it. If the change is carried out correctly, then support is not available for Python-related bugs, but is available for the Bright Cluster Manager-related features.

## 1.6 Running Bright View

**To run the Cluster Management GUI (Bright View) on the cluster from a workstation running X11:** A recent web browser should be used, and pointed to

`https://<head node address>:8081/bright-view/`

A suitable web browser is the latest Chrome from Google, but Opera, Firefox, Chromium, and similar should all also just work. The hardware on which the browser runs must be fast enough, and for a reasonable experience, should be roughly equivalent to that of a mid- to high-end desktop of 2016.

**The cluster should now be ready for running compute jobs.**

**For more information:**

- This manual, the *Installation Manual*, has more details and background on the installation of the cluster in the next chapters.
- The *Administrator Manual* describes the general management of the cluster.
- The *User Manual* describes the user environment and how to submit jobs for the end user
- The *Cloudbursting Manual* describes how to deploy the cloud capabilities of the cluster.
- The *Developer Manual* has useful information for developers who would like to program with Bright Cluster Manager.
- The *OpenStack Deployment Manual* describes how to deploy OpenStack with Bright Cluster Manager
- The *Machine Learning Manual* describes how to install and configure machine learning capabilities with Bright Cluster Manager.



# 2

## Introduction

This chapter introduces some features of Bright Cluster Manager and describes a basic cluster in terms of its hardware.

### 2.1 What Is Bright Cluster Manager?

Bright Cluster Manager 8.2 is a cluster management application built on top of major Linux distributions.

#### 2.1.1 What OS Platforms Is It Available For?

It is available for:

- Red Hat Enterprise Linux Server, CentOS, and Scientific Linux
  - Versions 6.x
  - Versions 7.x
- SLES versions:
  - SUSE Enterprise Server 12
- Ubuntu versions:
  - Xenial Xerus 16.04
  - Bionic Beaver 18.04

#### 2.1.2 What Architectures Does It Run On?

Within the distributions listed in section 2.1.1, the Bright Cluster Manager application runs on the following architectures:

- on the x86\_64 architecture that is supported by Intel and AMD 64-bit CPUs
- on the arm64 (AArch64) architecture that is supported by ARMv8 CPUs

#### 2.1.3 What OS Platforms Can It Be Managed From?

While Bright Cluster Manager runs directly on the OS platforms listed in section 2.1.1, Bright Cluster Manager can be managed from many more OS platforms, when controlled by these front ends:

- Bright View (section 2.4 of the *Administrator Manual*): a GUI which conveniently runs on all modern web browsers, and therefore on all operating system versions that support a modern browser. This includes Microsoft Windows, MacOS and iOS, Linux, and Android.
- cmsh (section 2.5 of the *Administrator Manual*): an interactive shell front end that can be accessed from any computing device with a secured SSH terminal access

## 2.2 Cluster Structure

In its most basic form, a cluster running Bright Cluster Manager contains:

- One machine designated as the *head node*
- Several machines designated as *compute nodes*
- One or more (possibly managed) *Ethernet switches*
- One or more *power distribution units* (Optional)

The head node is the most important machine within a cluster because it controls all other devices, such as compute nodes, switches and power distribution units. Furthermore, the head node is also the host that all users (including the administrator) log in to in a default cluster. The head node is typically the only machine that is connected directly to the external network and is usually the only machine in a cluster that is equipped with a monitor and keyboard. The head node provides several vital services to the rest of the cluster, such as central data storage, workload management, user management, DNS and DHCP service. The head node in a cluster is also frequently referred to as the *master node*.

Often, the head node is replicated to a second head node, frequently called a passive head node. If the active head node fails, the passive head node can become active and take over. This is known as a high availability setup, and is a typical configuration (Chapter 14 of the *Administrator Manual*) in Bright Cluster Manager.

A cluster normally contains a considerable number of non-head, or *regular nodes*, also referred to simply as nodes. The head node, not surprisingly, manages these regular nodes over the network.

Most of the regular nodes are *compute nodes*. Compute nodes are the machines that will do the heavy work when a cluster is being used for large computations. In addition to compute nodes, larger clusters may have other types of nodes as well (e.g. storage nodes and login nodes). Nodes typically install automatically through the (network bootable) node provisioning system that is included with Bright Cluster Manager. Every time a compute node is started, the software installed on its local hard drive is synchronized automatically against a software image which resides on the head node. This ensures that a node can always be brought back to a “known state”. The node provisioning system greatly eases compute node administration and makes it trivial to replace an entire node in the event of hardware failure. Software changes need to be carried out only once (in the software image), and can easily be undone. In general, there will rarely be a need to log on to a compute node directly.

In most cases, a cluster has a private internal network, which is usually built from one or multiple managed Gigabit Ethernet switches, or made up of an InfiniBand or Omni-Path fabric. The internal network connects all nodes to the head node and to each other. Compute nodes use the internal network for booting, data storage and interprocess communication. In more advanced cluster setups, there may be several dedicated networks. It should be noted that the external network—which could be a university campus network, company network or the Internet—is not normally directly connected to the internal network. Instead, only the head node is connected to the external network.

Figure 2.1 illustrates a typical cluster network setup.

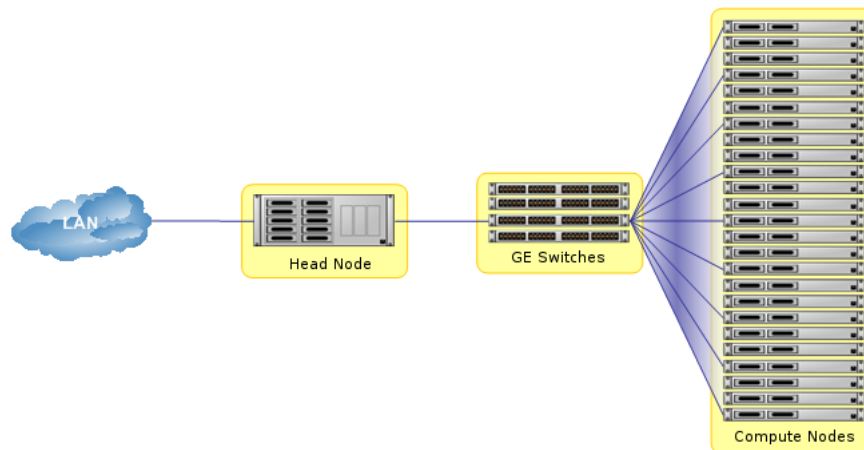


Figure 2.1: Cluster network

Most clusters are equipped with one or more power distribution units. These units supply power to all compute nodes and are also connected to the internal cluster network. The head node in a cluster can use the power control units to switch compute nodes on or off. From the head node, it is straightforward to power on/off a large number of compute nodes with a single command.



# 3

## Installing Bright Cluster Manager

This chapter describes in detail the installation of Bright Cluster Manager onto the head node of a cluster. Sections 3.1 and 3.2 list hardware requirements and supported hardware. Section 3.3.2 gives step-by-step instructions on installing Bright Cluster Manager from a DVD or USB drive onto a head node that has no operating system running on it initially, while section 3.4 gives instructions on installing onto a head node that already has an operating system running on it.

Once the head node is installed, the other, regular, nodes can (network) boot off the head node and provision themselves from it with a default image, without requiring a Linux distribution DVD or USB drive themselves. Regular nodes normally have any existing data wiped during the process of provisioning from the head node, which means that a faulty drive can normally simply be replaced by taking the regular node offline, replacing its drive, and then bringing the node back online, without special reconfiguration. The details of the network boot and provisioning process for the regular nodes are described in Chapter 5 of the *Administrator Manual*.

The installation of software on an already-configured cluster running Bright Cluster Manager is described in Chapter 11 of the *Administrator Manual*.

### 3.1 Minimal Hardware Requirements

The following are minimal hardware requirements, suitable for a cluster of one head node and two regular compute nodes:

#### 3.1.1 Head Node

- x86-64 or ARMv8 CPU
- 4GB RAM
- 80GB diskspace
- 2 Gigabit Ethernet NICs (for the most common Type 1 topology (section 3.3.7))
- DVD drive or USB drive

#### 3.1.2 Compute Nodes

- x86-64 or ARMv8 CPU
- 1GB RAM (at least 4GB is recommended for diskless nodes)
- 1 Gigabit Ethernet NIC

Recommended hardware requirements for larger clusters are discussed in detail in Appendix B.

## 3.2 Supported Hardware

The following hardware is supported:

### 3.2.1 Compute Nodes

- Asus
- Atos
- Cavium
- Cisco
- Cray
- Dell EMC
- Fujitsu
- HPE (Hewlett Packard Enterprise)
- Huawei
- IBM
- Lenovo
- NVIDIA DGX
- Oracle
- SuperMicro

Other brands are also expected to work, even if not explicitly supported.

### 3.2.2 Ethernet Switches

- Cisco
- Dell
- HP ProCurve
- Huawei
- Netgear
- Nortel
- SuperMicro

Other brands are also expected to work, although not explicitly supported.

### 3.2.3 Power Distribution Units

- APC (American Power Conversion) Switched Rack PDU

Other brands with the same SNMP MIB mappings are also expected to work, although not explicitly supported.

### 3.2.4 Management Controllers

- HP iLO 1/2/3
- iDRAC
- IPMI 1.5/2.0
- CIMC
- Redfish v1

### 3.2.5 InfiniBand

- Intel True Scale (formerly QLogic) InfiniBand switches
- Mellanox HCAs, and most other InfiniBand HCAs
- Mellanox, Voltaire, Flextronics InfiniBand switches
- Most other InfiniBand switches

### 3.2.6 GPUs

- AMD Radeon GPUs, as listed at <https://support.amd.com/en-us/kb-articles/Pages/Radeon-Software-for-Linux-Release-Notes.aspx>
- NVIDIA Tesla with latest recommended drivers
- NVIDIA GeForce and other older generations are mostly supported. Bright Computing can be consulted for details.
- NVIDIA DGX servers and workstations are supported.

### 3.2.7 MICs

- Xeon Phi: All Xeon Phi processor versions from Knights Landing onward. PCI-e coprocessor versions of Xeon Phi do not have direct integration with Bright Cluster Manager from Bright Cluster Manager version 8.2 onwards.

### 3.2.8 RAID

Software or hardware RAID are supported. Fake RAID is not regarded as a serious production option and is supported accordingly.

## 3.3 Head Node Installation: Bare Metal Method

A *bare metal* installation, that is, installing the head node onto a machine with no operating system on it already, is the recommended option. This is because it cannot run into issues from an existing configuration. An operating system from one of the ones listed in section 2.1 is installed during a bare metal installation. The alternative to a bare metal installation is the *add-on* installation of section 3.4.

Just to be clear, a bare metal installation can be a physical machine with nothing running on it, but it can also be a virtual machine—such as a VMware, VirtualBox, or KVM instance—with nothing running on it. Virtual instances may need some additional adjustment to ensure virtualization-related settings are dealt with correctly. Details on installing Bright Cluster Manager onto virtual instances can be found in the Bright Cluster Manager Knowledge Base at <http://kb.brightcomputing.com>.

To start a physical bare metal installation, the time in the BIOS of the head node is set to local time. The head node is then made to boot from DVD or USB, which can typically be done by appropriate keystrokes when the head node boots, or via a BIOS configuration.

**Special steps for installation from a bootable USB device:** If a bootable USB device is to be used, then the instructions within the Bright ISO, in the file `README.BRIGHTUSB` should be followed to copy the ISO image over to the USB device. After copying the ISO image, the MD5 checksum should be validated to verify that the copied ISO is not corrupt.

### 3.3.1 ISO Boot Menu

If booting from a DVD or USB drive, then a pre-installer menu called the *ISO boot menu* first loads up. The menu is automatically presented as either a BIOS (or UEFI legacy BIOS emulation) version, or as a UEFI version (figures 3.1 and 3.2) and effectively function in the same way.



Figure 3.1: Installation: ISO Boot Menu For Legacy BIOS



Figure 3.2: Installation: ISO Boot Menu For UEFI

The ISO Boot menu offers a default option of booting from the hard drive, with a countdown to starting the hard drive boot. To install Bright Cluster Manager cluster manager, the countdown should be interrupted by selecting the option of “Install Bright Cluster Manager (Graphical)” instead.

Selecting the option allows kernel parameter options to be provided to the installer.

Default kernel parameter options are provided so that the administrator can simply press the enter key to go straight on to start the installer, and bring up the welcome screen (section 3.3.2).



**Optional: The `netconf` Custom Kernel Parameter**

A non-default kernel parameter option is `netconf`. Setting configuration values for this option configures login and network settings for the cluster manager, and also means that SSH and VNC servers are launched as the welcome screen (section 3.3.2) of the Bright Cluster Manager installer starts up. This then allows the cluster administrator to carry out a remote installation, instead of having to remain at the console.

The `netconf` custom kernel parameter requires 3 settings:

1. a setting for the external network interface that is to be used. For example: `eth0` or `eth1`.
2. a setting for the network configuration of the external network, to be explained soon. The network configuration option can be built either using static IP addressing or with DHCP.
  - For static IP addressing, the network configuration format is comma-separated:  
`static,<IP address>,<gateway address>,<netmask>`
  - For DHCP addressing, the format is simply specified using the string `dhcp`.
3. a setting for the password, for example `secretpass`, for the login to the cluster manager that is about to be installed.

**Example**

With static IP addressing:

```
netconf=eth0:static:10.141.161.253,10.141.255.254,255.255.0.0:secretpass
```

**Example**

With DHCP addressing:

```
netconf=eth0:dhcp:secretpass
```

**3.3.2 Welcome Screen**

The welcome screen (figure 3.3) displays version and license information. Two installation modes are available: normal mode and express mode.

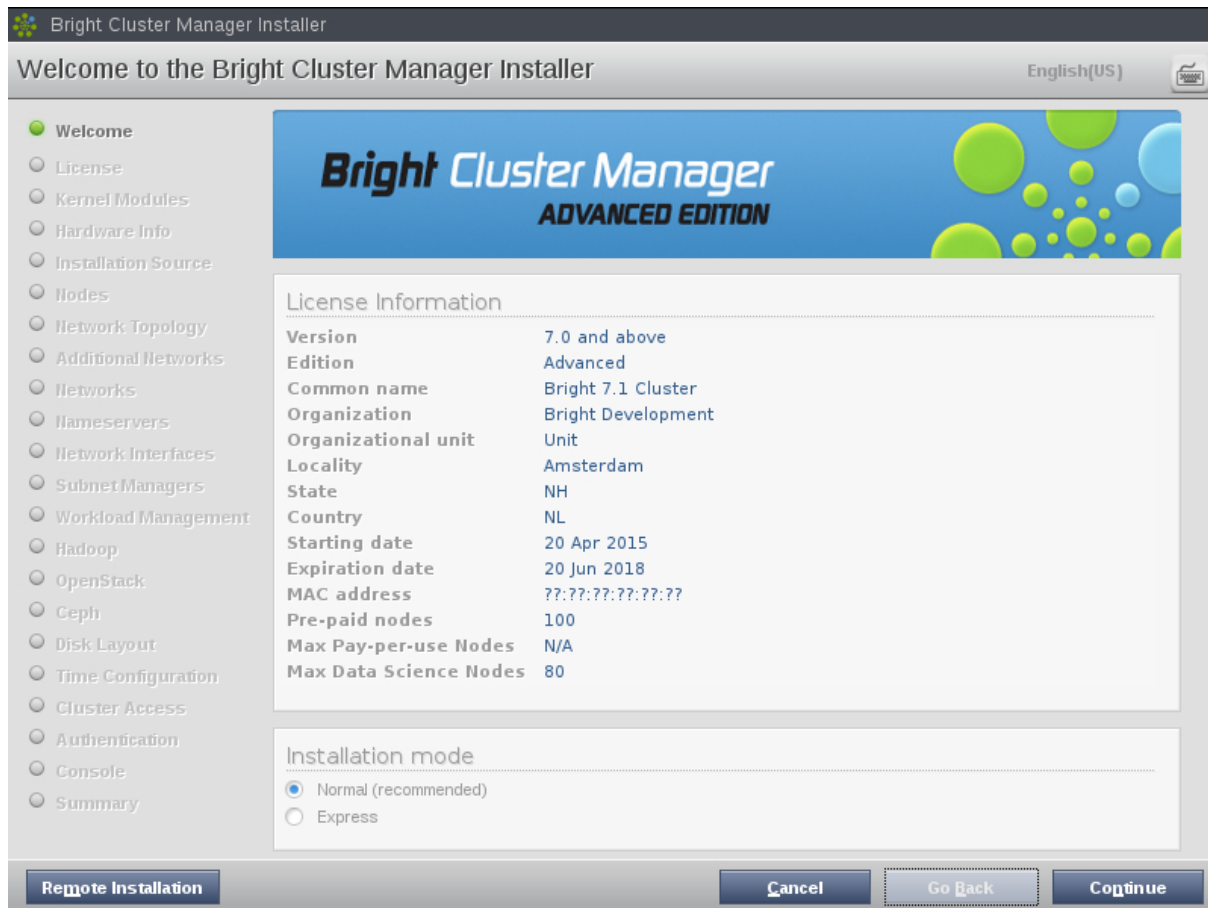


Figure 3.3: Installation welcome screen for Bright Cluster Manager

**Express mode behavior:** Selecting express mode installs the head node with the predefined configuration that the ISO image was created with. Express mode installation has the following behavior:

- The administrator password that is automatically set when express mode is selected is: `system`. Keeping that as a password is unwise for almost all use cases, so it should almost always be changed.
- A path to an XML build configuration file can be set via a pop-up. The path is `/cm/build-config.xml` by default.
- If the disk setup is left unconfigured in the build configuration file, then a disk setup screen appears.

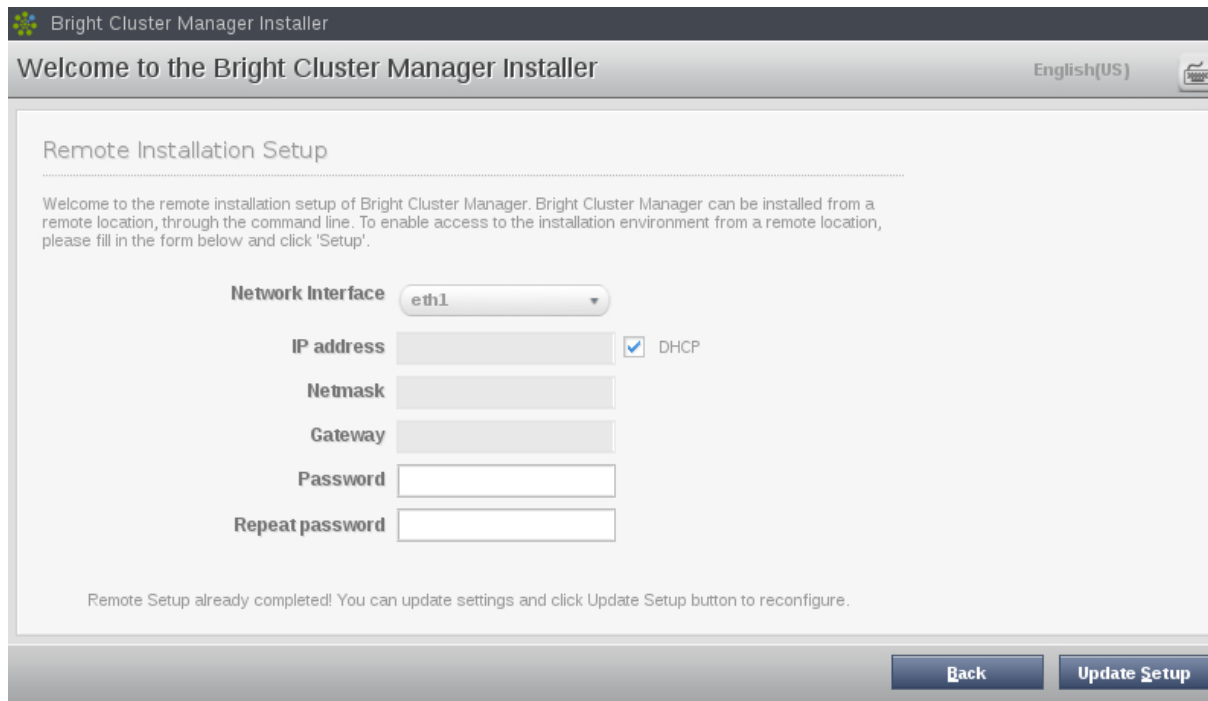
#### Alternative Installation Method: Remote Installation Button For Installation Via SSH Or VNC

At the welcome screen stage it is possible to continue installing while physically present at the head node. However it is possible to continue the installation remotely via the **Remote Installation** button from this point onwards. Remote installation is convenient for administrators who prefer to minimize the time they spend being physically at the head node. For example, if the head node is in a noisy data center.

Remote installation can also be configured earlier on than the welcome screen stage, during the ISO boot menu stage (figures 3.1 and 3.2) if the `netconf` kernel parameter (page 19) is used. If `netconf` has been set correctly, then remote access is already possible to the head node via SSH or VNC at the welcome screen stage, and remote installation can be already be carried out.

**No earlier configuration via netconf:** If the `netconf` parameter has not been set earlier on, then clicking the Remote Installation button displays a screen prompting for the network interface configuration and a password. These can be filled in at the console.

**Earlier configuration via netconf:** If the `netconf` parameter has been set earlier on, then clicking the Remote Installation button displays a similar screen (figure 3.4) prompting for the network interface configuration and a password, but pre-filled with the values set earlier via `netconf`. Errors are displayed here, and modifications can be carried out here.



The screenshot shows the 'Bright Cluster Manager Installer' window. The title bar says 'Welcome to the Bright Cluster Manager Installer' and 'English(US)'. The main content area is titled 'Remote Installation Setup'. It contains a welcome message: 'Welcome to the remote installation setup of Bright Cluster Manager. Bright Cluster Manager can be installed from a remote location, through the command line. To enable access to the installation environment from a remote location, please fill in the form below and click "Setup".' Below this is a form with the following fields: 'Network Interface' (a dropdown menu showing 'eth1'), 'IP address' (a text box with a checked 'DHCP' checkbox), 'Netmask' (a text box), 'Gateway' (a text box), 'Password' (a text box), and 'Repeat password' (a text box). At the bottom of the form area, it says 'Remote Setup already completed! You can update settings and click Update Setup button to reconfigure.' At the bottom right of the window are two buttons: 'Back' and 'Update Setup'.

Figure 3.4: Remote Installation: Network Configuration And Password Inputs Screen

Once appropriate interface, network, and password values have been set, then clicking on the Update Setup button goes on to start up or restart the SSH and VNC servers, and displays a screen that explains how to use VNC or SSH to access the head node remotely (figure 3.5).



Figure 3.5: Remote Installation: VNC and SSH access explanation

#### The remote installation access options:

- VNC client access allows a GUI connection from a remote location running to the host. The GUI is then the same GUI as is provided on the console during a normal installation, except that it can be controlled over VNC.
- SSH client access allows a non-GUI, text-based connection from a remote location to the host.
  - It allows an Ncurses installer, `cm-installer-nonnx`, to be run. This can install a basic cluster on the head node. The Ncurses option is not a preferred installation option, because it does not provide all the options of the GUI installation option, and because it is not as user-friendly. It is provided as a fallback method in case the GUI installation fails for some reason, but the host still has a working network configuration. Extra features that are missing from the Ncurses installation, but exist in the GUI installation, can be added manually after the Ncurses-based installation is complete.
  - If there is a need to install the cluster in text mode with some more complicated configuration, or for example from the configuration file used by another cluster manager, then the associated custom configuration file `/cm/build-config.xml` can be used. The command to install the cluster with that configuration is then carried out with: `/cm/cm-master-install -config /cm/build-config.xml`.

Out of these remote installation options, the VNC-based GUI installation option is the recommended option to install the head node of the cluster.

If the Remote Installation button of figure 3.3 is not clicked, then clicking on the Continue button instead brings up the Bright Cluster Manager software license screen, described next.

### 3.3.3 Software License

The “Bright Computing Software License” screen (figure 3.6) explains the applicable terms and conditions that apply to use of the Bright Cluster Manager software.

Accepting the terms and conditions, and clicking on the Continue button leads to the Base Distribution EULA (End User License Agreement) (figure 3.7).

Accepting the terms and conditions of the base distribution EULA, and clicking on the Continue button leads to two possibilities.

1. If express mode was selected earlier, and no disk setup information has been predefined, then the installer skips ahead to the Disk Partitioning And Layouts screen (page 44), where the partitioning and layout of the head node can be set. After that, it goes on to the Summary screen (figure 3.35), where it shows an overview of the predefined and just-defined installation parameters, and awaits user input to start the install.
2. Otherwise, if normal installation mode was selected earlier, then the “Kernel Modules” configuration screen is displayed, described next.

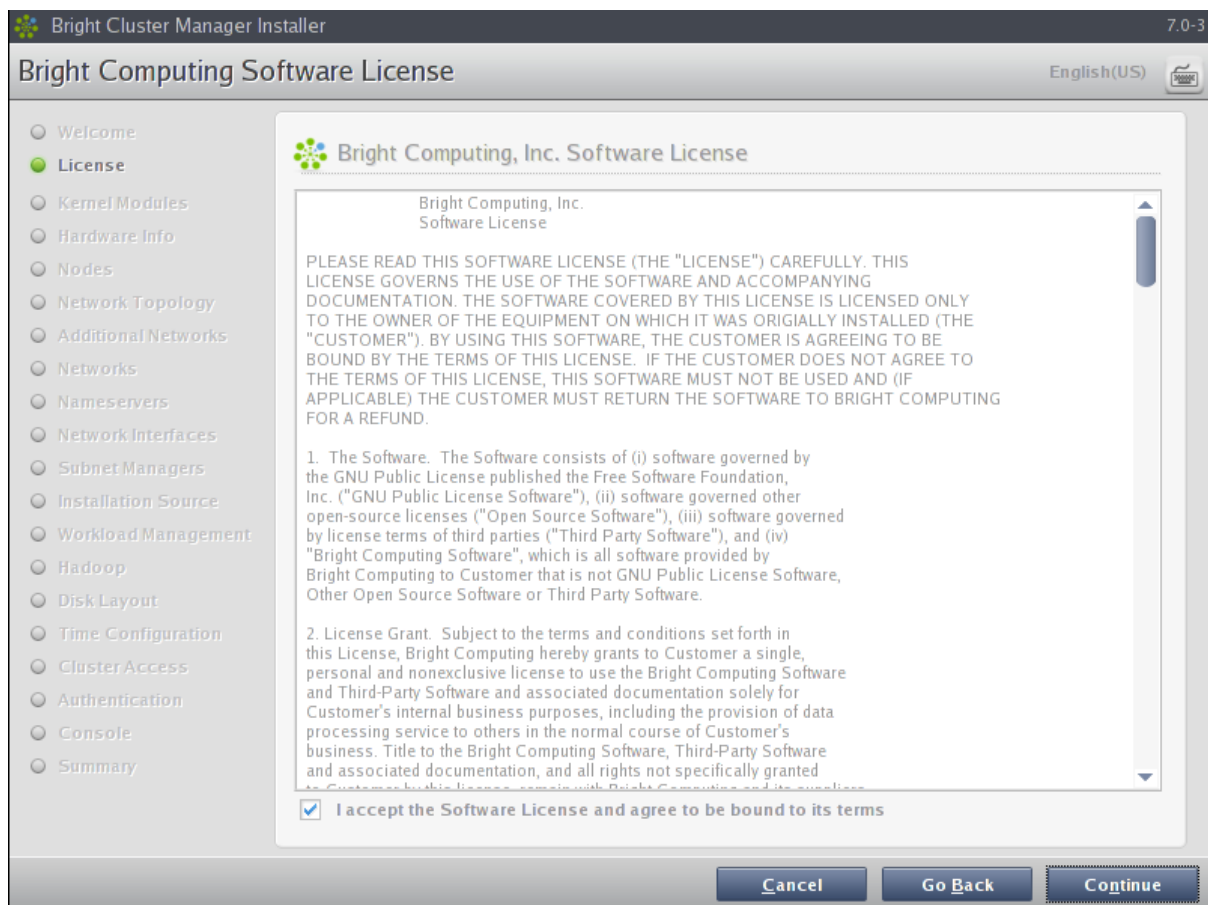


Figure 3.6: Bright Cluster Manager Software License

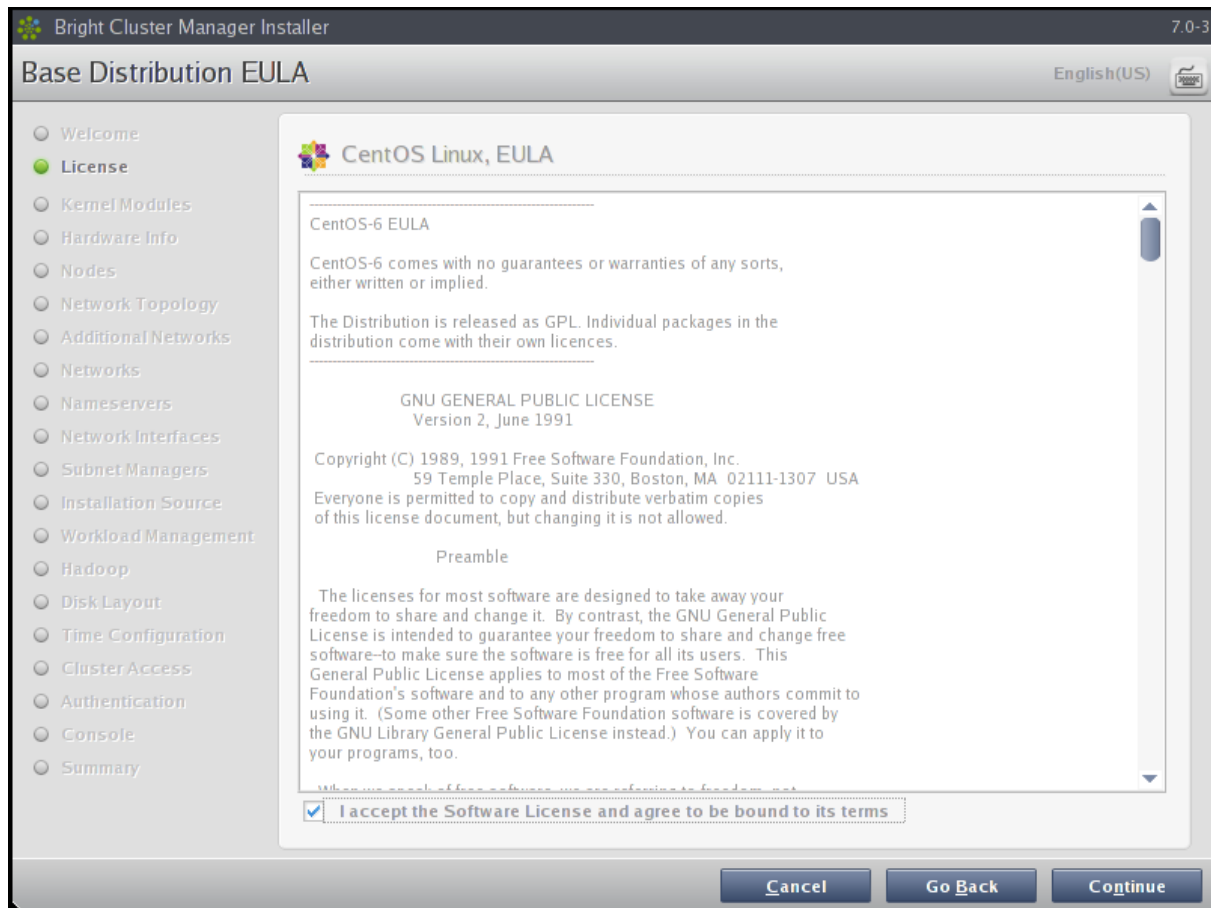


Figure 3.7: Base Distribution End User License Agreement

### 3.3.4 Kernel Modules Configuration

The Kernel Modules screen (figure 3.8) shows the kernel modules recommended for loading based on hardware auto-detection.

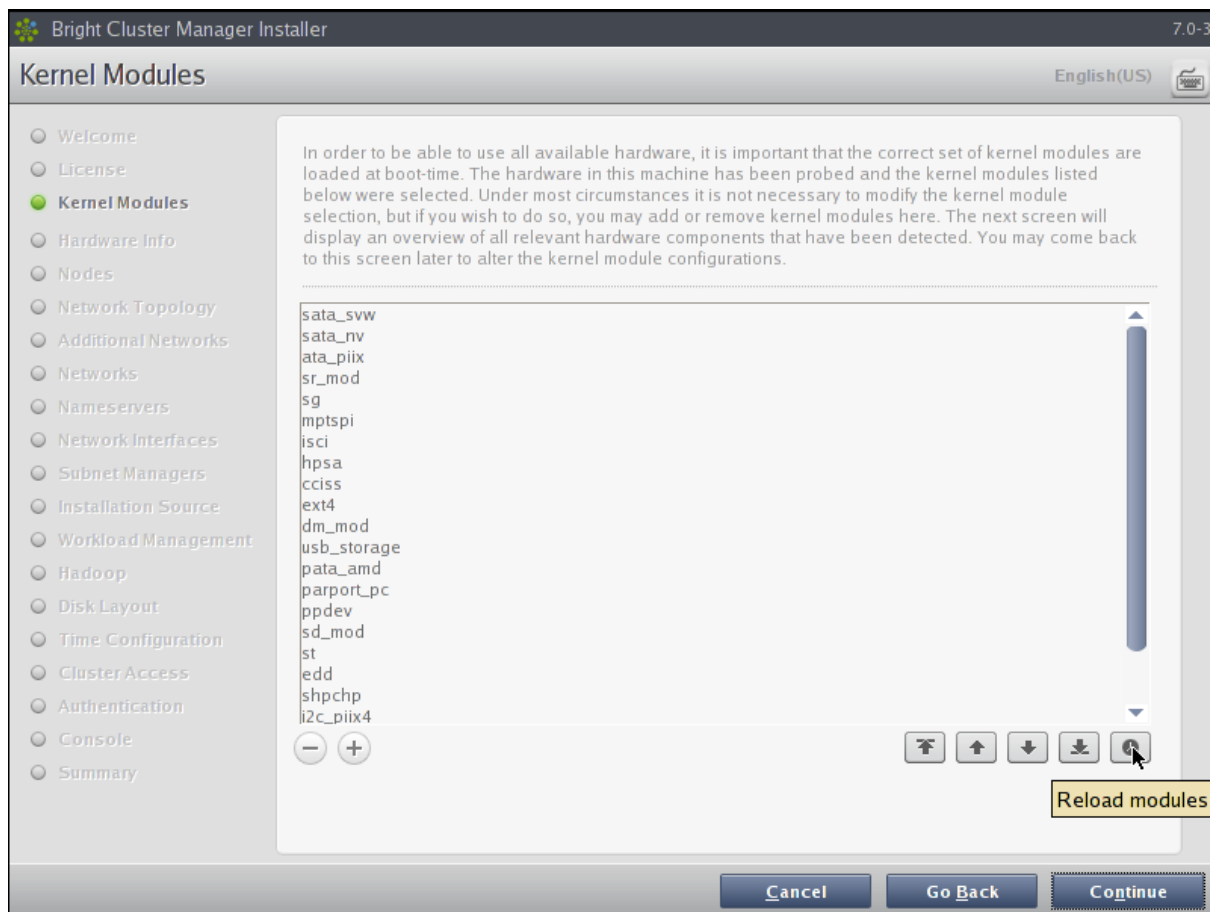


Figure 3.8: Kernel Modules Recommended For Loading After Probing

Changes to the modules to be loaded can be entered by reordering the loading order of modules, by removing modules, and adding new modules. Clicking the  $\oplus$  button opens an input box for adding a module name and optional module parameters (figure 3.9). The module can be selected from a built-in; it can be automatically extracted from a .deb or .rpm package; or it can simply be selected by selecting an available .ko kernel module file from the filesystem.

A module can also be blacklisted, which means it is prevented from being used. This can be useful when replacing one module with another.

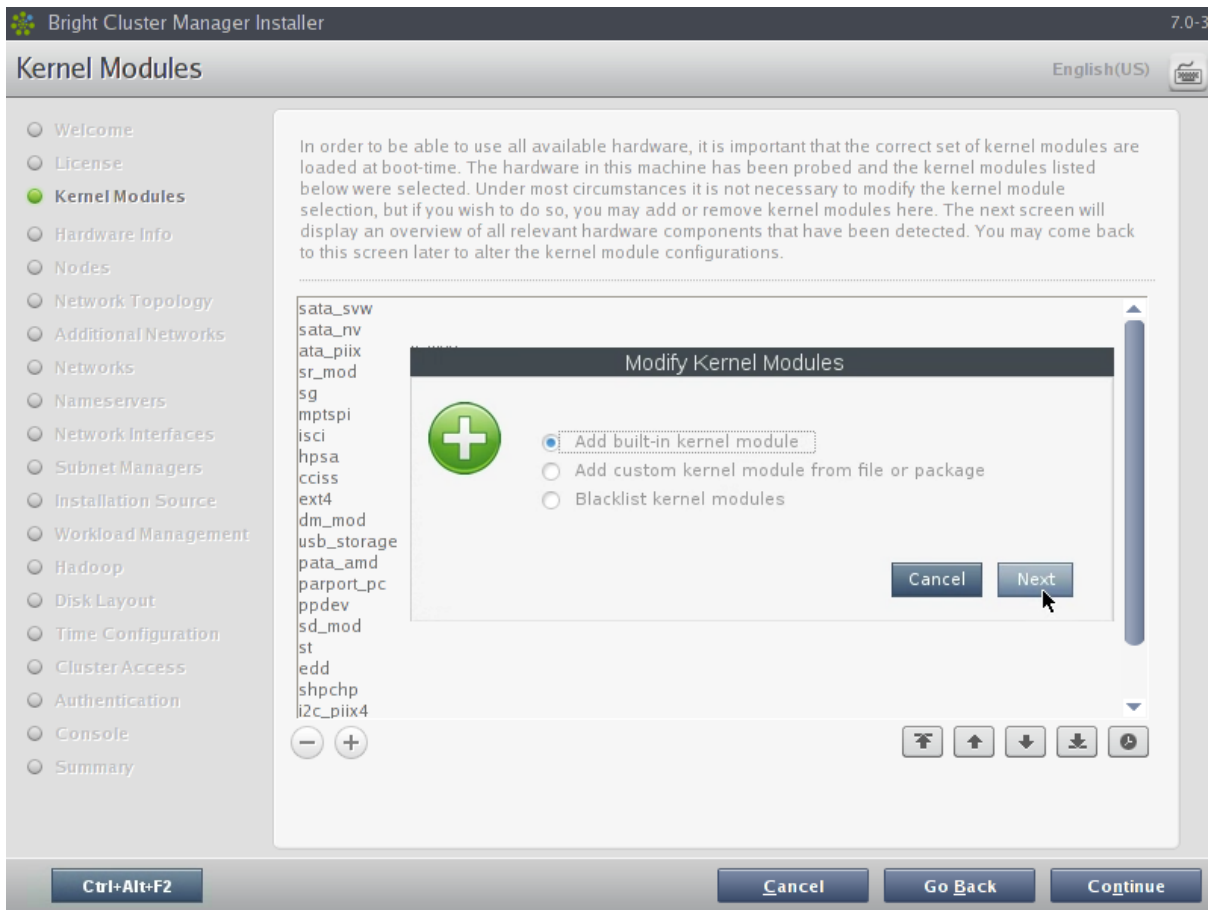


Figure 3.9: Adding Kernel Modules

Similarly, the ⊖ button removes a selected module from the list. The arrow buttons move a kernel module up or down in the list. Kernel module loading order decides the exact name assigned to a device (e.g. sda, sdb, eth0, eth1).

After optionally adding or removing kernel modules, clicking the reload button shows the modules list that will then be implemented.

Clicking Continue then leads to the “Hardware Information” overview screen, described next.

### 3.3.5 Hardware Overview

The “Hardware Information” screen (figure 3.10) provides an overview of detected hardware depending on the kernel modules that have been loaded. If any hardware is not detected at this stage, the “Go Back” button is used to go back to the “Kernel Modules” screen (figure 3.8) to add the appropriate modules, and then the “Hardware Information” screen is returned to, to see if the hardware has been detected. Clicking Continue in this screen leads to the Nodes configuration screen, described next.



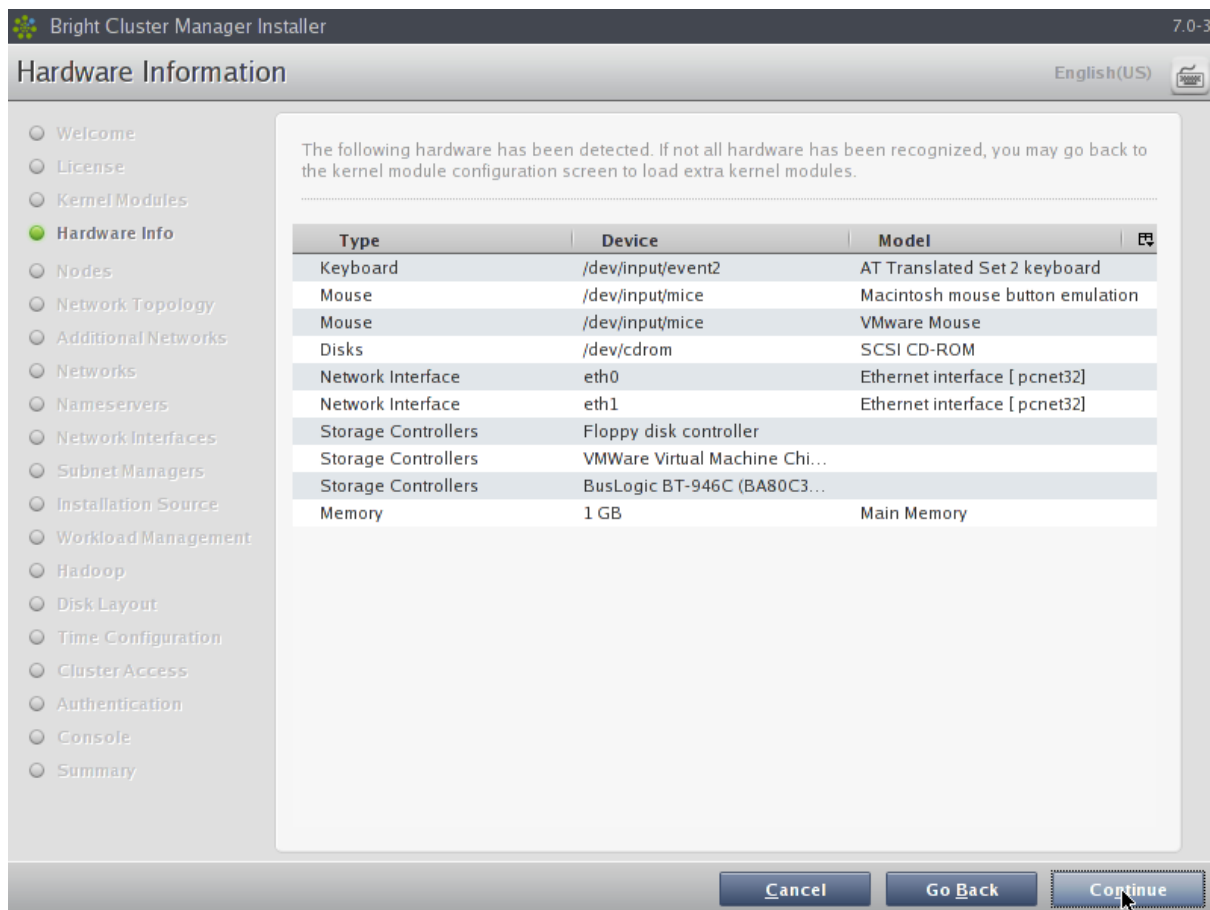


Figure 3.10: Hardware Overview Based On Loaded Kernel Modules

### 3.3.6 Nodes Configuration

The Nodes screen (figure 3.11) configures the number of racks, the number of regular nodes, the node basename, the number of digits for nodes, and the hardware manufacturer.

The maximum number of digits is 5, to keep the hostname reasonably readable.

The “Node Hardware Manufacturer” selection option initializes any monitoring parameters relevant for that manufacturer’s hardware. If the manufacturer is not known, then Other is selected from the list.

Clicking Continue in this screen leads to the “Network Topology” selection screen, described next.

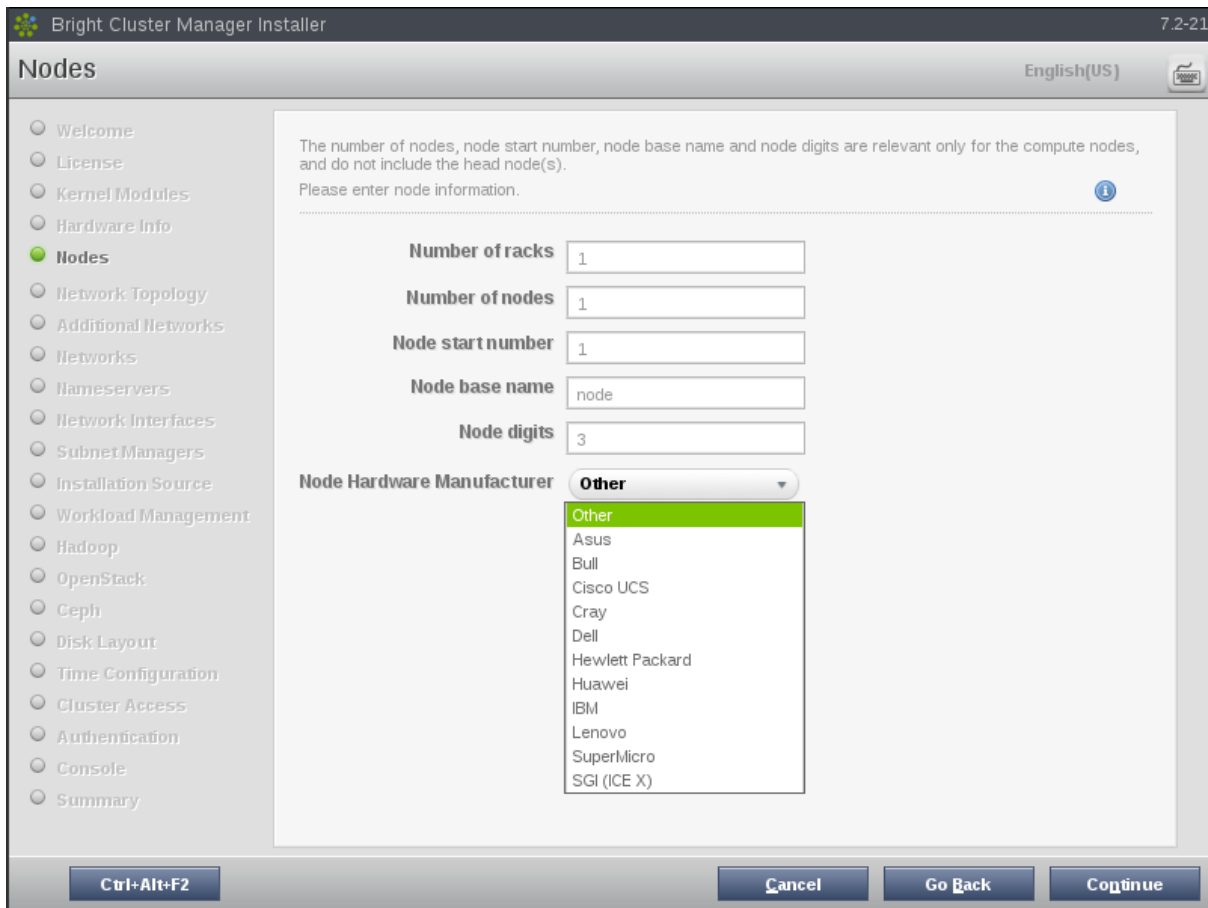


Figure 3.11: Nodes Configuration

### 3.3.7 Network Topology

Regular nodes are always located on an internal network, by default called `Internalnet`.

The “Network Topology” screen allows selection of one of three different network topologies.

A *type 1* network (figure 3.12), with nodes connected on a private internal network. This is the default network setup. In this topology, a network packet from a head or regular node destined for any external network that the cluster is attached to, by default called `Externalnet`, can only reach the external network by being routed and forwarded at the head node itself. The packet routing for `Externalnet` is configured at the head node.

A *type 2* network (figure 3.13) has its nodes connected via a router to a public network. In this topology, a network packet from a regular node destined for outside the cluster does not go via the head node, but uses the router to reach a public network. Packets destined for the head node however still go directly to the head node. Any routing for beyond the router is configured on the router, and not on the cluster or its parts. Care should be taken to avoid DHCP conflicts between the DHCP server on the head node and any existing DHCP server on the internal network if the cluster is being placed within an existing corporate network that is also part of `Internalnet` (there is no `Externalnet` in this topology). Typically, in the case where the cluster becomes part of an existing network, there is another router configured and placed between the regular corporate machines and the cluster nodes to shield them from effects on each other.

A *type 3* network (figure 3.14), with nodes connected on a routed public network. In this topology, a network packet from a regular node, destined for another network, uses a router to get to it. The head node, being on another network, can only be reached via a router too. The network

the regular nodes are on is called `Internalnet` by default, and the network the head node is on is called `Managementnet` by default. Any routing configuration for beyond the routers that are attached to the `Internalnet` and `Managementnet` networks is configured on the routers, and not on the clusters or its parts.

Selecting the network topology helps decide the predefined networks on the Networks settings screen later (figure 3.20). Clicking `Continue` here leads to the “Additional Network Configuration” screen, described next.

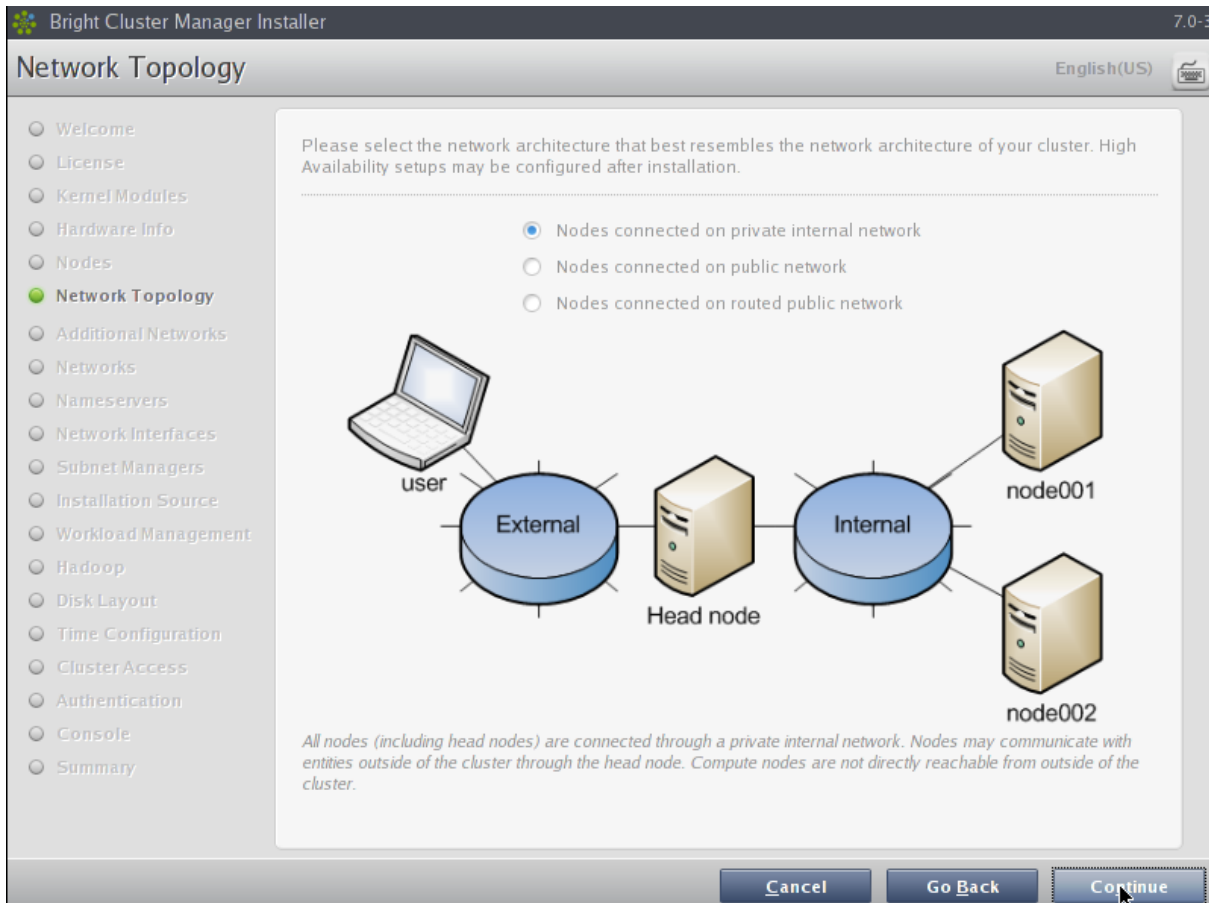


Figure 3.12: Networks Topology: nodes connected on a private internal network

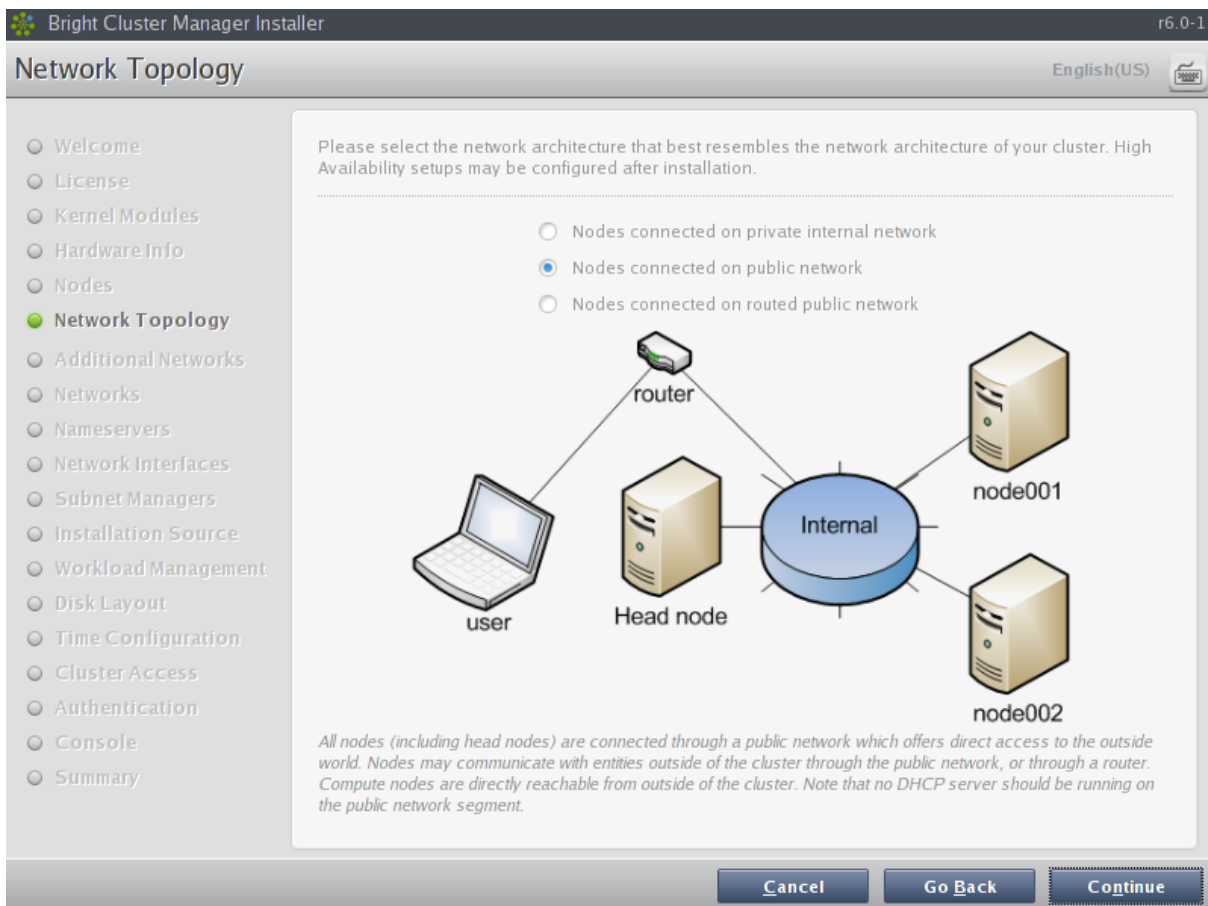


Figure 3.13: Networks Topology: nodes connected via router to a public network

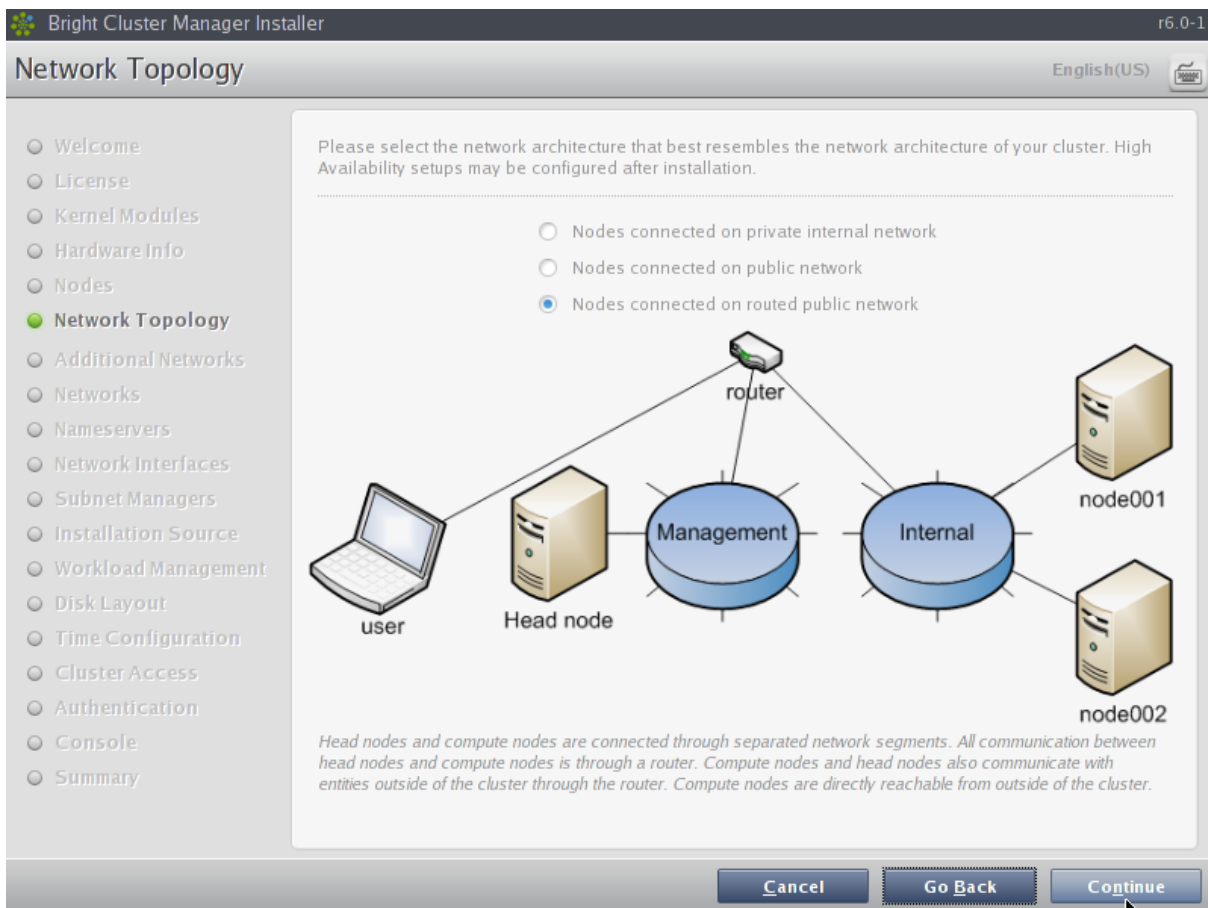


Figure 3.14: Network Topology: nodes connected on a routed public network

### 3.3.8 Additional Network Configuration

The “Additional Network Configuration” screen (figure 3.15) allows the configuration of the following extra networks:

1. additional high speed interconnect networks
2. BMC networks

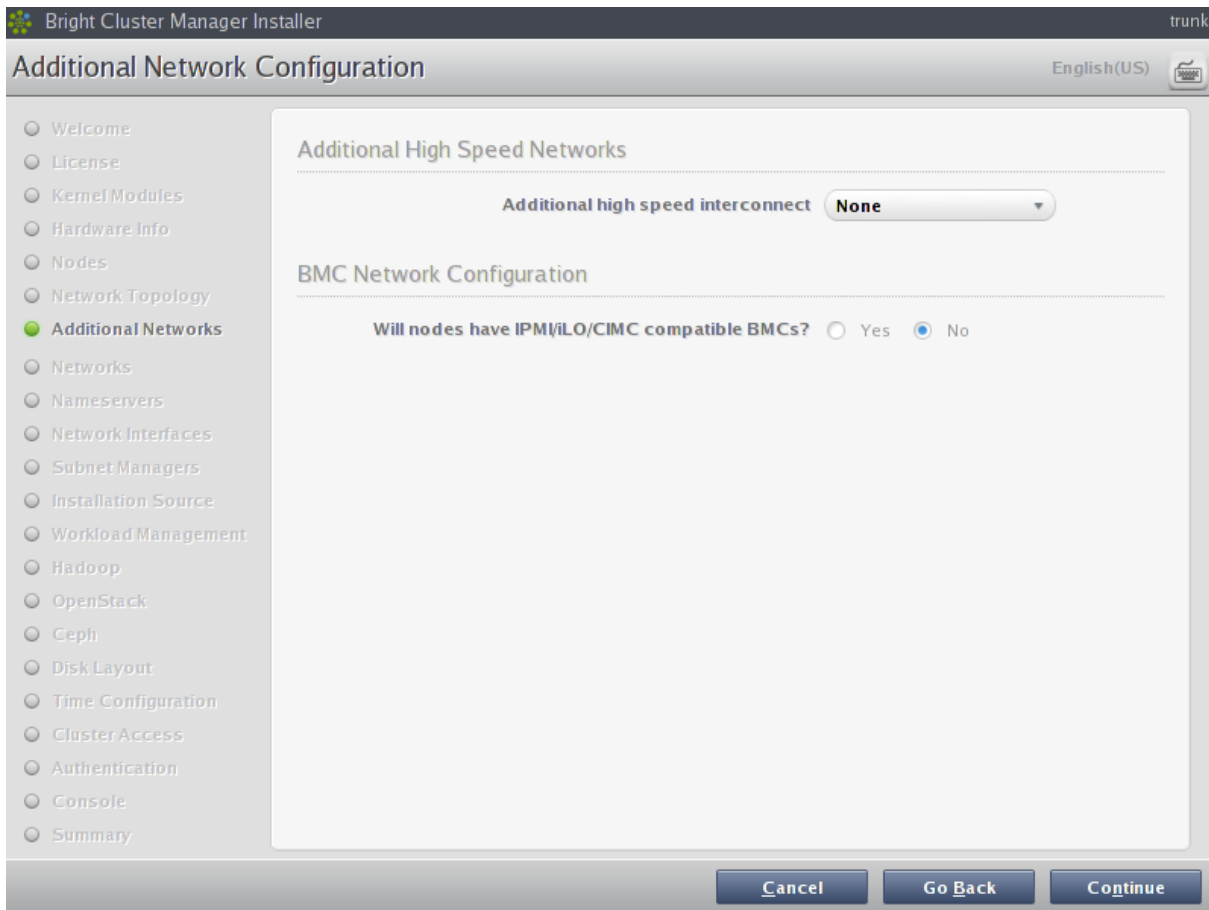


Figure 3.15: Additional Network Configuration: OFED and BMC Networking

- **Additional High Speed Networks:** The Additional high speed interconnect selector options configure the compute nodes so that they communicate quickly with each other while running computational workload jobs.

The choices include 10/40 Gig-E, Omni-Path, and InfiniBand RDMA OFED (figure 3.16).

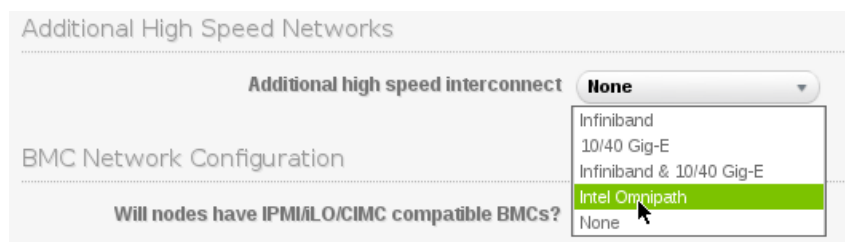


Figure 3.16: Additional Network Configuration: Interconnect Interface

The regular nodes of a cluster can be set to boot over the chosen option in all these three cases.

The Omni-Path choice appears only if the OPA software stack has been included on the Bright Cluster Manager installation medium.

- **Interconnect choice: Infiniband choices:** If InfiniBand is chosen in the screen of figure 3.16, then the OFED stack driver menu options are a choice between Mellanox versions, Intel True Scale (formerly QLogic), or the default parent distribution version (figure 3.17).

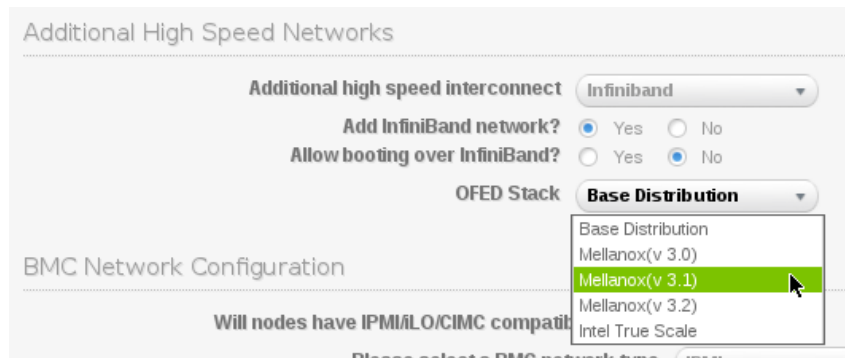


Figure 3.17: Additional Network Configuration: OFED stack

Currently, choosing the parent distribution stack is recommended, at least when first setting up a cluster, because it tends to be integrated better with the operating system. OFED installation is discussed further in section 7.6.

- **Interconnect choice: Omni-Path choices:** If Omni-Path is chosen in the screen of figure 3.16, then the OFED stack driver menu option shows the Intel OPA software stack (figure 3.18), if the stack has been included on the Bright Cluster Manager installation medium.

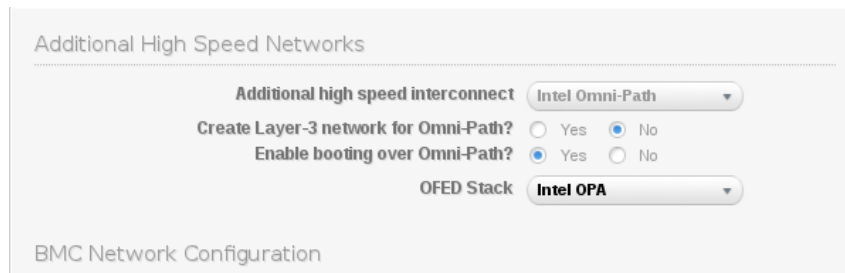


Figure 3.18: Additional Network Configuration: OPA stack

- **BMC Network Configuration:** If the administrator confirms that the nodes are to use BMCs (Base-board Management Controllers) that are compatible with IPMI, iLO, CIMC, iDRAC, or Redfish, then the BMC network options appear (figure 3.19).

**Additional Network Configuration** English(US)

- Welcome
- License
- Kernel Modules
- Hardware Info
- Nodes
- Network Topology
- Additional Networks**
- Networks
- Nameservers
- Network Interfaces
- Subnet Managers
- Installation Source
- Workload Management
- Hadoop
- OpenStack
- Ceph
- Disk Layout
- Time Configuration
- Cluster Access
- Authentication
- Console
- Summary

**Additional High Speed Networks**

Additional high speed interconnect None

**BMC Network Configuration**

Will nodes have IPMI/iLO/CIMC compatible BMCs? ☒ Yes ☐ No

Please select a BMC network type CIMC

To which Ethernet segment are the BMCs connected? Other

Create new layer-3 network (i.e. IP subnet) for BMC interfaces? ☒ Yes ☐ No

Use DHCP to obtain BMC IP addresses? ☒ Yes ☐ No

Will the head node use a dedicated interface to reach the IPMI subnet? ☒ Yes ☐ No

Automatically configure BMC when node boots? ☒ Yes ☐ No

Cancel Go Back Continue

Figure 3.19: Additional Network Configuration: BMC Network

These options configure the BMC network for the regular nodes:

- IPMI, iLO, CIMC, iDRAC, or Redfish: sets the BMC network type.
  - External Network, Internal Network, or Other: sets whether the ethernet segment that the BMCs connect with is the internal network, the external network, or another network.
- Depending on the assigned ethernet segment, further settings can be specified as indicated by the following table:



Setting	Ethernet Segment		
	Internal	External	Other
Create new layer-3 BMC subnet?	Yes/No	<i>Not applicable</i>	Yes
Use DHCP for BMC?	<i>Not applicable</i>	Yes/No	Yes/No
Dedicate head node interface for BMC?	Yes/No	Yes/No	Yes/No
Automatically Configure BMC On Node Boot?	Yes/no	Yes/No	Yes/No

If a BMC is to be used, then the BMC password is set to a random value. Retrieving and changing a BMC password is covered in section 3.7.2 of the *Administrator Manual*. BMC configuration is discussed further in section 3.7 of the *Administrator Manual*.

The remaining options—adding the network, and automatically configuring the network—can then be set.

Clicking the Continue button shown in figure 3.15 or figure 3.19 leads to the Networks configuration screen, described next.

### 3.3.9 Networks Configuration

The Networks configuration screen (figure 3.20) displays the predefined list of networks, based on the selected network topology. BMC and high speed interconnect networks are defined based on selections made in the “Additional Network Configuration” screen earlier (figure 3.15).

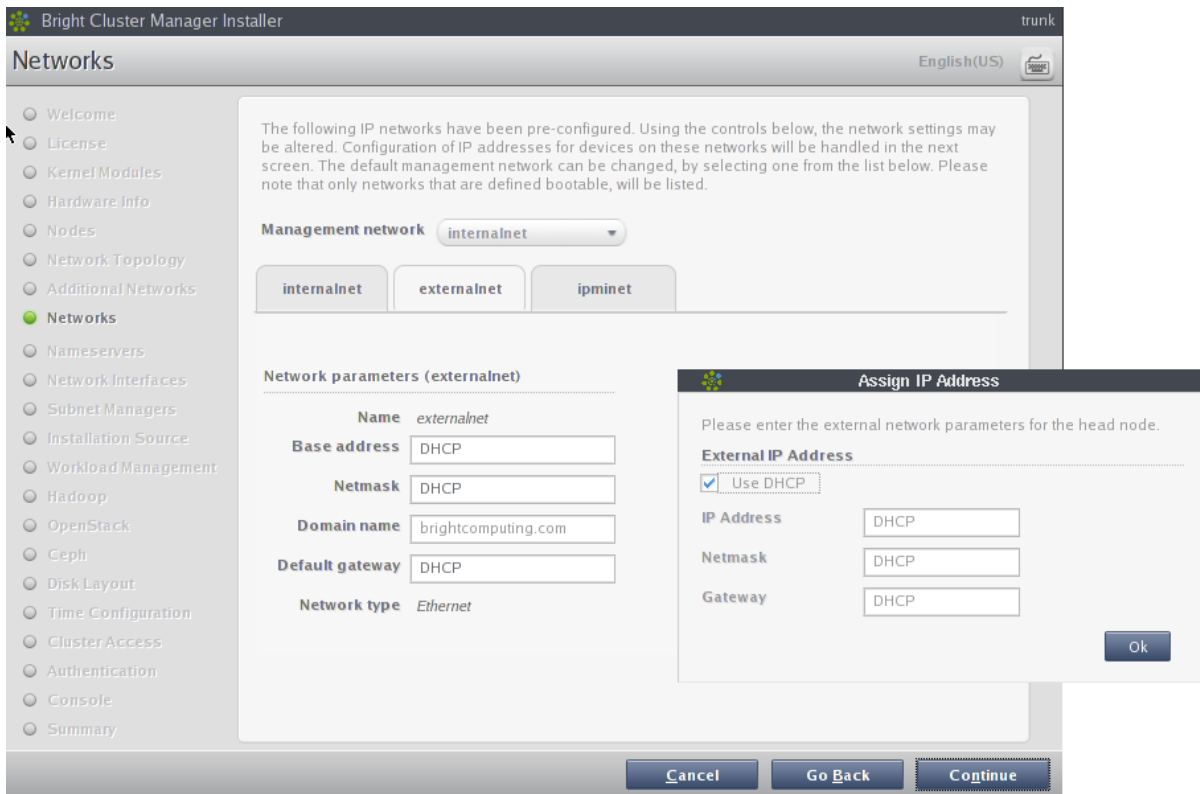


Figure 3.20: Networks Configuration

The parameters of the network interfaces can be configured in this screen.

For a *type 1* setup, an external network and an internal network are always defined.

For a *type 2* setup only an internal network is defined and no external network is defined.

For a *type 3* setup, an internal network and a management network are defined.

A pop-up screen is used to help fill these values in for a type 1 network. The values can be provided via DHCP, but usually static values are used in production systems to avoid confusion. The pop-up screen asks for IP address details for the external network, where the network `externalnet` corresponds to the site network that the cluster resides in (e.g. a corporate or campus network). The IP address details are therefore the details of the head node for a type 1 `externalnet` network (figure 3.12).

Clicking Continue in this screen validates all network settings. Invalid settings for any of the defined networks cause an alert to be displayed, explaining the error. A correction is then needed to proceed further.

If all settings are valid, the installation proceeds on to the Nameservers screen, described in the next section.

### 3.3.10 Nameservers And Search Domains

Search domains and external name servers can be added or removed using the Nameservers screen (figure 3.21). Using an external name server is recommended. Clicking on Continue leads to the “Network Interfaces” configuration screen, described next.

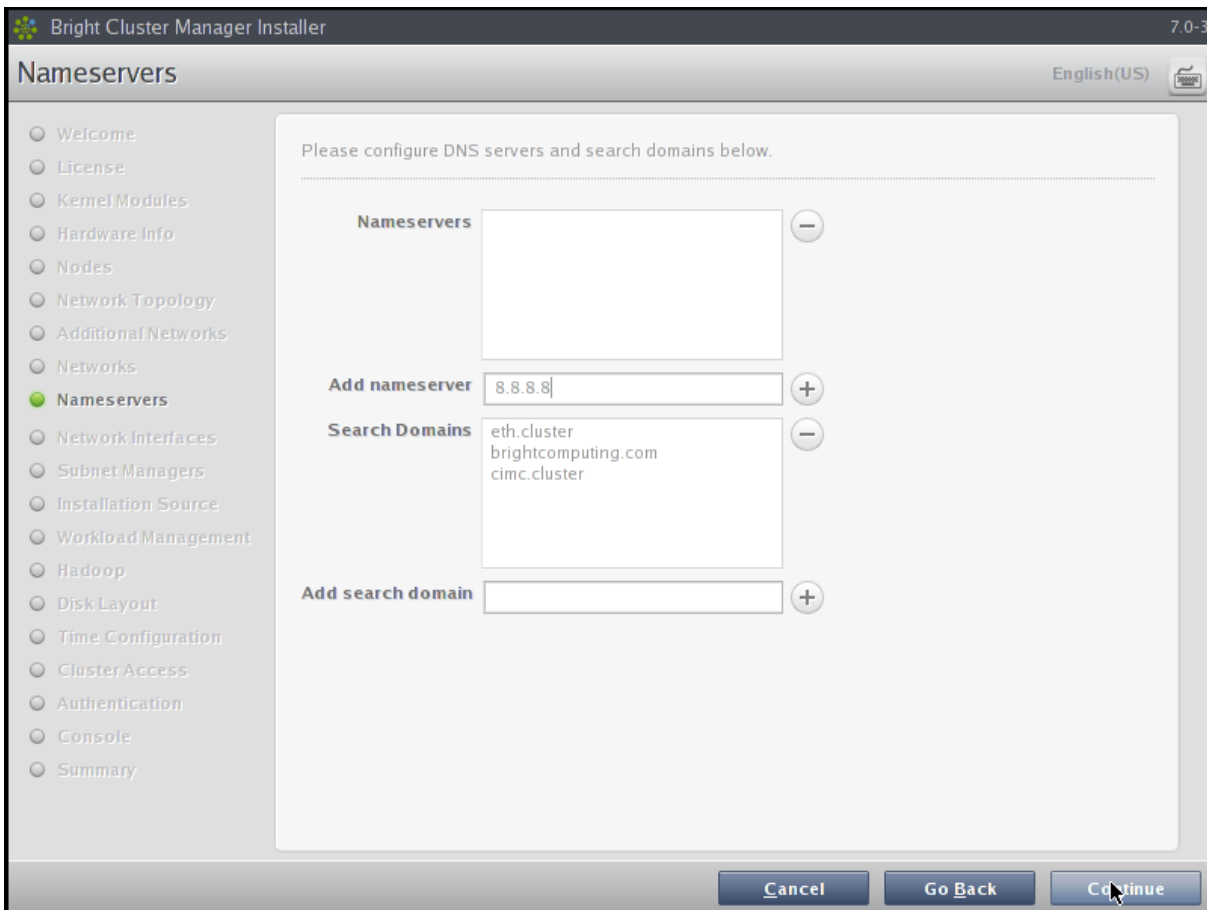


Figure 3.21: Nameservers and search domains

### 3.3.11 Network Interfaces Configuration

The “Network Interfaces” screen (figure 3.22) allows a review of the list of network interfaces with their proposed settings. The head node and regular nodes each have a settings pane for their network configurations. If a BMC network is to be shared with a regular network—which an option in the screen shown in figure 3.19—then an alias interface is shown too. In figure 3.22 an alias interface, `eth0:ipmi`, is shown.

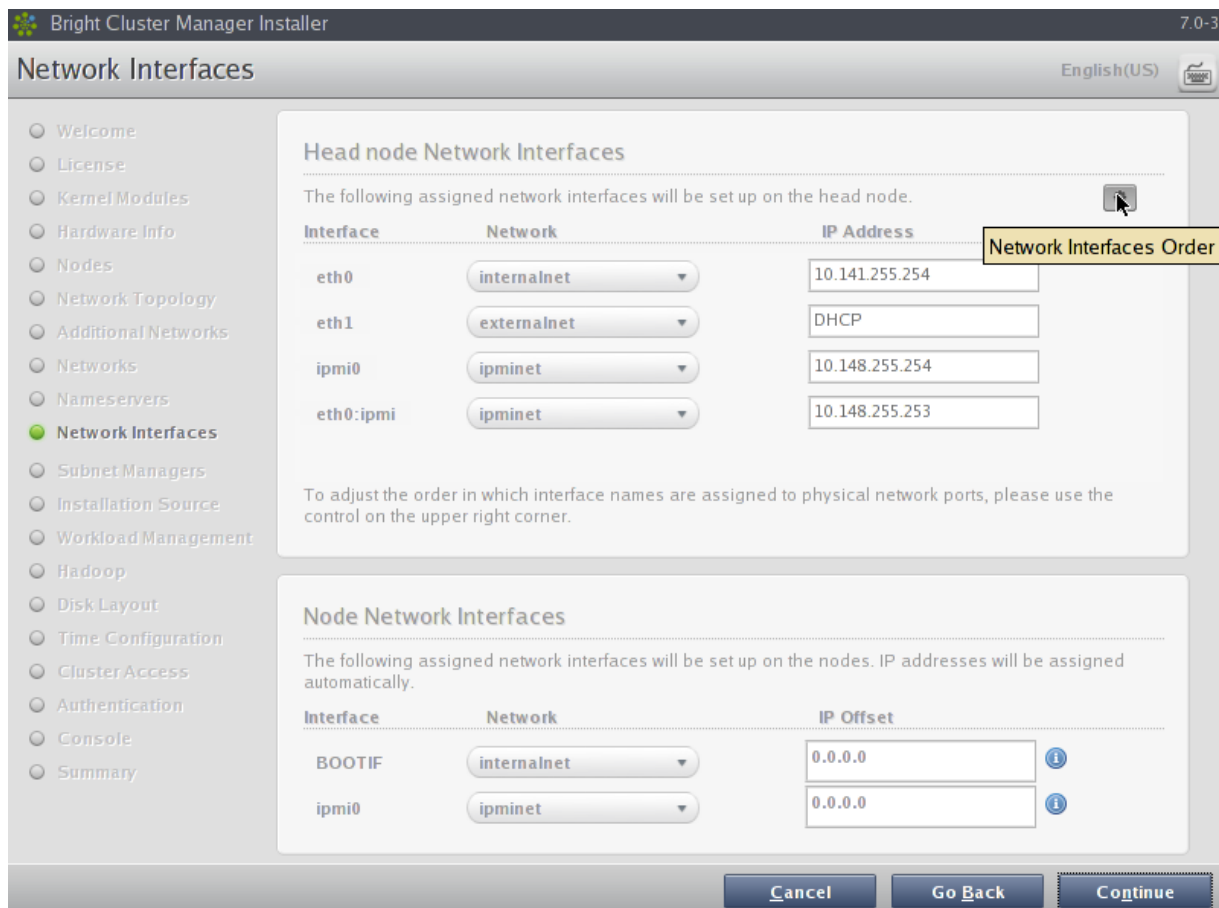


Figure 3.22: Network Interface Configuration

An icon in the Head Node Interfaces section, where the hover text is showing in the figure, allows the Ethernet network interface order to be changed on the head node. For example, if the interfaces with the names eth0 and eth1 need to be swapped around, clicking on the icon brings up a screen allowing the names to be associated with specific MAC addresses (figure 3.23).

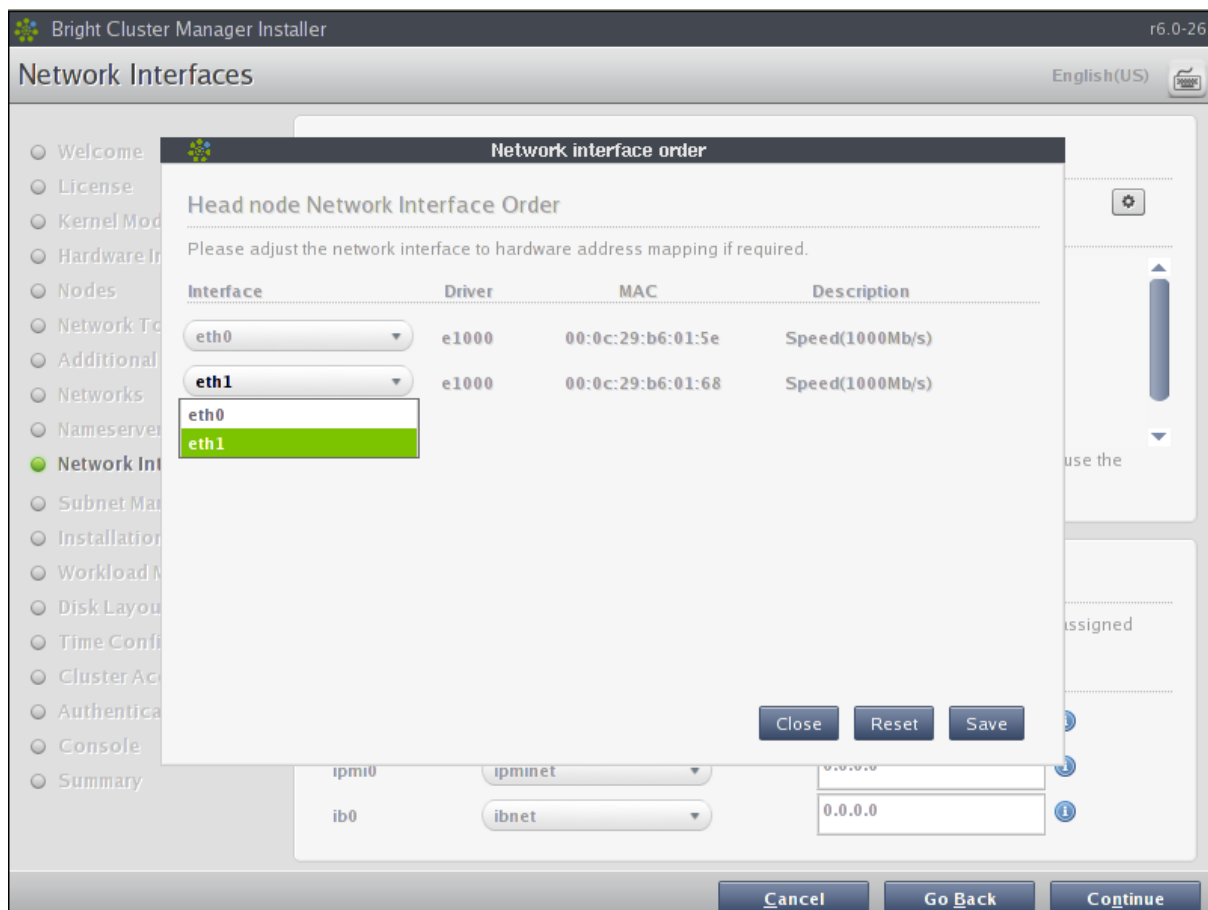


Figure 3.23: Network Interface Configuration Order Changing

For the node network interfaces of figure 3.22, the *IP offset* can be modified.<sup>1</sup>

A different network can be selected for each interface using the drop-down box in the Network column. Selecting Unassigned disables a network interface.

If the corresponding network settings are changed (e.g., base address of the network) the IP address of the head node interface needs to be modified accordingly. If IP address settings are invalid, an alert is displayed, explaining the error.

<sup>1</sup> The IP offset is used to calculate the IP address assigned to a regular node interface. The nodes are conveniently numbered in a sequence, so their interfaces are typically also given a network IP address that is in a sequence on a selected network. In Bright Cluster Manager, interfaces by default have their IP addresses assigned to them sequentially, in steps of 1, starting after the network base address.

The default IP offset is 0.0.0.0, which means that the node interfaces by default start their range at the usual default values in their network.

With a modified IP offset, the point at which addressing starts is altered. For example, a different offset might be desirable when no IPMI network has been defined, but the nodes of the cluster do have IPMI interfaces in addition to the regular network interfaces. If a modified IP offset is not set for one of the interfaces, then the BOOTIF and ipmi0 interfaces get IP addresses assigned on the same network by default, which could be confusing.

However, if an offset is entered for the ipmi0 interface, then the assigned IPMI IP addresses start from the IP address specified by the offset. That is, each modified IPMI address takes the value:

address that would be assigned by default + IP offset

#### Example

Taking the case where BOOTIF and IPMI interfaces would have IP addresses on the same network with the default IP offset:

Then, on a cluster of 10 nodes, a modified IPMI IP offset of 0.0.0.20 means:

- the BOOTIF interfaces stay on 10.141.0.1,...,10.141.0.10 while
- the IPMI interfaces range from 10.141.0.21,...,10.141.0.30

Clicking Continue on a “Network Interfaces” screen validates IP address settings for all node interfaces.

If all settings are correct, and if InfiniBand networks have been defined, then clicking on Continue leads to the “Subnet Managers” screen (figure 3.24), described in the next section.

If no InfiniBand networks are defined, or if InfiniBand networks have not been enabled on the networks settings screen, then clicking Continue instead leads to the CD/DVD ROMs selection screen (figure 3.25).

### 3.3.12 Select Subnet Managers

The “Subnet Managers” screen in figure 3.24 is only displayed if an InfiniBand network was defined, and lists all the nodes that can run the InfiniBand subnet manager. The nodes assigned the role of a subnet manager are ticked, and the Continue button is clicked to go on to the “CD/DVD ROMs” selection screen, described next.

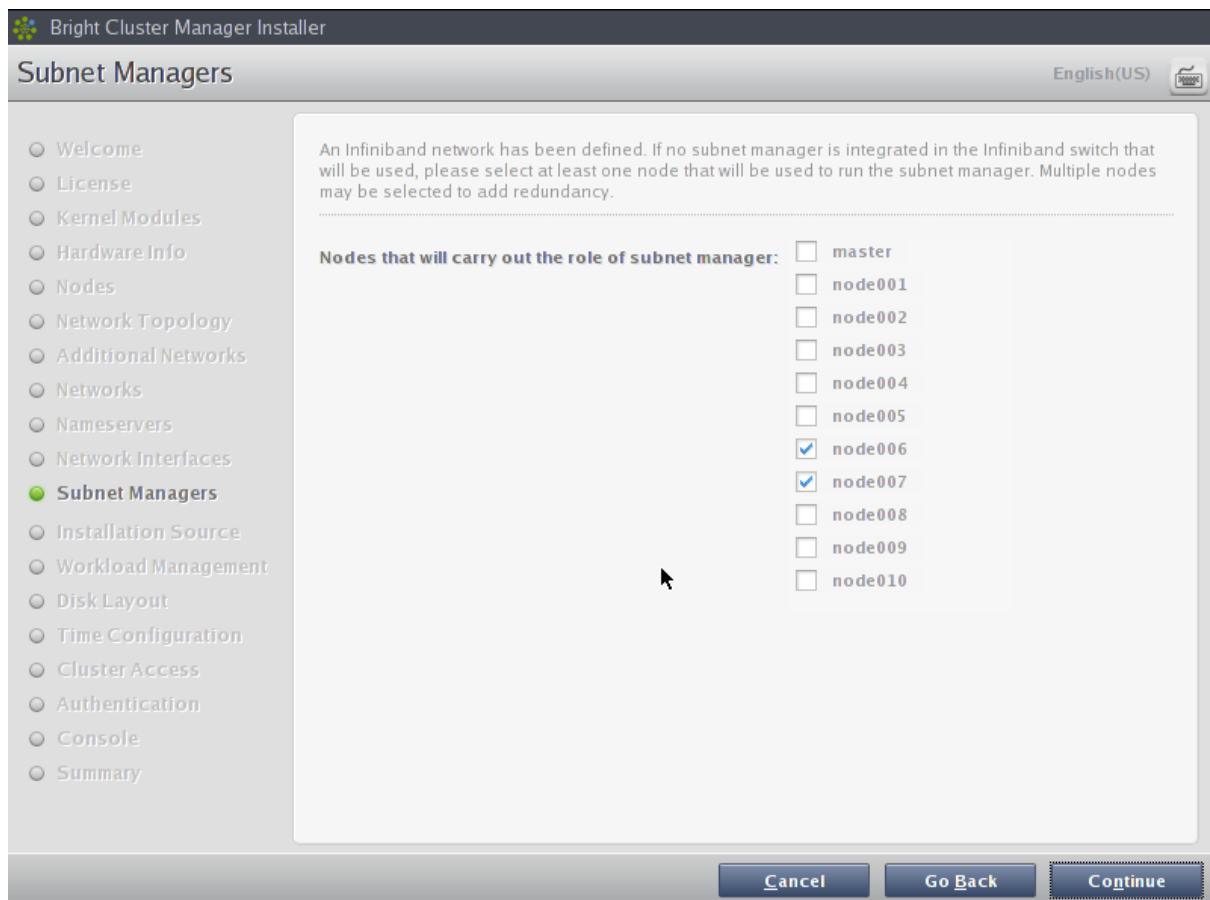


Figure 3.24: Subnet Manager Nodes

### 3.3.13 Select CD/DVD ROM

The “CD/DVD ROMs” screen in figure 3.25 lists all detected CD/DVD-ROM devices. If multiple drives are found, then the drive with the Bright Cluster Manager DVD needs to be selected by the administrator. If the installation source is not detected, it can be added manually using the ⊕ button.

Optionally, a media integrity check can be set.

Clicking on the Continue button starts the media integrity check, if it was set. The media integrity check can take about a minute to run. If all is well, then the “Workload Management” setup screen is displayed, as described next.

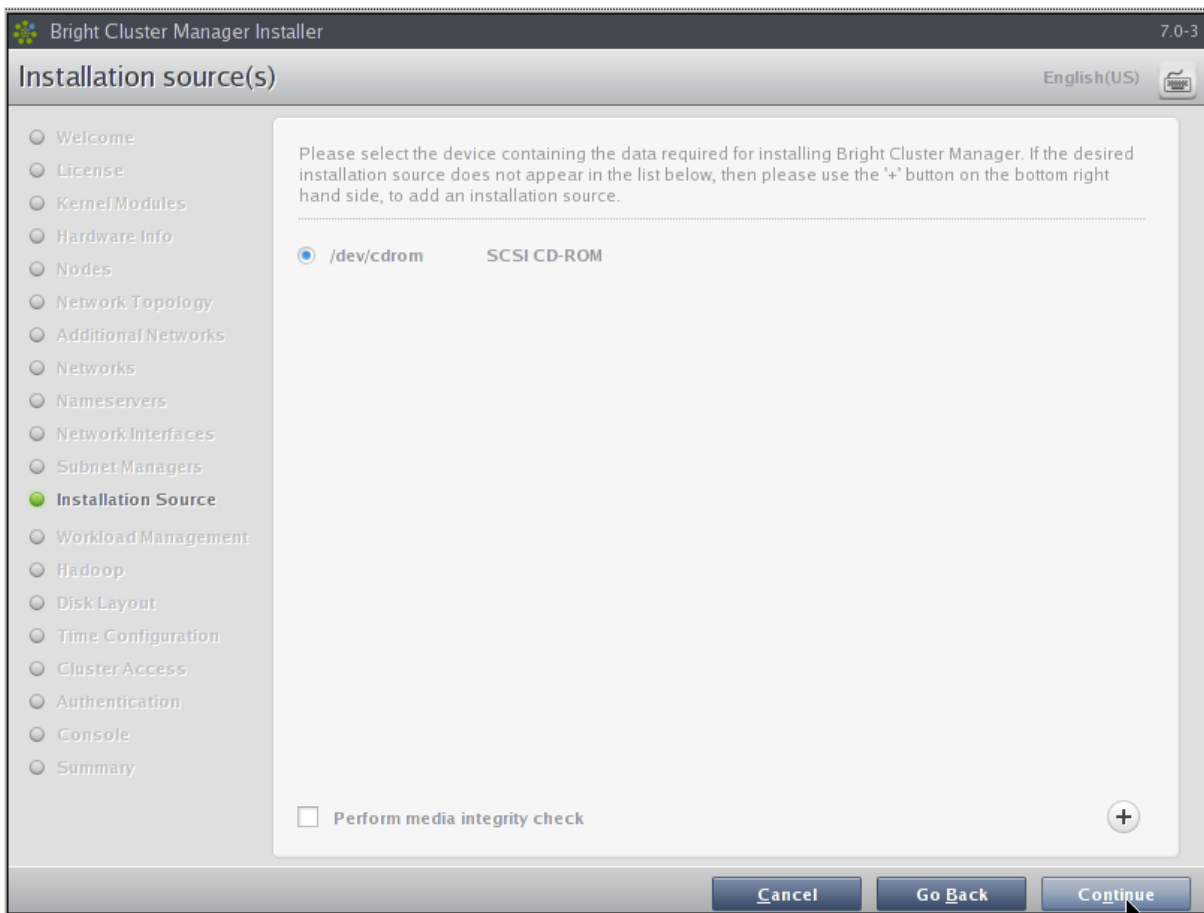


Figure 3.25: DVD Selection

### 3.3.14 Workload Management Configuration

The “Workload Management” configuration screen (figure 3.26) allows selection from a list of supported workload managers. A workload management system is highly recommended to run multiple compute jobs on a cluster.

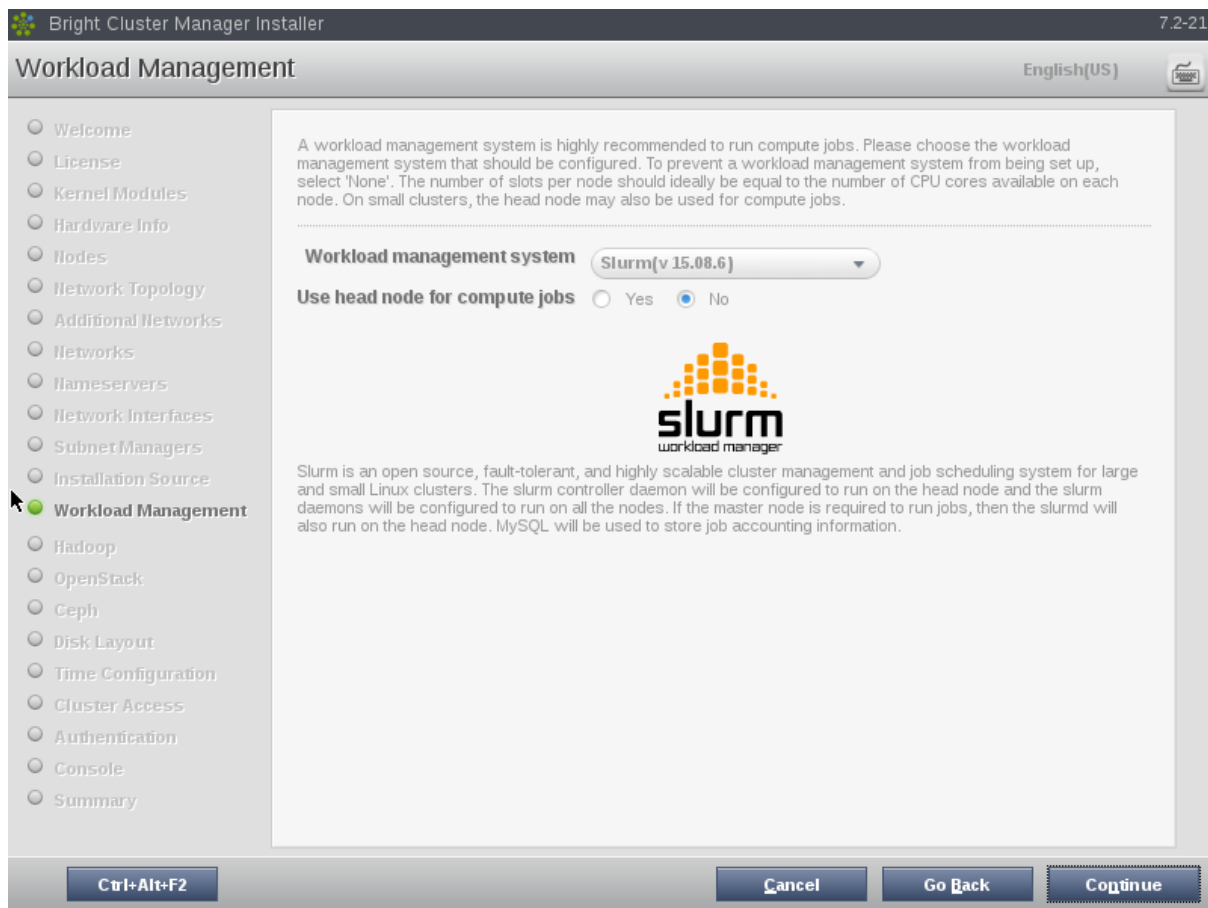


Figure 3.26: Workload Management Setup

If no workload manager is selected here, then it can be installed later on after the cluster installation without the workload manager has been done. Details on installing a workload manager later on are given in Chapter 7 on workload management of the *Administrator Manual*.

To prevent a workload management system from being set up, the option to select is: None. If a workload management system is selected, then the number of slots per node is set by default to 8.

The head node can also be selected for use as a compute node, which can be a sensible choice on small clusters.

Clicking Continue on this screen leads to the “OpenStack” screen, if the OpenStack edition of Bright Cluster Manager has been purchased.

### 3.3.15 OpenStack

OpenStack is an Open Source implementation of cloud services. It is under rapid development, but Bright Cluster Manager integrates a relatively stable implementation of it in the Bright Cluster Manager OpenStack edition. Selecting it means that the OpenStack packages will be installed onto the head node, ready for deployment.



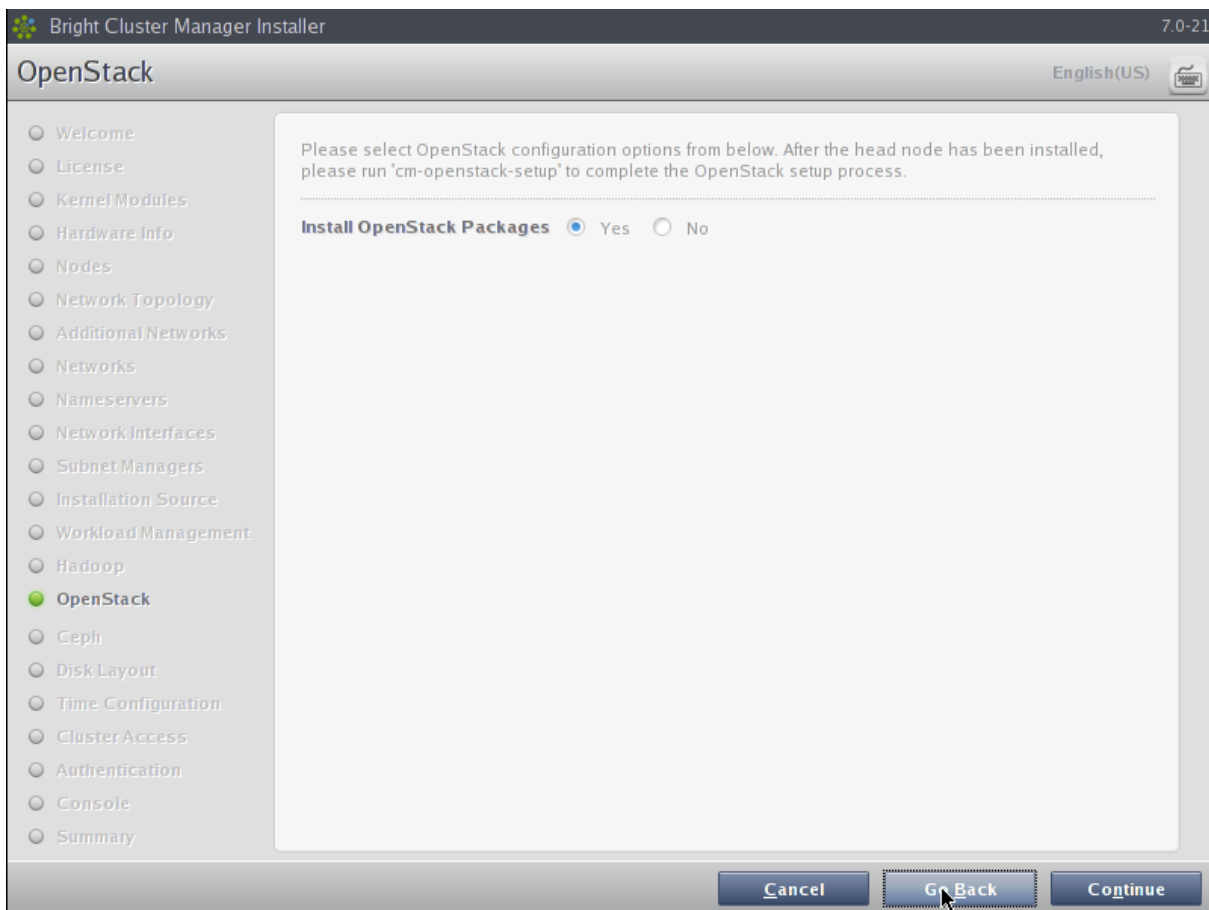


Figure 3.27: OpenStack Option

Clicking Continue on this screen leads to the “Ceph” screen.

### 3.3.16 Ceph

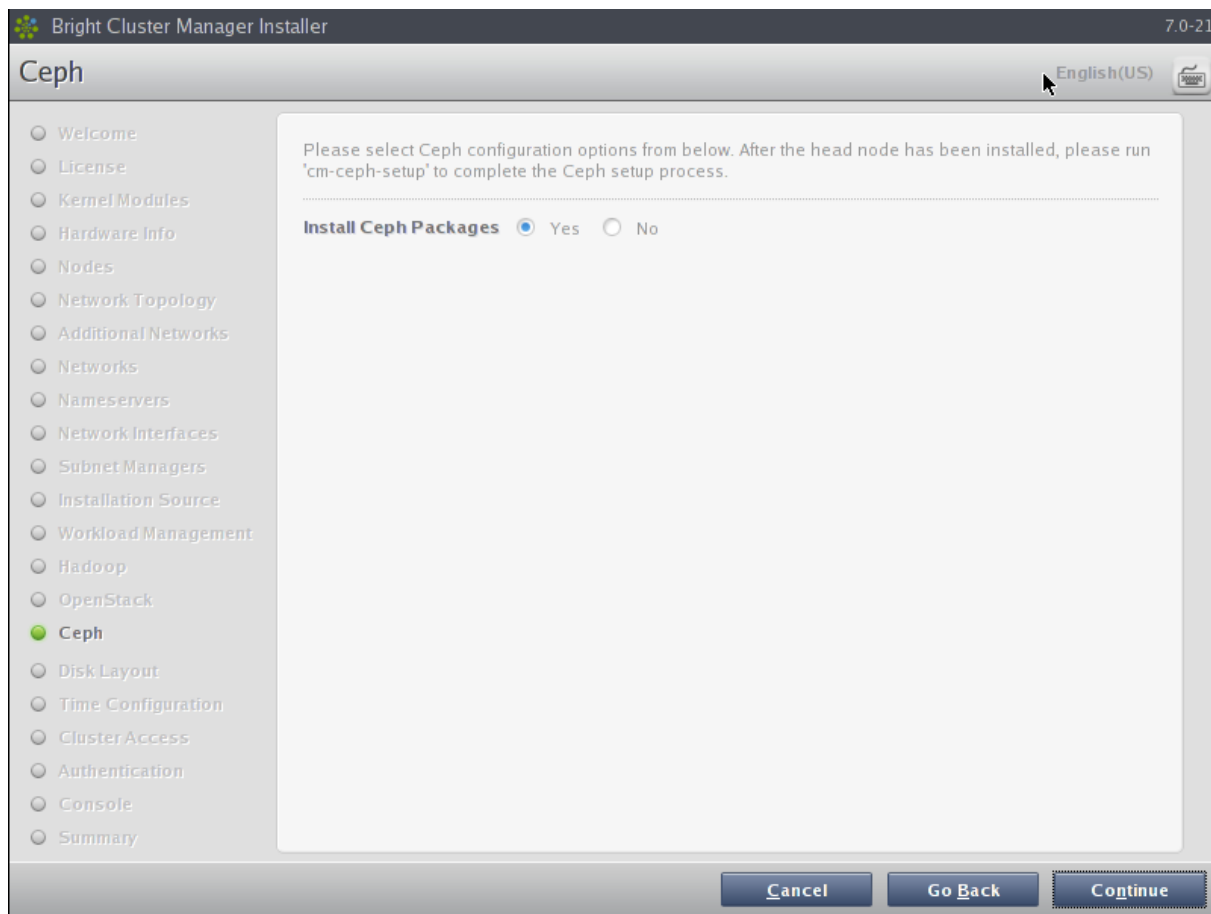


Figure 3.28: Ceph Option

Ceph is an object-based distributed parallel filesystem with self-managing and self-healing features. Object-based means it handles each item natively as an object, along with meta-data for that item. Ceph is typically used with OpenStack, but it can also be used for storage independently from OpenStack. Selecting Ceph in this screen means that the Ceph packages will be installed onto the head node, ready for deployment.

Clicking Continue on this screen leads to the “Disk Partitioning and Layouts” screen, described next.

### 3.3.17 Disk Partitioning And Layouts

The partitioning layout XML schema is described in detail in Appendix D of the *Administrator Manual*.

Within the “Disk Partitioning and Layouts” configuration screen (figure 3.29):

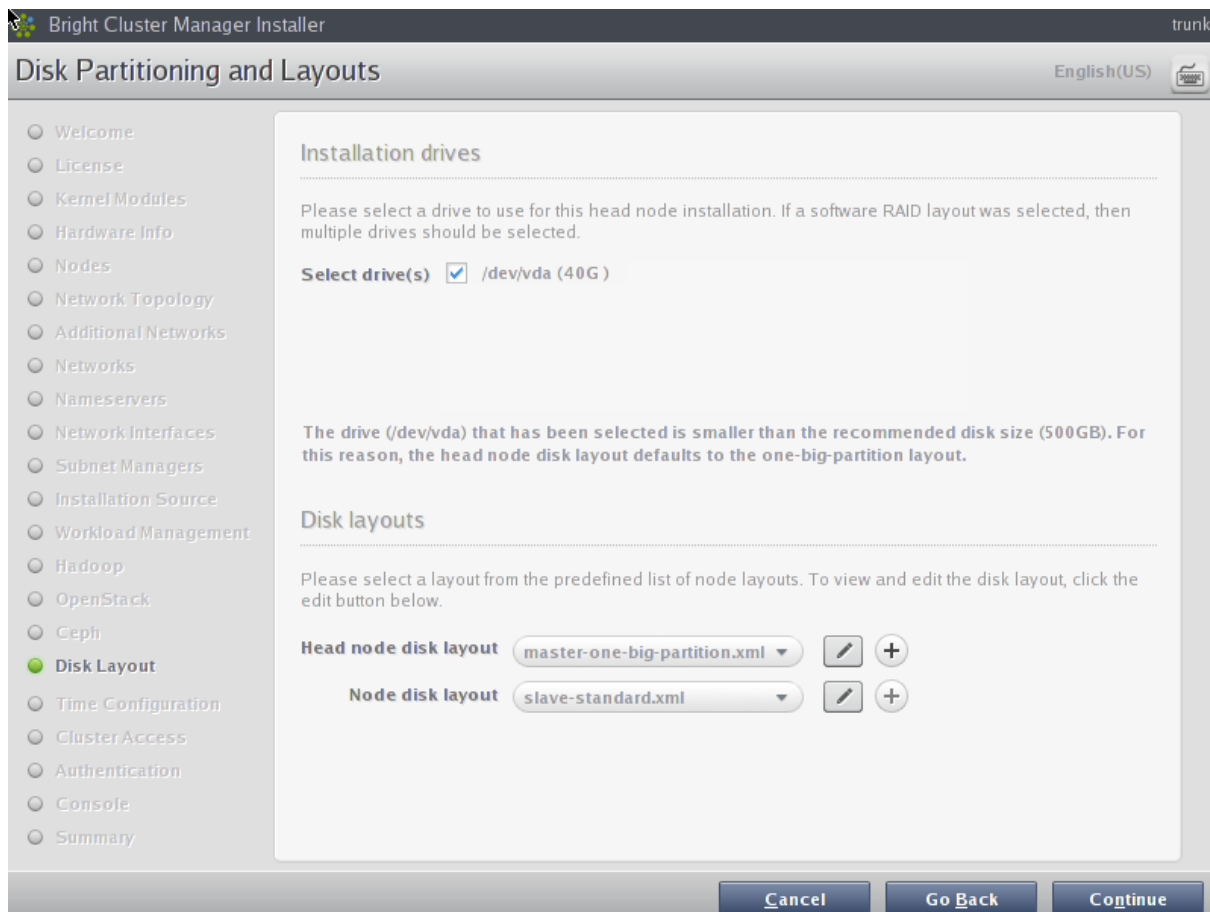


Figure 3.29: Disk Partitioning And Layouts

- the administrator must select the drive on the head node where the cluster manager is to be installed.
- the administrator must set the disk partitioning layout for the head node and regular nodes with the two options: “Head node disk layout” and “Node disk layout”.
  - \* The head node by default uses
    - one big partition if it has a drive size smaller than about 500GB
    - several partitions if it has a drive size greater than or equal to about 500GB.
  - \* The regular node by default uses several partitions.

A partitioning layout other than the default can be selected for installation from the drop-down boxes for the head node and regular nodes. Possible partitioning options include RAID, failover, and STIG-compliant schemes.

A custom partitioning layout can also be used by adding the file to the options with the ⊕ button.

- The head node partitioning layout is the only installation setting that cannot easily be changed after the completion (section 3.3.23) of installation. It should therefore be decided upon with care.
- By default, Bright Cluster Manager mounts ext2/3/4 filesystems on the head node with ACLs set and extended attributes set.
- A text editor pops up when the edit button of a partitioning layout is clicked (figure 3.30). This allows the administrator to view and change layout values within the layout’s configuration XML file using the schema in Appendix D.1 of the *Administrator Manual*.

The Save and Reset buttons are enabled on editing, and save or undo the text editor changes. Once saved, the changes cannot be reverted automatically in the text editor, but must be done manually.

The XML schema allows the definition of a great variety of layouts in the layout's configuration XML file. For example:

1. for a large cluster or for a cluster that is generating a lot of monitoring or burn data, the default partition layout partition size for /var may fill up with log messages because log messages are usually stored under /var/log/. If /var is in a partition of its own, as in the default head node partitioning layout presented when the hard drive is about 500GB or more, then providing a larger size of partition than the default for /var allows more logging to take place before /var is full. Modifying the value found within the `<size></size>` tags associated with that partition in the XML file (figure 3.30) modifies the size of the partition that is to be installed.
2. the administrator could specify the layout for multiple non-RAID drives on the head node using one `<blockdev></blockdev>` tag pair within an enclosing `<device></device>` tag pair for each drive.

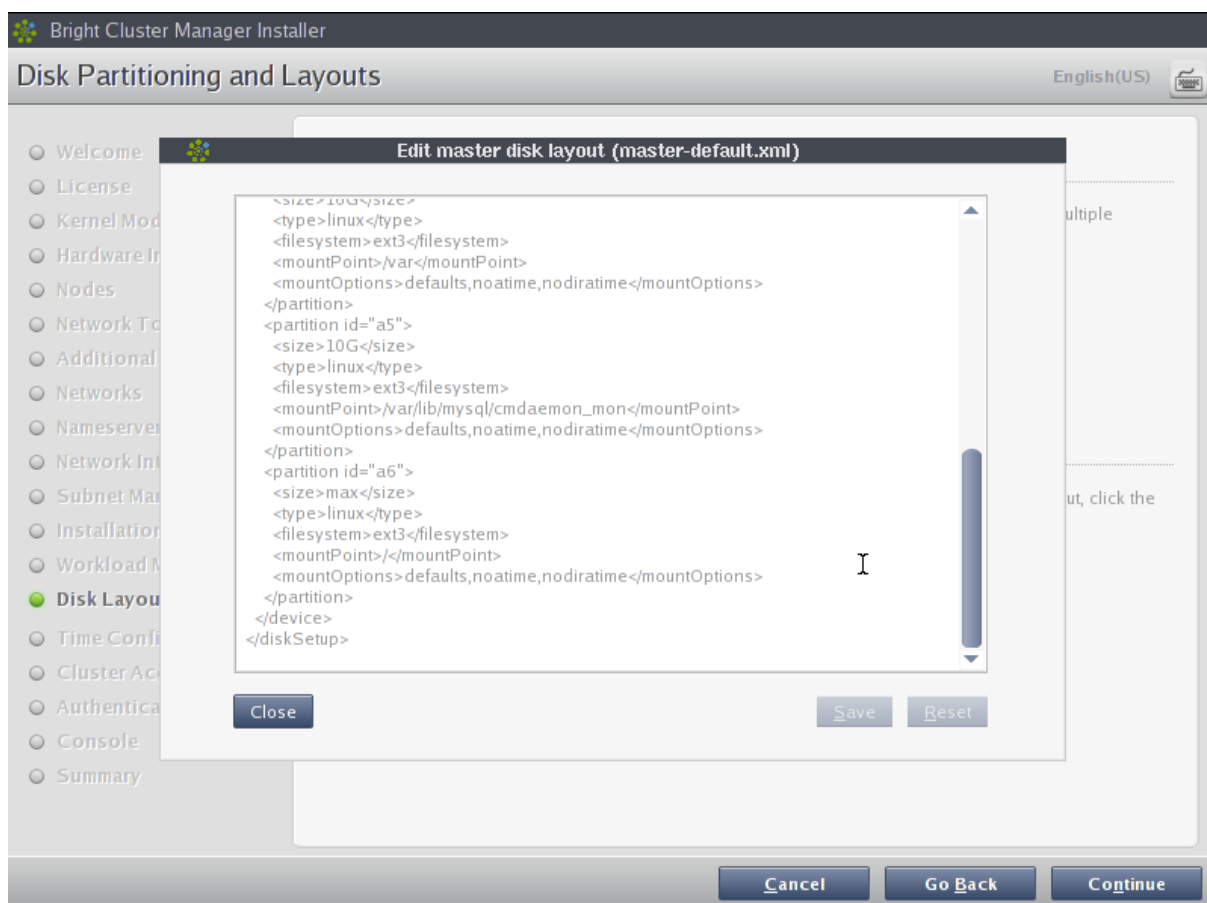


Figure 3.30: Edit Head Node Disk Partitioning

Clicking Continue on the “Disk Partitioning and Layouts” screen leads to the “Time Configuration” screen, described next.

### 3.3.18 Time Configuration

The “Time Configuration” screen (figure 3.31) displays a predefined list of time servers.

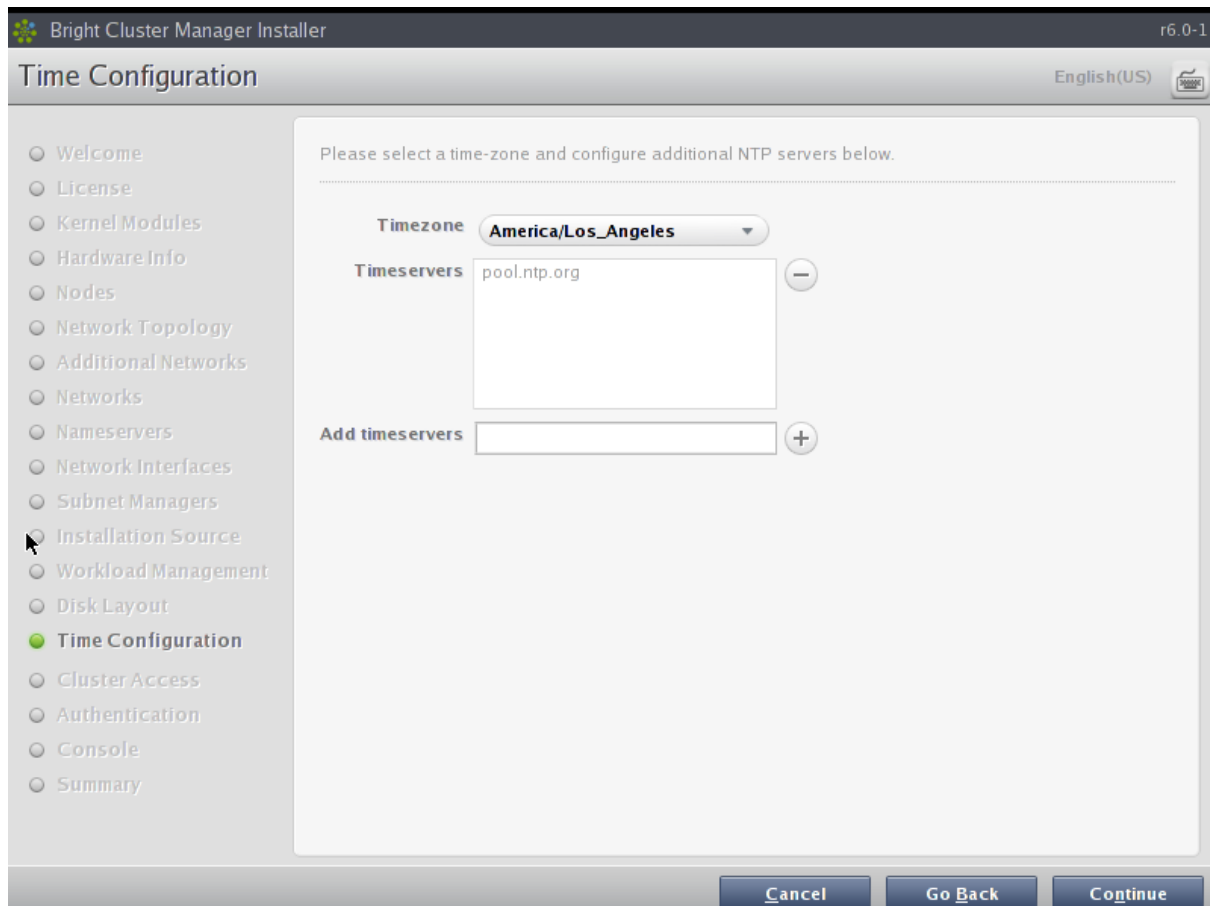


Figure 3.31: Time Configuration

Timeservers can be removed by selecting a time server from the list and clicking the  $\ominus$  button. Additional time servers can be added by entering the name of the time server and clicking the  $\oplus$  button. A timezone can be selected from the drop-down box if the default is incorrect. Clicking **Continue** leads to the “Cluster Access” screen, described next.

### 3.3.19 Cluster Access

The “Cluster Access” screen (figure 3.32) sets the existence of a cluster management web portal service, and also sets network access to several services.

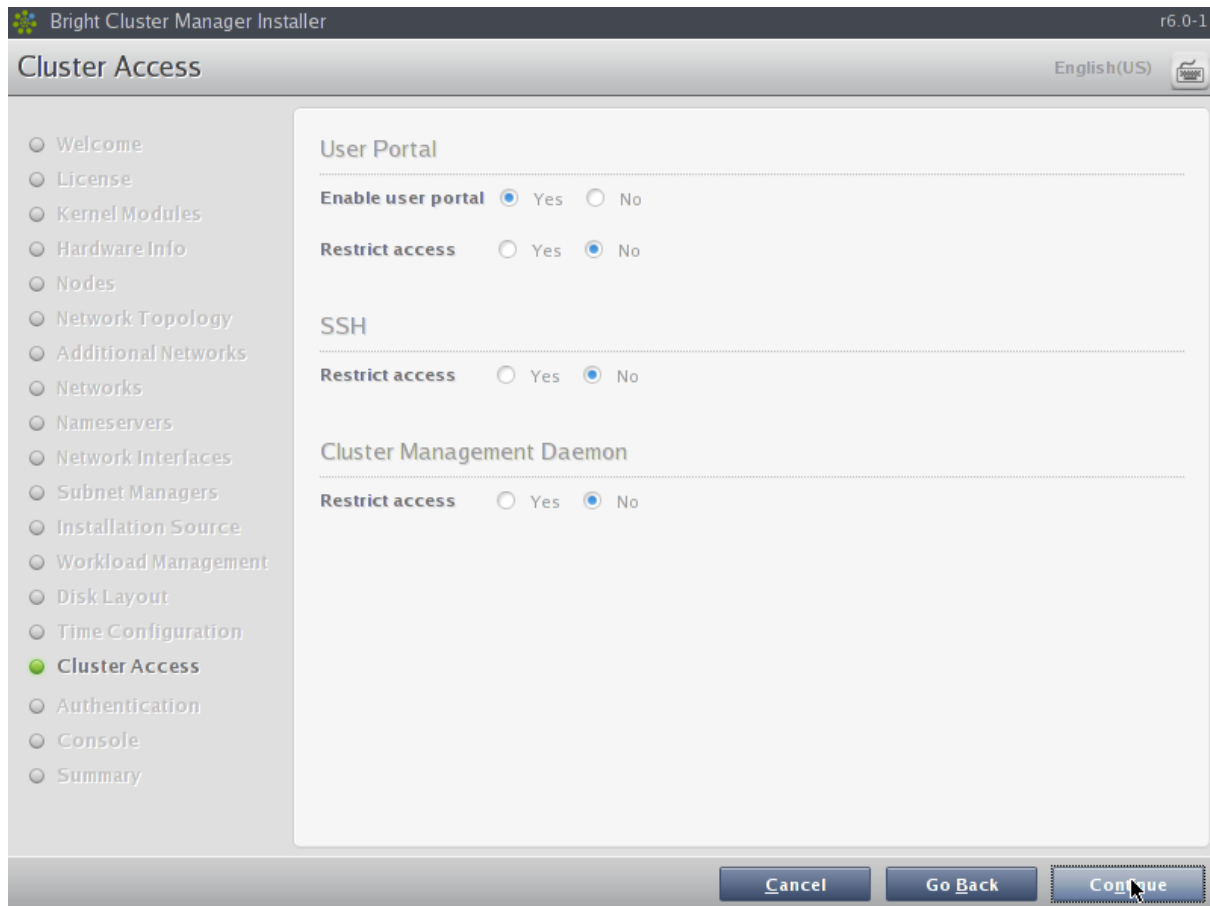


Figure 3.32: Cluster Access

These services are the web portal, ssh, and the cluster management daemon.

If restricting network access for a service is chosen, then an editable list of networks that may access the service is displayed. By default the list has no members. The screen will not move on to the next screen until the list contains at least one CIDR-format network IP address.

If the conditions for this screen are satisfied, then clicking **Continue** leads to the **Authentication** screen, described next.

### 3.3.20 Authentication

The **Authentication** screen (figure 3.33) requires the password to be set twice for the cluster administrator.

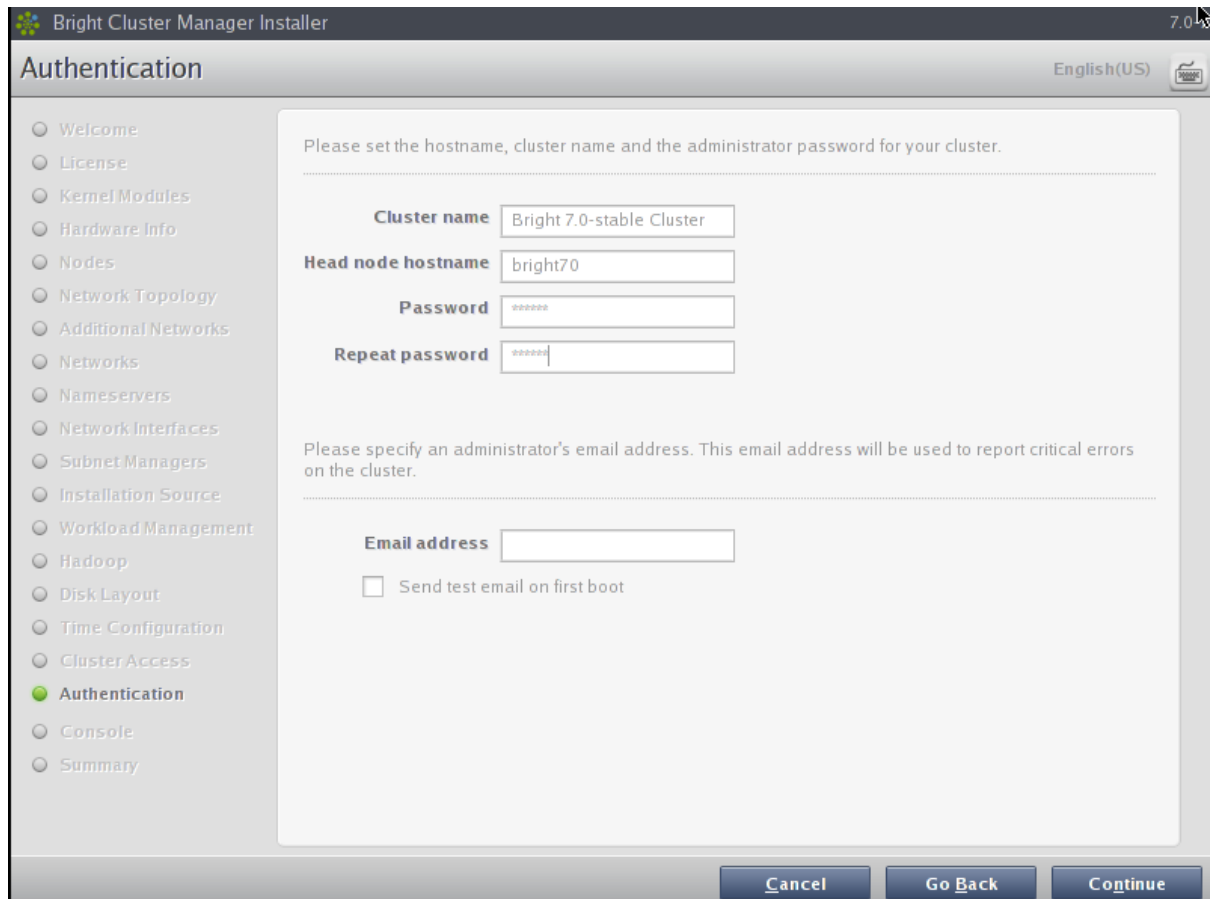
The following parameters can also be set in this screen:

- the cluster name
- the head node hostname
- the administrator e-mail
- the test e-mail checkbox

The administrator e-mail is where critical cluster mail is sent. If it is left blank then such mail is sent by default to the mail spool at `/var/spool/mail/root`, where it can be viewed with a mail client such as `mutt`.

If the `Send test email on first boot` checkbox is checked, then a test mail is sent the first time that the head node boots after installation, so that the administrator can verify that the mail system is working as expected.

Clicking `Continue` validates the passwords that have been entered, and if successful, leads to the `Console` screen, described next.



The screenshot shows the 'Bright Cluster Manager Installer' window at the 'Authentication' step. The window has a title bar with the product name and version '7.0'. On the left is a sidebar with a list of installation steps: Welcome, License, Kernel Modules, Hardware Info, Nodes, Network Topology, Additional Networks, Networks, Nameservers, Network Interfaces, Subnet Managers, Installation Source, Workload Management, Hadoop, Disk Layout, Time Configuration, Cluster Access, Authentication (highlighted with a green dot), Console, and Summary. The main area contains two sections. The first section, titled 'Please set the hostname, cluster name and the administrator password for your cluster.', has four input fields: 'Cluster name' (containing 'Bright 7.0-stable Cluster'), 'Head node hostname' (containing 'bright70'), 'Password' (masked with '\*\*\*\*\*'), and 'Repeat password' (masked with '\*\*\*\*\*'). The second section, titled 'Please specify an administrator's email address. This email address will be used to report critical errors on the cluster.', has an 'Email address' input field and a checkbox labeled 'Send test email on first boot' which is currently unchecked. At the bottom right are three buttons: 'Cancel', 'Go Back', and 'Continue'.

Figure 3.33: Authentication

### 3.3.21 Console

The `Console` screen (figure 3.34) allows selection of a graphical mode or a text console mode for when the head node or regular nodes boot. Clicking `Continue` leads to the `Summary` screen, described next.

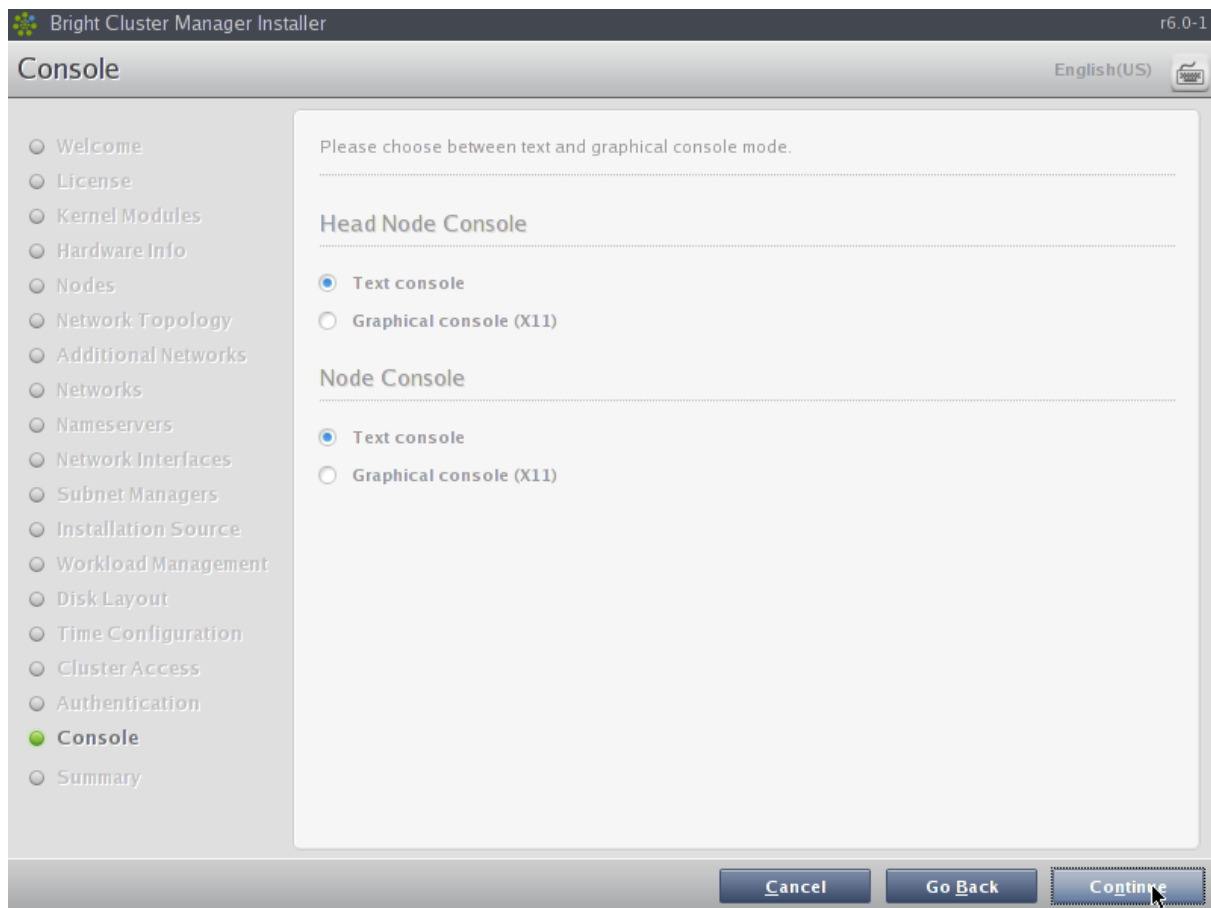


Figure 3.34: Console

### 3.3.22 Summary

The Summary screen (figure 3.35), summarizes some of the installation settings and parameters configured during the previous stages. If the express mode installation was chosen, then it summarizes the predefined settings and parameters. Changes to the values on this screen are made by navigating to previous screens and correcting the values there.

When the summary screen displays the right values, clicking on the Start button leads to the “Installation Progress” screen, described next.



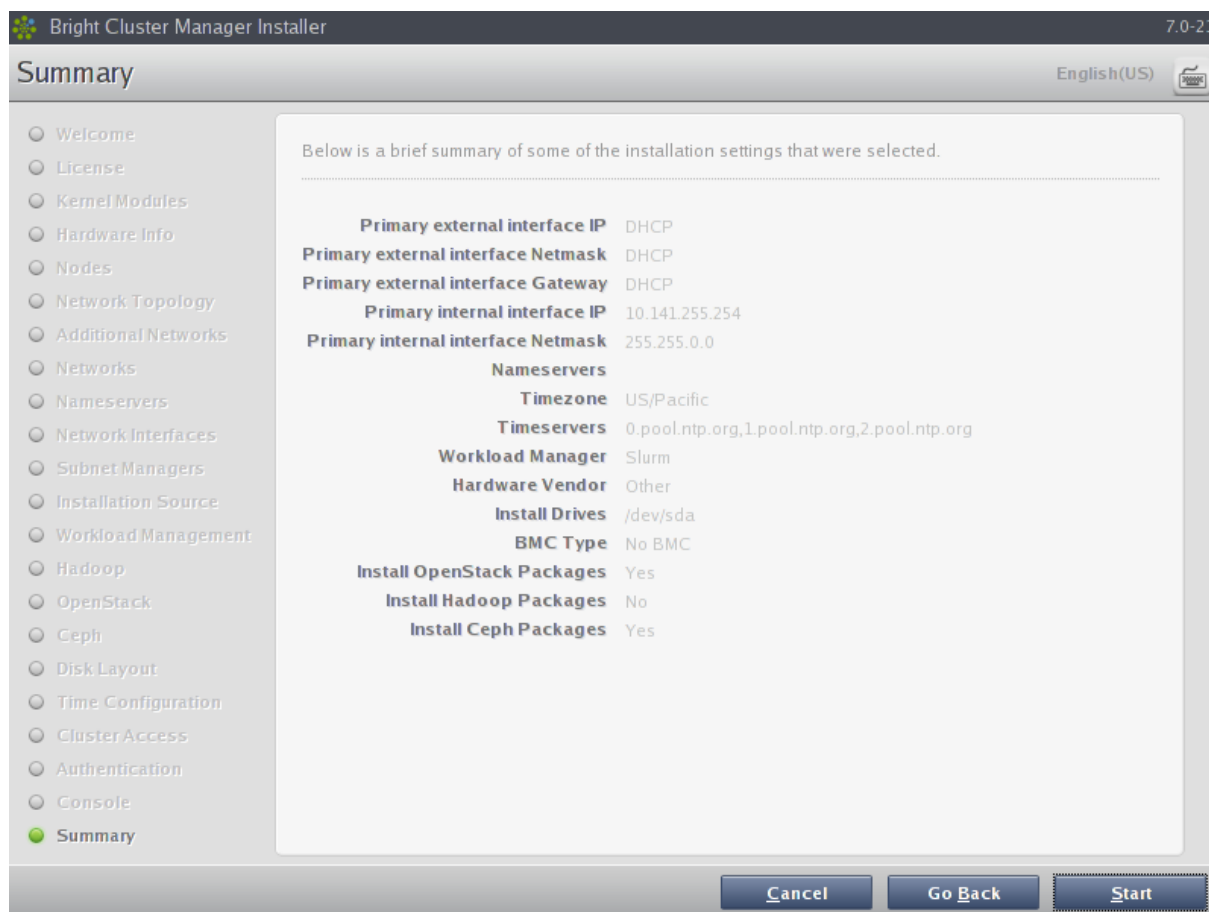


Figure 3.35: Summary of Installation Settings

### 3.3.23 Installation

The “Installation Progress” screen (figure 3.36) shows the progress of the installation. It is not possible to navigate back to previous screens once the installation has begun. When the installation is complete (figure 3.37), the installation log can be viewed in detail by clicking on “Install Log”.

The Reboot button restarts the machine. The BIOS boot order may need changing or the DVD should be removed, in order to boot from the hard drive on which Bright Cluster Manager has been installed.

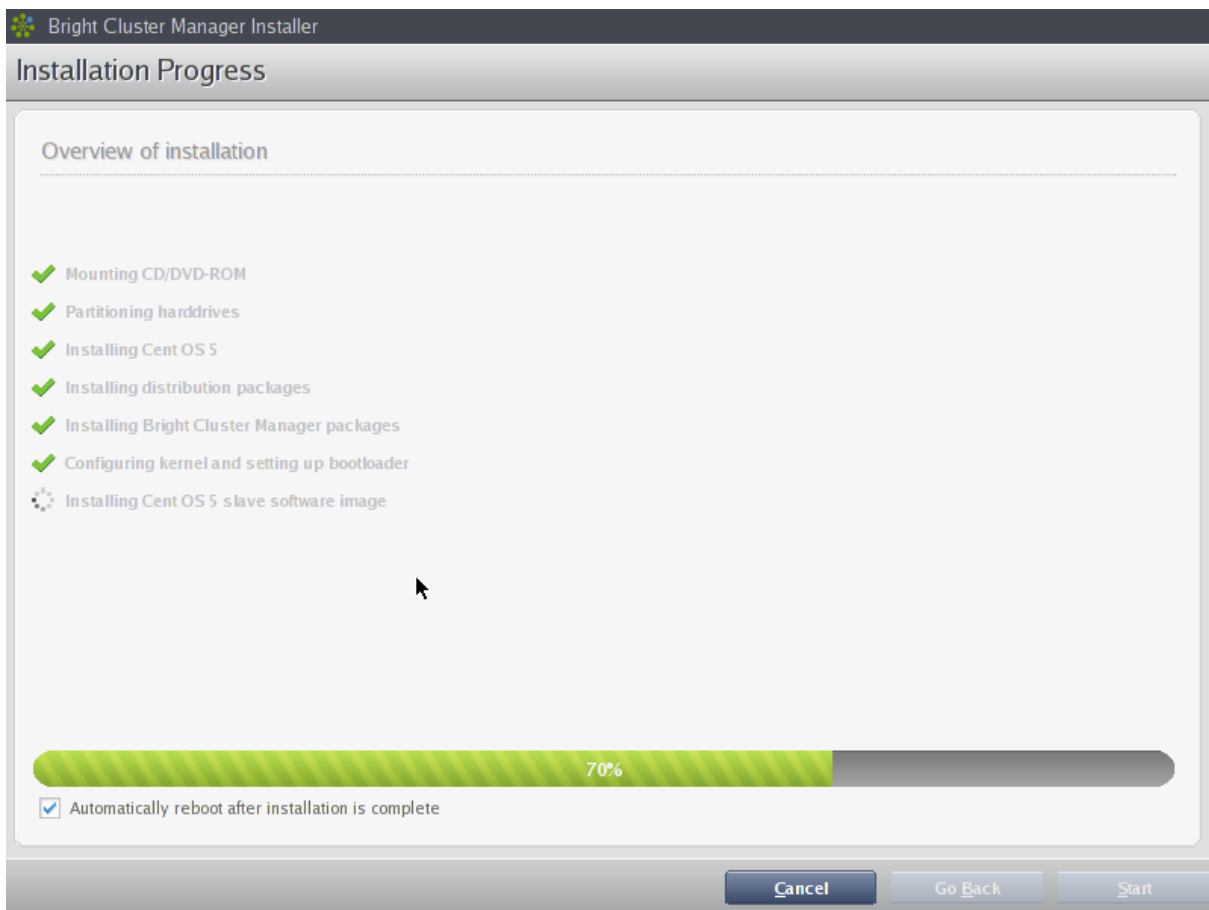


Figure 3.36: Installation Progress

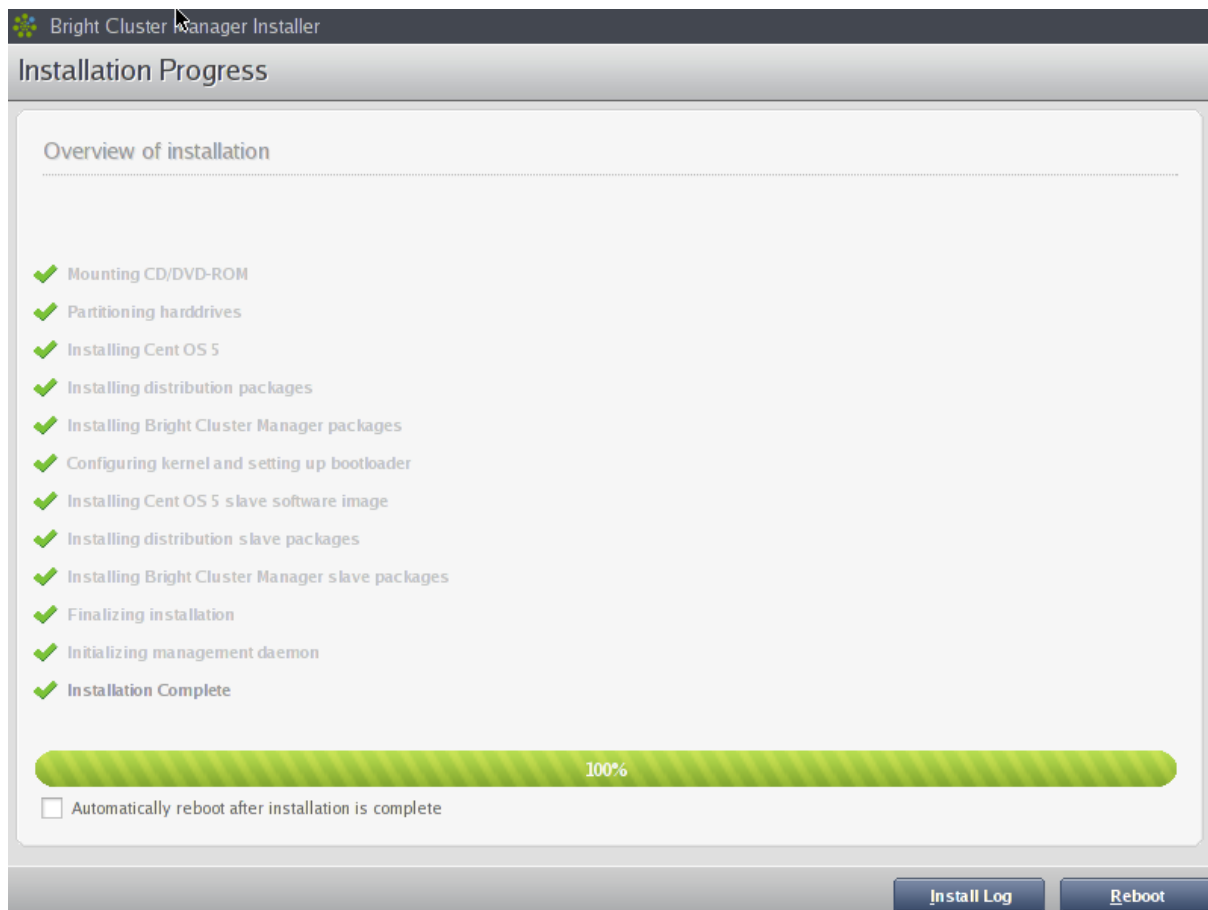


Figure 3.37: Installation Completed

After rebooting, the system starts and presents a login prompt. After logging in as root using the password that was set during the installation procedure, the system is ready to be configured. If express installation mode was chosen earlier as the install method, then the password is preset to system.

### 3.3.24 Licensing And Further Configuration

The administrator with no interest in the add-on method of installation can skip on to installing the license (Chapter 4). After that, the administrator can look through the *Administrator Manual*, where tools and concepts used with Bright Cluster Manager are introduced, so that further cluster configuration can be carried out.

## 3.4 Head Node Installation: Add-On Method

An *add-on* installation, in contrast to the bare metal installation (section 3.3), is an installation that is done onto a machine that is already running one of the supported distributions of section 2.1. The installation of the distribution can therefore be skipped for this case. However, unlike the bare metal installation, the add-on is not recommended for inexperienced cluster administrators. This is because of the following reasons:

- The installation configuration may conflict with what has already been installed. The problems that arise can always be resolved, but an administrator that is not familiar with Bright Cluster Manager should be prepared for troubleshooting.
- Additional repositories typically need to be added (section 3.4.1).

- After the add-on installation has been carried out on the head node, a software image for the regular nodes must still be installed into a directory on the head node. The software image is what is provisioned to regular nodes when they are powered up. The creation and installation of a software image requires some understanding of the Linux operating system as well as Bright Cluster Manager. Software image management is described in section 11.6 of the *Administrator Manual*.

### 3.4.1 Prerequisites

For the add-on method

- The operating system must obviously follow system administration best practices so that it works properly with the official distribution, when Bright Cluster Manager is added on
- The items of software that Bright Cluster Manager adds must be allowed to overrule in any conflict with what is already installed, or the end result of the installation cannot be supported.
- MariaDB must be installed. If MariaDB is already deployed, then care must be taken to ensure that any configuration conflict with the Bright Cluster Manager configuration is resolved.
- It is highly recommended to use a freshly-installed distribution rather than one which is already in use.
- A product key is needed
- There must be repository access to the supported distribution.
  - Internet access makes up-to-date repository access possible. RHEL and SLES repository access requires a subscription from Red Hat or SUSE (Chapter 5).
  - For high-security environments without internet access, an alternative is to mount a DVD device or ISO image to the head node containing a local repository snapshot of the parent distribution, and specify the repository location when running the installation command. Configuring a local repository is described in section 11.6.3 of the *Administrator Manual*.
  - For RHEL, the existing repository list can be seen with `yum repolist`.

Repository access is required to these repositories:

```
* rhel-7-server-rpms
* rhel-7-server-optional-rpms
* rhel-7-server-extras-rpms
* rhel-7-server-supplementary-rpms
* rhel-7-server-openstack-14-rpms
* rhel-7-server-openstack-14-devtools-rpms
```

The repositories can be enabled with the RHEL7 subscription manager using a command of the form:

```
subscription-manager repos --enable=rhel-7-server-rpms --enable=rhel-7-server-optional-...
```

EPEL repository access must also be enabled:

#### Example

```
yum install epel-release
```

### 3.4.2 Installing The Installer

To carry out an add-on installation, the `bright-installer` package and its dependencies must be installed with a package installer.

The `bright-installer` package and its dependencies can be obtained from a Bright Cluster Manager installation DVD, in the directory `/addon/`. Additionally, there must be access to the Linux distribution's repositories as well the EPEL repository in the case of RHEL-based distributions. All packages under the `addon/` directory can be installed as follows:

```
[root@rhel6 ~]# cd <path to mounted Bright DVD addon directory>
[root@rhel6 addon]# yum install *.rpm
```

If installing to Ubuntu, then instead of the `yum` command, the `dpkg -i` command is used to install the `.deb` packages that are in the `addon` directory.

Some additional dependencies may be installed by the package manager. Installation progress is logged in `/var/log/install-bright.log`.

### 3.4.3 Running The Installer

**The Help Text For `install-bright`**

The installer is run with the command `install-bright`. Running it with the `-h` option displays the following help text:

```
[root@bright82 ~]# install-bright
usage: install-bright [-h] (-d <path to dvd> | -n | -l) [-c <path to config>]
                    [-x <pkg1-name, pkg2-name, ..., pkgN-name> | @excludefile]
                    [-v] [-m] [-f] [-s] [--no-hpc]

optional arguments:
  -h, --help                show this help message and exit
  -d <path to dvd>, --fromdvd <path to dvd>
                           Path to a Bright DVD/USB device,
                           or mounted directory or path to a
                           Bright ISO file
  -n, --network              Install over network
  -l, --localrepo            Do not update any repo configuration,
                           just use existing repository settings
  -c <path to config>, --useconfig <path to config>
                           Use predefined config file
  -x <pkg1-name, pkg2-name, ..., pkgN-name> | @excludefile, --excludepackages
                           <pkg1-name, pkg2-name, ..., pkgN-name> | @excludefile
                           Comma-separated list of packages to exclude from
                           being installed or a path to a file with the exclude list
  -v, --verbose              Turn on verbose mode
  -m, --minimalinstall       Only install Bright packages and dependencies
  -f, --ignoreconflicts      Ignore package conflicts check
  -s, --skippackagesetup     Skip repository configuration, validation and package
                           installation
  --no-hpc                   Disable installing HPC packages.
```

1. `install-bright -n`
2. `install-bright -l`
3. `install-bright -d /dev/sr0`
4. `install-bright -d /media/Bright-DVD`
5. `install-bright -d /tmp/bright7.0-rhel6u5.iso`
6. `install-bright -d /tmp/bright7.0-rhel6u5.iso -x libXTrap,xorg-x11-resutils`

**Usage Examples For** `install-bright`

- Install Bright Cluster Manager directly from the Bright Computing repositories over the internet:

```
install-bright -n
```

- Install Bright Cluster Manager using a Bright Computing DVD as the package repository:

```
install-bright -d /dev/sr0
```

- Install Bright Cluster Manager using a Bright Computing ISO as the package repository:

```
install-bright -d /tmp/bright-centos5.iso
```

- Install Bright Cluster Manager from a local repository which has already been configured. This also assumes that the repository configuration files for zypper/YUM/APT use are already in place:

```
install-bright -l
```

**An Installation Run For** `install-bright`

The most common installation option is with an internet connection. Any required software packages are asked for at the start:

**Example**

```
[root@rhel6 ~]# install-bright -n
```

```
Please install the follow pre-requisites
```

```
-----
```

```
createrepo
```

```
[root@rhel6 ~]# yum install createrepo
```

```
...
```

After all the packages are installed on the head node, the installer can be run again. It checks for some software conflicts, and warns about the ones it runs into.:

**Example**

```
[root@rhel6 ~]# install-bright -n
```

```
INFO/ERROR/WARNING:
```

```
-----
```

```
WARNING:
```

```
A DHCP daemon is already running. Bright Cluster Manager
provides a customized DHCP server, and will update the
'dhcpd' configuration files. It is highly recommended
that you stop your existing DHCP server, and let Bright
Cluster Manager configure your dhcp server.
```

```
You can also choose to ignore this message, and proceed
with the existing DHCP server, which may or may not work.
```

```
-----
```

```
Continue(c)/Exit(e)? e
```

```
[root@rhel6 ~]# service dhcpd stop
```

```
Shutting down dhcpd:
```

```
[ OK ]
```

Having resolved potential software conflicts, the product key (supplied by Bright Computing or its vendor) is supplied:

### Example

```
[root@rhel6 ~]# install-bright -n
Bright Cluster Manager Product Key Activation
-----
Product key [XXXXX-XXXXX-XXXXX-XXXXX-XXXXX]: 001323-134122-134134-314384-987986
...
License Parameters
-----
        Country Name (2 letter code) []: US
        State or Province Name (full name) []: CA
            Locality (city) []: San Francisco
        Organization Name (e.g. company) []: Bright
        Organization Unit (e.g. department) []: Development
            Cluster Name []: bright82
        MAC address [?:?:?:?:?:?:?:?:]: 08:B8:BD:7F:59:4B

Submit certificate request to Bright Computing? [y(yes)/n(no)]: y

Contacting license server ... License granted.
License has been installed in /cm/local/apps/cmd/etc/
```

The software license is displayed, and can be clicked through. Some warning is given about the configuration changes about to take place:

Please be aware that the Bright Cluster Manager will re-write the following configuration on your system:

- Update network configuration files.
- Start a DHCP server on the management network.
- Update syslog configuration

The software configuration sections is reached. Default Bright Cluster Manager values are provided, but should normally be changed to appropriate values for the cluster. Questions asked are:

```
Management network parameters
-----
        Network Name [internalnet]:
        Base Address [10.141.0.0]:
            Netmask Bits [16]:
        Domain Name [eth.cluster]:

Management interface parameters
-----
        Interface Name [eth0]:
        IP Address [10.141.255.254]:

External network parameters
-----
        Network Name [externalnet]:
        Base Address [DHCP]:
            Netmask Bits [24]:
        Domain Name []: cm.cluster

External interface parameters
-----
        Interface Name [eth1]:
```

```

                IP Address [DHCP]:

External name servers list (space separated)
-----
                List [10.150.255.254]:

Root password
-----

Please enter the cluster root password:

MySQL root password
-----

Please enter the MySQL root password:

```

The Bright Cluster Manager packages are then installed and configured. The stages include, towards the end:

### Example

```

                Setting up repositories ..... [ OK ]
            Installing required packages ..... [ OK ]
        Updating database authentication ..... [ OK ]
            Setting up MySQL database ..... [ OK ]
                Starting syslog ..... [ OK ]
    Initializing cluster management daemon ..... [ OK ]
            Generating admin certificates ..... [ OK ]
        Starting cluster management daemon ..... [ OK ]

```

If all is well, a congratulatory message then shows up, informing the administrator that Bright Cluster Manager has been installed successfully, that the host is now a head node.

### Installing The Software Image For Regular Nodes After The `install-bright` Installation Run

A functional cluster needs regular nodes to work with the head node. The regular nodes at this point of the installation still need to be set up. To do that, a software image (section 2.1.2 of the *Administrator Manual*) must now be created for the regular nodes on the head node. The regular nodes, when booting, use such a software image when they boot up to become a part of the cluster. A software image can be created using the base tar image included on the DVD, or as a custom image. The details on how to do this with `cm-create-image` are given in section 11.6 of the *Administrator Manual*.

Once the head node and software image have been built, the head node installation is complete, and the cluster is essentially at the same stage as that at the end of section 3.3.23 of the bare metal installation, except for that the software image is possibly a more customized image than the default image provided with the bare-metal installation.

### The Build Configuration Files

This section is mainly intended for deploying installations that have been pre-configured by the administrator. It can therefore be skipped in a first reading.

The build configuration file of a cluster contains the configuration scheme for a cluster. The bare metal and add-on installations both generate their own, separate build configuration files, stored in separate locations.

Most administrators do not deal with a build configuration file directly, partly because a need to do this arises only in rare and special cases, and partly because it is easy to make mistakes. An overview, omitting details, is given here to indicate how the build configuration file relates to the installations carried out in this chapter and how it may be used.



**The bare metal build configuration file:** The file at:

```
/root/cm/build-config.xml
```

on the head node contains cluster configuration settings and the list of distribution packages that are installed during the bare metal installation. Once the installation has completed, this file is static, and does not change as the cluster configuration changes.

**The add-on installation build configuration file:** Similarly, the file at:

```
/root/.brightcm/build-config.xml
```

contains configuration settings. However, it does not contain a list of distribution packages. The file is created during the add-on installation, and if the installation is interrupted, the installation can be resumed at the point of the last confirmation prior to the interruption. This is done by using the `-c` option to `install-bright` as follows:

### Example

```
install-bright -c /root/.brightcm/build-config.xml
```

**Both original “build” configuration XML files can be copied and installed via the `-i` initialize option:** For example:

```
service cmd stop
cmd -i build-config-copy.xml      #reinitializes CMDaemon from scratch
service cmd start
```

overwrites the old configuration. It means that the new cluster presents the same cluster manager configuration as the old one did initially. This can only be expected to work with identical hardware because of hardware dependency issues.

**An XML configuration file can be exported via the `-x` option to `cmd`:** For example:

```
service cmd stop
cmd -x myconfig.xml
service cmd start
```

Exporting the configuration is sometimes helpful in examining the XML configuration of an existing cluster after configuration changes have been made to the original installation. This “snapshot” can then, for example, be used to customize a `build-config.xml` file in order to deploy a custom version of Bright Cluster Manager.

An exported configuration cannot replace the original bare-metal `build-config.xml` during the installation procedure. For example, if the original bare-metal file is replaced by the exported version by opening up another console with `alt-f2`, before the point where the “Start” button is clicked (figure 3.35), then the installation will fail. This is because the replacement does not contain the list of packages to be installed.

The exported configuration can however be used after a distribution is already installed. This is true for a head node that has been installed from bare-metal, and is also true for a head node that has undergone or is about to undergo an add-on installation. This is because a head node does not rely on a packages list in the XML file in the case of

- after a bare-metal installation, and
- before or after an add-on installation.

These possibilities for an export file are indicated by the following table:

Can the <code>cmd -x export</code> file be used as-is for cluster installation?		
install type	before or after installation	cluster installs from export?
bare metal	before	no
bare metal	after	yes
add-on install	before	yes
add-on install	after	yes

## 3.5 Mass Cluster Installation

### 3.5.1 The `cluster-sync` Cluster Replication Utility

`cluster-sync` is a tool to replicate a Bright cluster to one or more replica clusters.

It is intended to replicate software images and cluster objects<sup>2</sup> using `rsync`.

The `cluster-sync` tool uses an XML user-defined synchronization definition file to specify what is replicated from the images and objects defined in `CMDaemon`. A sample definition file is shown in section 3.5.7. The file can be extended to replicate many additional cluster object types, including multiples of each type, to as many remote clusters as are needed.

### 3.5.2 Download And Install

The `cluster-sync` tool can be picked up from GitHub using `git`.

#### Example

```
[root@bright82 ~]# yum install git
[root@bright82 ~]# git clone https://github.com/Bright-Computing/cluster-sync
```

A best practice in general is to update Bright Cluster Manager regularly with a `yum update`. In particular, the `cluster-sync` tool only works with recent versions of `CMDaemon`, so that a minimal update to ensure that `cluster-sync` works is to carry out a `yum update cmdaemon`.

### 3.5.3 Establishing One-way Trust

To carry out replication over what may be an insecure link, `ssh` is used. To enable replication over `ssh`, the root `ssh` public key from the master should be added to the `authorized_keys` file of the root account on the replica cluster. This establishes a one-way trust. That is: the replica cluster trusts the root account of the master cluster, but the master cluster cannot trust the replica cluster.

#### Example

```
[root@bright82 ~]# ssh-copy-id -i ~/.ssh/id_dsa.pub root@replica-headnode
root@replica-headnode's password: <root password of replica head node>
```

`CMDaemon` on the replica cluster also needs to trust the `CMDaemon` on the master cluster. Using a secure copy program, the X509 keys from the root account of the replica cluster must be copied over by the administrator to a secure local directory on the master cluster. The permissions of both the directory and the keys must match the permissions shown in the following, where the directory permissions are 0700, and the keys permissions are 0600:

<sup>2</sup>If the aim is only to copy an image from one cluster to another, then this can be done by first creating the new image with the `cm-create-image` command (section 11.6.2 of the *Administrator Manual*), as follows:

```
[root@bright82 ~]# cm-create-image -d <path to image to be synced> -n <new image name>
```

The new image can then be transferred to the correct path on the new cluster under `/cm/images/<new image name>`.

### Example

```
[root@bright82 ~]# scp root@replica-headnode:/root/.cm/cmsh/{admin.key,admin.pem} \
bright-cluster-replication/replica/keys
[root@bright82 ~]# ls -lR bright-cluster-replication/replica/
replica:
total 4
drwx----- 2 root root 4096 Aug 14 14:34 keys
replica/keys:
total 8
-rw----- 1 root root 1869 Aug 14 15:14 admin.key
-rw----- 1 root root 1427 Aug 14 15:14 admin.pem
```

If the root certificate keys are stored in a file path other than that shown in the preceding example, then the synchronization definition file must be edited by the administrator so that the PEM and key file paths defined in the file match the actual paths. The XML section to modify looks like:

```
<brightcert>
  <pemfile>/root/bright-cluster-replication/replica/keys/admin.pem</pemfile>
  <keyfile>/root/bright-cluster-replication/replica/keys/admin.key</keyfile>
</brightcert>
```

### 3.5.4 Replication Configuration

The objects that are replicated are specified by the synchronization definition file. A sample definition file schema is given in section 3.5.7.

### 3.5.5 Usage Of cluster-sync

After cloning cluster-sync from GitHub (section 3.5.2), the Python script should be made executable:

```
[root@bright82 ~]# cd cluster-sync && chmod +x cluster-sync.py
[root@bright82 cluster-sync]# ./cluster-sync.py -v -f cluster-sync.xml
```

A help text is shown if it is run without any arguments:

```
[root@bright82 cluster-sync]# ./cluster-sync.py
Usage: cluster-sync.py -f <file> -x <exclude> [-v -d -n]

Options
  -f | --file <file>          Synchronization definition file
  -v | --verbose               Be verbose in output
  -x | --exclude <file>       Exclude files according to specification in <file> from rsync
                                operations
  -d | --dry                   Perform a dry run
  -n | --preserve-fsmounts     Preserve FSMounts on target head node.
  -r | --preserve-roles        Preserve roles on target head node's categories.
```

### 3.5.6 Excluding Files In The Software Image From Being Transferred

Certain files in the software image of the target cluster may need to be different because they contain server-specific settings. In this case, the user should exclude the files from being synchronized by providing an exclude list file to the `-x|--exclude` option of `cluster-sync`. The format is the same as for a typical `rsync` `excludelist` (section 5.6.1 of the *Administrator Manual*).

For a source path of, for example:

```
/cm/images/test-image
```

and a destination path of, for example:

target\_headnode:/cm/images/test-image

an exclude list file line entry could be, if specified as a relative path:

etc/sssds/sssds.conf (relative path)

or:

- etc/sssds/sssds.conf

If specified as an absolute path, the line entry is, for example:

- /usr

In the absolute path case shown in the preceding text, /cm/images/test-image/usr will not be synced to the target.

In the relative path cases shown in the preceding text, both /cm/images/test-image/etc/sssds/sssds.conf and /cm/images/test-image/root/backup/etc/sssds/sssds.conf are excluded. That is, all paths ending with that pattern are excluded.

The format is the same as for the exclude lists (section 5.6.1 of the *Administrator Manual*) that are defined by the administrator for node categories. The only difference is that the no-new-files directive cannot be used.

no-new-files: - /tftpboot/\*

### Additional Options For Node Categories

In certain cases it might be desirable to exclude certain node categories and attributes from being replicated. The current version of cluster-sync

- skips the synchronization of file system mounts with the -n|--preserve-fsmounts option
- skips roles associated with a node category with the -r|--preserve-roles option.

### 3.5.7 Sample cluster-sync Definition File

The XML user-defined synchronization definition file used by cluster-sync has a pattern illustrated by the following example:

#### Example

```
<syncdefinition>
<local>
  <host>source-headnode.example.com</host>
  <brightport>8081</brightport>
  <brightcert>
    <pemfile>/root/.cm/admin.pem</pemfile>
    <keyfile>/root/.cm/admin.key</keyfile>
  </brightcert>
</local>
<cluster array="yes">
  <name>target-headnode.example.com</name>
  <host>10.141.100.254</host>
  <brightport>8081</brightport>
  <sshport>22</sshport>
  <brightcert>
    <pemfile>/root/bright-cluster-replication/replica/keys/admin.pem</pemfile>
```

```
<keyfile>/root/bright-cluster-replication/replica/keys/admin.key</keyfile>
</brightcert>
<action array="yes">
  <name>sync</name>
  <type>softwareimage</type>
  <src>image-compute</src>
  <dest>image-compute</dest>
</action>
<action array="yes">
  <name>sync</name>
  <type>softwareimage</type>
  <src>image-gpunodes</src>
  <dest>image-gpunodes</dest>
</action>
<action>
  <name>sync</name>
  <type>Metric</type>
  <src>*</src>
  <dest>*</dest>
</action>
<action>
  <name>sync</name>
  <type>HealthCheck</type>
  <src>*</src>
  <dest>*</dest>
</action>
<action>
  <name>sync</name>
  <type>category</type>
  <src>compute-nodecat</src>
  <dest>compute-nodecat</dest>
</action>
<action>
  <name>sync</name>
  <type>MonitoringConfiguration</type>
  <src>compute-nodecat</src>
  <dest>compute-nodecat</dest>
</action>
<action>
  <name>sync</name>
  <type>category</type>
  <src>compute-gpucat</src>
  <dest>compute-gpucat</dest>
</action>
<action>
  <name>sync</name>
  <type>MonitoringConfiguration</type>
  <src>compute-gpucat</src>
  <dest>compute-gpucat</dest>
</action>
<action>
  <name>sync</name>
  <type>category</type>
  <src>login</src>
  <dest>login</dest>
```

```
</action>
<action>
  <name>sync</name>
  <type>MonitoringConfiguration</type>
  <src>login</src>
  <dest>login</dest>
</action>
</cluster>
</syncdefinition>
```

# 4

## Licensing Bright Cluster Manager

This chapter explains how a Bright Cluster Manager license is viewed, verified, requested, and installed.

Typically, for a new cluster that is purchased from a reseller, the cluster may have Bright Cluster Manager already set up on it.

Bright Cluster Manager can be run with a temporary, or evaluation license, which allows the administrator to try it out. This typically has some restrictions on the period of validity for the license, or the number of nodes in the cluster. The evaluation license also comes with the online ISO download for Bright Cluster Manager, which is available for product key owners via <http://customer.brightcomputing.com/Download>

The other type of license is the full license, which is almost always a subscription license. Installing a full license allows the cluster to function without the restrictions of the evaluation license. The administrator therefore usually requests a full license, and installs it. This normally only requires the administrator to:

- Have the product key at hand
- Run the `request-license` script on the head node

The preceding takes care of the licensing needs for most administrators, and the rest of this chapter can then usually conveniently be skipped.

Administrators who would like a better background understanding on how licensing is installed and used in Bright Cluster Manager can go on to read the rest of this chapter.

CMDaemon can run only with an unexpired evaluation or unexpired full license. CMDaemon is the engine that runs Bright Cluster Manager, and is what is normally recommended for further configuration of the cluster. Basic CMDaemon-based cluster configuration is covered in Chapter 3 of the *Administrator Manual*.

Any Bright Cluster Manager installation requires a *license file* to be present on the head node. The license file details the attributes under which a particular Bright Cluster Manager installation has been licensed.

### Example

- the “Licensee” details, which include the name of the organization, is an attribute of the license file that specifies the condition that only the specified organization may use the software
- the “Licensed nodes” attribute specifies the maximum number of nodes that the cluster manager may manage. Head nodes are also regarded as nodes for this attribute.

- the “Expiration date” of the license is an attribute that sets when the license expires. It is sometimes set to a date in the near future so that the cluster owner effectively has a trial period. A new license with a longer period can be requested (section 4.3) after the owner decides to continue using the cluster with Bright Cluster Manager

A license file can only be used on the machine for which it has been generated and cannot be changed once it has been issued. This means that to change licensing conditions, a new license file must be issued.

The license file is sometimes referred to as the *cluster certificate*, or *head node certificate*, because it is the X509v3 certificate of the head node, and is used throughout cluster operations. Its components are located under `/cm/local/apps/cmd/etc/`. Section 2.3 of the *Administrator Manual* has more information on certificate-based authentication.

## 4.1 Displaying License Attributes

Before starting the configuration of a cluster, it is important to verify that the attributes included in the license file have been assigned the correct values. The license file is installed in the following location:

```
/cm/local/apps/cmd/etc/cluster.pem
```

and the associated private key file is in:

```
/cm/local/apps/cmd/etc/cluster.key
```

### 4.1.1 Displaying License Attributes Within Bright View

If using Bright View<sup>1</sup>, then to verify that the attributes of the license have been assigned the correct values, the license details can be displayed by selecting the Cluster resource, then in the Partition base window that opens up, selecting the License info menu option (figure 4.1):

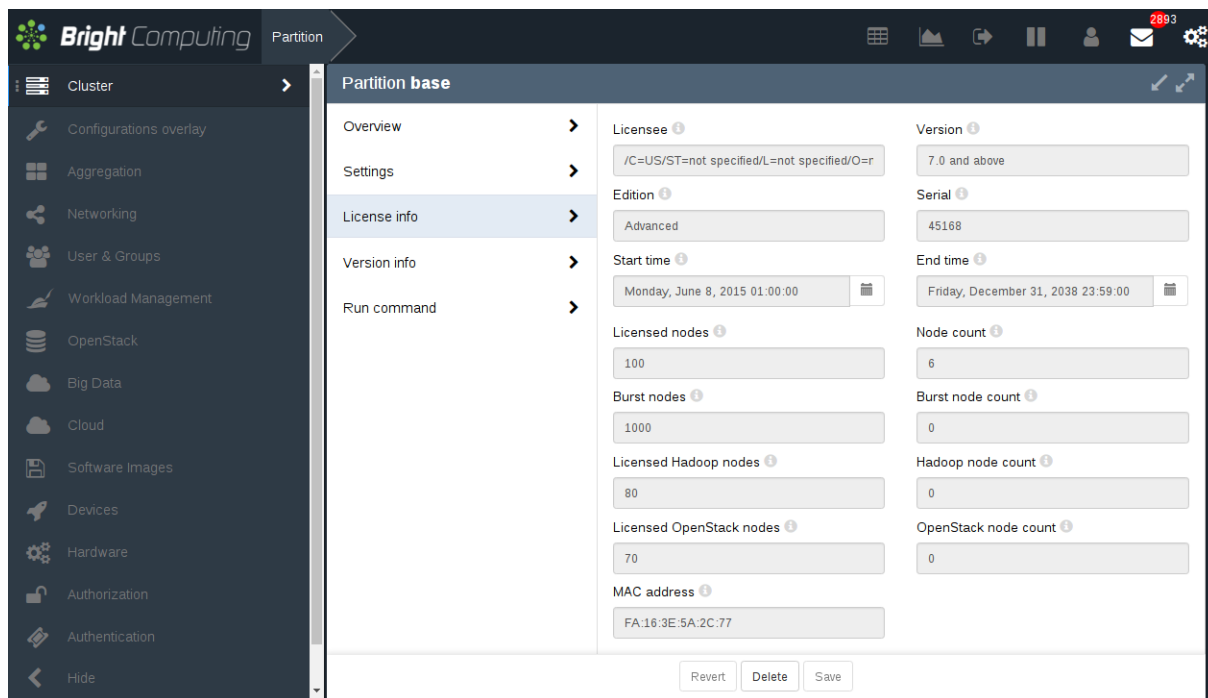


Figure 4.1: License Information

<sup>1</sup>Bright View is typically accessed via a “home” URL in the form of `https://<head node address>:8081/bright-view/`



### 4.1.2 Displaying License Attributes Within cmsh

Alternatively the licenseinfo command within the main mode of cmsh may be used:

#### Example

```
[root@bright82 ~]# cmsh
[bright82]% main licenseinfo
License Information
-----
Licensee                /C=US/ST=California/L=San Jose/O=Bright
                        Computing/OU=Temporary Licensing/CN=003040
Serial Number           98388
Start Time              Mon Oct 16 01:00:00 2017
End Time                Fri Dec 31 23:59:00 2038
Version                 7.0 and above
Edition                 Advanced
Pre-paid Nodes          100
Max Pay-per-use Nodes   1000
Max Data Science Nodes  80
Max OpenStack Nodes     70
Node Count              4
Accounting & Reporting  Yes
Allow edge sites        Yes
Data Science Node Count 0
OpenStack Node Count    0
MAC Address / Cloud ID  FA:16:3E:37:5F:97
[bright82]%
```

The license in the example above allows 1000 pay-per-use nodes to be used. It is tied to a specific MAC address, so it cannot simply be used elsewhere. For convenience, the Node Count field in the output of licenseinfo shows the current number of nodes used.

## 4.2 Verifying A License—The verify-license Utility

### 4.2.1 The verify-license Utility Can Be Used When licenseinfo Cannot Be Used

Unlike the licenseinfo command in cmsh (section 4.1), the verify-license utility can check licenses even if the cluster management daemon is not running.

When an invalid license is used, the cluster management daemon cannot start. The license problem is logged in the cluster management daemon log file:

#### Example

```
[root@bright82 ~]# service cmd start
Waiting for CMDaemon to start...
CMDaemon failed to start please see log file.
[root@bright82 ~]# tail -1 /var/log/cmdaemon
Dec 30 15:57:02 bright82 CMDaemon: Fatal: License has expired
```

but further information cannot be obtained using Bright View or cmsh, because these clients themselves obtain their information from the cluster management daemon.

In such a case, the verify-license utility allows the troubleshooting of license issues.

### 4.2.2 Using The verify-license Utility To Troubleshoot License Issues

There are four ways in which the verify-license utility can be used:

**1. Using verify-license with no options:** simply displays a usage text:

#### Example

```
[root@bright82 ~]# verify-license
Usage: verify-license <path to certificate> <path to keyfile> <verify|info|monthsleft[=12]>
       verify-license <verify|info|monthsleft[=12]> (uses /cm/local/apps/cmd/etc/cluster.pem,key)
```

**2. Using verify-license with the info option:** prints license details:

#### Example

```
[root@bright82 ~]# verify-license info
===== Certificate Information =====
Version:          7.0 and above
Edition:          Advanced
Common name:      bright82
Organization:     Bright Computing
Organizational unit: Development
Locality:         San Jose
State:            California
Country:          US
Serial:           98388
Starting date:    16 Oct 2017
Expiration date:  31 Dec 2038
MAC address:      FA:16:3E:37:5F:97
Pre-paid nodes:   100
Max Pay-per-use Nodes: 1000
Max Data Science Nodes: 80
Max OpenStack Nodes: 70
Accounting & reporting: Yes
Edge sites:       N/A
=====
[root@bright82 etc]#
```

**3. Using verify-license with the verify option:** checks the validity of the license:

- If the license is valid, then no output is produced and the utility exits with exit-code 0.
- If the license is invalid, then output is produced indicating what is wrong. Messages such as these are then displayed:
  - If the license is old:

#### Example

```
[root@bright82 ~]# verify-license verify
License has expired
License verification failed.
```

- If the certificate is not from Bright Computing:

#### Example

```
[root@bright82 ~]# verify-license verify
Invalid license: This certificate was not signed by
Bright Computing
License verification failed.
```

**4. Using `verify-license` with the `monthsleft [=<value>]` option:**

- If a number value is set for `monthsleft`, then
  - if the license is due to expire in more than that number of months, then the `verify-license` command returns nothing.
  - if the license is due to expire in less than that number of months, then the `verify-license` command returns the date of expiry
- If a number value is not set for `monthsleft`, then the value is set to 12 by default. In other words, the default value means that if the license is due to expire in less than 12 months, then the date of expiry of the license is displayed.

**Example**

```
[root@bright82 etc]# date
Wed Sep 19 14:55:16 CET 2018
[root@bright82 etc]# verify-license monthsleft
Bright Cluster Manager License expiration date: 31 Dec 2018
[root@bright82 etc]# verify-license monthsleft=3
[root@bright82 etc]# verify-license monthsleft=4
Bright Cluster Manager License expiration date: 31 Dec 2018
```

**4.2.3 Using The `versioninfo` Command To Verify The Cluster Manager Version**

The license version should not be confused with the cluster version. The license version is a license format version that rarely changes between cluster manager version releases. Thus a cluster can have a license with version 7.0, which was the license format introduced during Bright Cluster Manager 7.0, and have a cluster manager version 8.1.

The version of a cluster can be viewed with using the `versioninfo` command, which can be run from the main mode of `cmsh` as follows:

**Example**

```
root@bright82 ~]# cmsh
[bright82]% main
[bright82->main]% versioninfo
Version Information
-----
Cluster Manager      8.2
CMDaemon             1.9
CMDaemon Build       137793_34f576c826
Database Version      36125
```

In the preceding example, the version of the cluster manager is 8.2.

**4.3 Requesting And Installing A License Using A Product Key**

The license file is introduced at the start of this chapter (Chapter 4). As stated there, most administrators that have installed a new cluster, and who need to install a license on the cluster in order to make their Bright Cluster Manager fully functional, only need to do the following:

- Have their product key at hand
- Run the `install-license` script on the head node

The details of this section are therefore usually only of interest if a more explicit understanding of the process is required for some reason.

### 4.3.1 Is A License Needed?—Verifying License Attributes

Before installing a license, the license attributes should be verified (section 4.2) to check if installation is actually needed. If the attributes of the license are correct, the remaining parts of this section (4.3) may safely be skipped. Otherwise the *product key* (page 70) is used to install a license.

Incorrect license attributes will cause cluster configuration to fail or may lead to a misconfigured cluster. A misconfigured cluster may, for example, not have the ability to handle the full number of nodes. In particular, the license date should be checked to make sure that the license has not expired. If the license is invalid, and it should be valid according to the administrator, then the Bright Computing reseller that provided the software should be contacted with details to correct matters.

If Bright Cluster Manager is already running with a regular license, and if the license is due to expire, then reminders are sent to the administrator e-mail address (page 56 of the *Administrator Manual*).

### 4.3.2 The Product Key

A product key is issued by an account manager for Bright Cluster Manager. The product key allows a license to be obtained to run Bright Cluster Manager.

An account manager is the person at Bright Computing who checks that the product key user has the right entitlements to use the key before it is issued. The customer is informed who the account manager is when Bright Cluster Manager is purchased. Purchasing and licensing period queries are normally dealt with by the account manager, while other technical queries that cannot be answered by existing documentation can be dealt with by Bright Cluster Manager technical support (section 13.2 of the *Administrator Manual*).

The following product key types are possible:

- **Evaluation product key:** An evaluation license is a temporary license that can be installed via an evaluation product key. The evaluation product key is valid for a maximum of 3 months from a specified date, unless the account manager approves a further extension.

If a cluster has Bright Cluster Manager installed on it, then a temporary license to run the cluster can be installed with an evaluation product key. Such a key allows the cluster to run with defined attributes, such as a certain number of nodes and features enabled, depending on what was agreed upon with the account manager. The temporary license is valid until the product key expires, unless the account manager has approved further extension of the product key, and the license has been re-installed.

DVD downloads of Bright Cluster Manager from the Bright Computing website come with a built-in license that overrides any product key attributes. The license is valid for a maximum of 3 months from the download date. An evaluation product key allows the user to download such a DVD, and the built-in license then allows 2-node clusters to be tried out. Such a cluster can comprise 1 head node and 1 compute node, or comprise 2 head nodes.

- **Subscription product key:** A subscription license is a license can be installed with a subscription product key. The subscription product key has some attributes that decide the subscription length and other settings for the license. At the time of writing (September 2017), the subscription duration is a maximum of 5 years from a specified date.

If a cluster has Bright Cluster Manager installed on it, then a subscription license to run the cluster can be installed with a subscription product key. Such a key allows the cluster to run with defined attributes, such as a certain number of nodes and features enabled, depending on what was agreed upon with the account manager. The subscription license is valid until the subscription product key expires.

- **Hardware lifetime product key:** This is a legacy product key that is supported for the hardware lifetime. It is no longer issued.

**The product key looks like:** the following pattern of digits:

000354-515786-112224-207441-186713

**If the product key has been used on the cluster already:** then it can be retrieved from the CSR file (page 72) with the command:

```
cm-get-product-key
```

**The product key allows:** the administrator:

- to obtain and activate a license, which allows the cluster to function
- to register the key using the Bright Computing customer portal (section 4.3.9) account. This allows cluster extension cloudbursting (Chapter 3 of the *Cloudbursting Manual*) to function.

**The following terminology is used:** when talking about product keys, locking, licenses, installation, and registration:

- **activating a license:** A product key is obtained from any Bright Cluster Manager (re)seller. It is used to obtain and *activate* a license file. Activation means that Bright Computing records that the product key has been used to obtain a license file. The license obtained by product key activation permits the cluster to work with particular settings. For example, the subscription period, and the number of nodes. The subscription start and end date cannot be altered for the license file associated with the key, so an administrator normally activates the license file as soon as possible after the starting date in order to not waste the subscription period.
- **locking a product key:** The administrator is normally allowed to use a product key to activate a license only once. This is because a product key is *locked* on activation of the license. A locked state means that product key cannot activate a new license—it is “used up”.

An activated license only works on the hardware that the product key was used with. This could obviously be a problem if the administrator wants to move Bright Cluster Manager to new hardware. In such a case, the product key must be unlocked. Unlocking is possible for a subscription license via the customer portal (section 4.3.9). Unlocking an evaluation license, or a hardware lifetime license, is possible by sending a request to the account manager at Bright Computing to unlock the product key. Once the product key is unlocked, then it can be used once again to activate a new license.

- **license installation:** *License installation* occurs on the cluster after the license is activated and issued. The installation is done automatically if possible. Sometimes installation needs to be done manually, as explained in the section on the `request-license` script (page 71). The license can only work on the hardware it was specified for. After installation is complete, the cluster runs with the activated license.
- **product key registration:** *Product key registration* occurs on the customer portal (section 4.3.9) account when the product key is associated with the account. Registered customers can view their cloud services billing information amongst other items.

#### 4.3.3 Requesting A License With The `request-license` Script

If the license has expired, or if the license attributes are otherwise not correct, a new license file must be requested.

The request for a new license file is made using a product key (page 70) with the `request-license` command.

The `request-license` command is used to request and activate a license, and works most conveniently with a cluster that is able to access the internet. The request can also be made regardless of cluster connectivity to outside networks.

There are three options to use the product key to get the license:

1. **Direct WWW access:** If the cluster has access to the WWW port, then a successful completion of the `request-license` command obtains and activates the license. It also locks the product key.

- **Proxy WWW access:** If the cluster uses a web-proxy, then the environment variable `http_proxy` must be set before the `request-license` command is run. From a bash prompt this is set with:

```
export http_proxy=<proxy>
```

where `<proxy>` is the hostname or IP address of the proxy. An equivalent alternative is that the `ScriptEnvironment` directive (page 654 of the *Administrator Manual*), which is a `CMDaemon` directive, can be set and activated (page 639 of the *Administrator Manual*).

2. **Off-cluster WWW access:** If the cluster does not have access to the WWW port, but the administrator does have off-cluster web-browser access, then the point at which the `request-license` command prompts "Submit certificate request to `http://licensing.brightcomputing.com/licensing/index.cgi ?`" should be answered negatively. CSR (Certificate Sign Request) data generated is then conveniently displayed on the screen as well as saved in the file `/cm/local/apps/cmd/etc/cluster.csr.new`. The `cluster.csr.new` file may be taken off-cluster and processed with an off-cluster browser.

The CSR file should not be confused with the private key file, `cluster.key.new`, created shortly beforehand by the `request-license` command. In order to maintain cluster security, the private key file must, in principle, never leave the cluster.

At the off-cluster web-browser, the administrator may enter the `cluster.csr.new` content in a web form at:

```
http://licensing.brightcomputing.com/licensing
```

A signed license text is returned. At Bright Computing the license is noted as having been activated, and the product key is locked.

The signed license text received by the administrator is in the form of a plain text certificate. As the web form response explains, it can be saved directly from most browsers. Cutting and pasting the text into an editor and then saving it is possible too, since the response is plain text. The saved signed license file, `<signedlicense>`, should then be put on the head node. If there is a copy of the file on the off-cluster machine, the administrator should consider wiping that copy in order to reduce information leakage.

The command:

```
install-license <signedlicense>
```

installs the signed license on the head node, and is described further on page 73. Installation means the cluster now runs with the activated certificate.

3. **Fax or physical delivery:** If no internet access is available at all to the administrator, the CSR data may be faxed or sent as a physical delivery (postal mail print out, USB flash drive/floppy disk) to any Bright Cluster Manager reseller. A certificate will be faxed or sent back in response, the license will be noted by Bright Computing as having been activated, and the associated product key will be noted as being locked. The certificate can then be handled further as described in option 2.

## Example

```
[root@bright82 ~]# request-license
Product Key (XXXXXX-XXXXXX-XXXXXX-XXXXXX-XXXXXX):
000354-515786-112224-207440-186713

Country Name (2 letter code): US
State or Province Name (full name): California
Locality Name (e.g. city): San Jose
Organization Name (e.g. company): Bright Computing, Inc.
Organizational Unit Name (e.g. department): Development
Cluster Name: bright82
Private key data saved to /cm/local/apps/cmd/etc/cluster.key.new

MAC Address of primary head node (bright82) for eth0 [00:0C:29:87:B8:B3]:
Will this cluster use a high-availability setup with 2 head nodes? [y/N] n

Certificate request data saved to /cm/local/apps/cmd/etc/cluster.csr.new
Submit certificate request to http://licensing.brightcomputing.com/licensing/ ? [Y/n] y

Contacting http://licensing.brightcomputing.com/licensing/...
License granted.
License data was saved to /cm/local/apps/cmd/etc/cluster.pem.new
Install license ? [Y/n] n
Use "install-license /cm/local/apps/cmd/etc/cluster.pem.new" to install the license.
```

#### 4.3.4 Installing A License With The `install-license` Script

Referring to the preceding `request-license` example output:

The administrator is prompted to enter the MAC address for `eth0`.

After the certificate request is sent to Bright Computing and approved, the license is granted.

If the prompt “Install license?” is answered with a “Y” (the default), the `install-license` script is run automatically by the `request-license` script.

If the prompt is answered with an “n” then the `install-license` script must be run explicitly later on by the administrator in order to complete installation of the license. This is typically needed for clusters that have no direct or proxy web access (page 72).

The decision that is made at the prompt also has consequences for the reboot requirements of nodes. These consequences are explained in detail in section 4.3.8.

The `install-license` script takes the temporary location of the new license file generated by `request-license` as its argument, and installs related files on the head node. Running it completes the license installation on the head node.

#### Example

Assuming the new certificate is saved as `cluster.pem.new`:

```
[root@bright82 ~]# install-license /cm/local/apps/cmd/etc/cluster.pem.new
===== Certificate Information =====
Version:           8.2
Edition:           Advanced
Common name:       bright82
Organization:      Bright Computing, Inc.
Organizational unit: Development
Locality:          San Jose
State:             California
Country:           US
Serial:            9463
Starting date:     23 Dec 2012
```



```

Expiration date:      31 Dec 2013
MAC address:         08:0A:27:BA:B9:43
Pre-paid nodes:      10
Max Pay-per-use Nodes: 1000
=====

```

Is the license information correct ? [Y/n] y

Installed new license

Restarting Cluster Manager Daemon to use new license: OK

#### 4.3.5 Re-Installing A License After Replacing The Hardware

If a new head node is to be run on new hardware then:

- If the old head node is not able to run normally, then the new head node can have the head node data placed on it from the old head node data backup.
- If the old head node is still running normally, then the new head node can have data placed on it by a cloning action run from the old head node (section 14.4.8 of the *Administrator Manual*).

If the head node hardware has changed, then:

- a user with a subscription license can unlock the product key directly via the customer portal (section 4.3.9).
- a user with a hardware license almost always has the license under the condition that it expires when the hardware expires. Therefore, a user with a hardware license who is replacing the hardware is almost always restricted from a license reinstallation. Users without this restriction may request the account manager at Bright Computing to unlock the product key.

Using the product key with the `request-license` script then allows a new license to be requested, which can then be installed by running the `install-license` script. The `install-license` script may not actually be needed, but it does no harm to run it just in case afterwards.

#### 4.3.6 Re-Installing A License After Wiping Or Replacing The Hard Drive

If the head node hardware has otherwise not changed:

- The full drive image can be copied on to a blank drive and the system will work as before.
  - Alternatively, if a new installation from scratch is done
    - then after the installation is done, a license can be requested and installed once more using the same product key, using the `request-license` command. Because the product key is normally locked when the previous license request was done, a request to unlock the product key usually needs to be sent to the account manager at Bright Computing before the license request can be executed.
    - If the administrator wants to avoid using the `request-license` command and having to type in a product key, then some certificate key pairs must be placed on the new drive from the old drive, in the same locations. The procedure that can be followed is:
      1. in the directory `/cm/local/apps/cmd/etc/`, the following key pair is copied over:
        - \* `cluster.key`
        - \* `cluster.pem`
- Copying these across means that `request-license` does not need to be used.



2. The `admin.{pem|key}` key pair files can then be placed in the directory `/root/.cm/cmsh/`. Two options are:

- \* the following key pair can be copied over:

- `admin.key`
- `admin.pem`

or

- \* a fresh `admin.{pem|key}` key pair can be generated instead via a `cmd -b` option:

#### Example

```
[root@bright82 ~]# service cmd stop
[root@bright82 ~]# cmd -b
[root@bright82 ~]# [...]
Tue Jan 21 11:47:54 [ CMD ] Info: Created certificate in admin.pem
Tue Jan 21 11:47:54 [ CMD ] Info: Created certificate in admin.key
[root@bright82 ~]# [...]
[root@bright82 ~]# chmod 600 admin.*
[root@bright82 ~]# mv admin.* /root/.cm/cmsh/
[root@bright82 ~]# service cmd start
```

It is recommended for security reasons that the administrator ensure that unnecessary extra certificate key pair copies no longer exist after installation on the new drive.

### 4.3.7 Re-Installing A License With An Add-On Attribute

An add-on to a product key, such as the Data Science add-on, can be enabled on a license that does not originally have that attribute. For the Data Science add-on, the URL <http://licensing.brightcomputing.com/licensing/activate-data-science> provides a wizard to activate the Bright Data Science functionalities. For other add-ons, Bright support can be contacted via <http://support.brightcomputing.com> for further instructions.

### 4.3.8 Rebooting Nodes After An Install

**The first time a product key is used:** After using a product key with the command `request-license` during a cluster installation, and then running `install-license`, a reboot is required of all nodes in order for them to pick up and install their new certificates (section 5.4.1 of the *Administrator Manual*). The `install-license` script has at this point already renewed the administrator certificates on the head node that are for use with `cmsh` and Bright View. The parallel execution command `pdsh -g computenode reboot` suggested towards the end of the `install-license` script output is what can be used to reboot all other nodes. Since such a command is best done by an administrator manually, `pdsh -g computenode reboot` is not scripted.

**The subsequent times that the same product key is used:** If a license has become invalid, a new license may be requested. On running the command `request-license` for the cluster, the administrator is prompted on whether to re-use the existing keys and settings from the existing license:

#### Example

```
[root@bright82 ~]# request-license
Product Key (XXXXXX-XXXXXX-XXXXXX-XXXXXX-XXXXXX): 061792-900914-800220-270420-077926
```

Existing license was found:

```
Country: US
State: None
Locality: None
Organization: None
Organizational Unit: None
```

Cluster Name: bright82

You can choose whether to re-use private key and settings from existing license.

If you answer NO, existing certificates will be invalidated and nodes will have to be rebooted.

...

- If the existing keys are kept, a `pdsh -g computenode reboot` is not required. This is because these keys are X509v3 certificates issued from the head node. For these:
  - Any node certificates (section 5.4.1 of the *Administrator Manual*) that were generated using the old certificate are therefore still valid and so regenerating them for nodes via a reboot is not required, allowing users to continue working uninterrupted. On reboot new node certificates are generated and used if needed.
  - User certificates (section 6.4 of the *Administrator Manual*) become invalid during certificate regeneration when CMDaemon restarts itself. It is therefore advised to install a permanent license as soon as possible, or alternatively, to not bother creating user certificates until a permanent license has been set up for the cluster.
- If the existing keys are not re-used, then node communication ceases until the nodes are rebooted. If there are jobs running on the Bright Cluster Manager nodes, they cannot then complete.

After the license is installed, verifying the license attribute values is a good idea. This can be done using the `licenseinfo` command in `cmsh`, or by selecting the `License info` menu option from within the `Partition base` window in Bright View's Cluster resource (section 4.1).

### The License Log File

License installation and changes are logged in

`/var/spool/cmd/license.log`

to help debug issues.

### 4.3.9 The Customer Portal

Bright Cluster Manager owners with a subscription license can use the customer portal at <https://customer.brightcomputing.com/Customer-Login> to:

- Register a subscription product key
- Unlock a subscription product key
- Request support, including with a non-activated key
- Opt-in to receive release notes e-mails
- Enable cloudbursting
- See usage statistics
- See AWS-related prices and account balance

# 5

## Linux Distributions That Use Registration

This chapter describes setting up registered access for the Bright Cluster Manager with the Red Hat and SUSE distributions.

The head node and regular node images can be set up with registered access to the enterprise Linux distributions of Red Hat and SUSE so that updates from their repositories can take place on the cluster correctly. This allows the distributions to continue to provide support and security updates. Registered access can also be set up in order to create an up-to-date custom software image (section 11.6 of the *Administrator Manual*) if using Red Hat or SUSE as the base distribution.

Registered access can be avoided for the head node and regular node images by moving the registration requirement to outside the cluster. This can be done by configuring registration to run from a local mirror to the enterprise Linux distributions. The head node and regular node images are then configured to access the local mirror repository. This configuration has the benefit of reducing the traffic between the local network and the internet. However it should be noted that the traffic from node updates scales according to the number of regular node images, rather than according to the number of nodes in the cluster. In most cases, therefore, the added complication of running a separate repository mirror, is unlikely to be worth implementing.

### 5.1 Registering A Red Hat Enterprise Linux Based Cluster

To register a Red Hat Enterprise Linux (RHEL) system, Red Hat subscriptions are needed as described at <https://www.redhat.com/>. Registration with the Red Hat Network is needed to install new RHEL packages or receive RHEL package updates, as well as carry out some other tasks.

#### 5.1.1 Registering A Head Node With RHEL

An RHEL head node can be registered from the command line with the `subscription-manager` command. This uses the Red Hat subscription service username and password as shown:

```
[root@bright82 ~]# subscription-manager register --username <username> --password <password> \
--auto-attach
```

The `--auto-attach` option allows a system to update its subscription automatically, so that the system ends up with a valid subscription state.

If the head node has no direct connection to the internet, then an HTTP proxy can be configured as a command line option. The `subscription-manager` man pages give details on configuring the proxy from the command line.

A valid subscription means that, if all is well, then the RHEL server RPMs repository (`rhel-6-server-rpms` or `rhel-7-server-rpms`) is enabled, and means that RPMs can be picked up from that repository.

The optional RPMs repository (rhel-6-server-optional-rpms, rhel-7-server-optional-rpms) must still be enabled using, for example:

```
[root@bright82 ~]# subscription-manager repos --enable rhel-7-server-optional-rpms
Repository 'rhel-7-server-optional-rpms' is enabled for this system.
```

For some RHEL7 packages, the RHEL7 extras repository has to be enabled in a similar manner. The option used is then `--enable rhel-7-server-extras-rpms`.

A list of the available repositories for a subscription can be retrieved using:

```
[root@bright82 ~]# subscription-manager repos --list
+-----+
| Available Repositories in /etc/yum.repos.d/redhat.repo |
+-----+
Repo ID:    rhel-7-server-dotnet-debug-rpms
Repo Name:  dotNET on RHEL Debug RPMs for Red Hat Enterprise Linux 7 Server
Repo URL:   https://cdn.redhat.com/content/dist/rhel/server/7/$releasever/$basearch/dotnet/1/debug
Enabled:    0
....
```

After registration, the yum subscription-manager plugin is enabled. This means that yum can now be used to install and update from the Red Hat Network repositories.

### 5.1.2 Registering A Software Image With RHEL

The subscription-manager command can be used to register an RHEL software image. If the head node, on which the software image resides, has no direct connection to the internet, then an HTTP proxy can be configured as a command line option. The subscription-manager man pages give details on configuring the proxy from the command line.

The default software image, default-image, can be registered by mounting some parts of the filesystem image, and then carrying out the registration within the image by using the Red Hat subscription service username and password. This can be carried out on the head node, with the help of the Bright Cluster Manager `cm-chroot-sw-img` tool (page 442 of the *Administrator Manual*) as follows:

```
[root@bright82 ~]# cm-chroot-sw-img /cm/images/default-image subscription-manager register --username \
<username> --password <password> --auto-attach
```

After the software image is registered, the optional and extras RPMs repository must be enabled using, for RHEL7 systems:

```
[root@bright82 ~]# cm-chroot-sw-img /cm/images/default-image subscription-manager repos --enable \
rhel-7-server-optional-rpms
[root@bright82 ~]# cm-chroot-sw-img /cm/images/default-image subscription-manager repos --enable \
rhel-7-server-extras-rpms
```

After registration, the yum subscription-manager plugin is enabled within the software image. This means that yum can now be used to install and update the software image from the Red Hat Network repositories

## 5.2 Registering A SUSE Linux Enterprise Server Based Cluster

To register a SUSE Linux Enterprise Server system, SUSE Linux Enterprise Server subscriptions are needed as described at <http://www.suse.com/>. Registration with Novell helps with installing new SLES packages or receiving SLES package updates, as well as to carry out some other tasks.

### 5.2.1 Registering A Head Node With SUSE

The SUSEConnect command can be used to register a SUSE 12 head node. If the head node has no direct connection to the internet, then the HTTP\_PROXY and HTTPS\_PROXY environment variables can be set, to access the internet via a proxy. Running the registration command with the help option, "--help", provides further information about the command and its options.

The head node can be registered as follows:

```
[root@bright82~]# SUSEConnect -e <e-mail address> -r regcode-\
sles=<activation code> -u https://scc.suse.com #for SLES12
```

The e-mail address used is the address that was used to register the subscription with Novell. When logged in on the Novell site, the activation code or registration code can be found at the products overview page after selecting "SUSE Linux Enterprise Server".

After registering, the SLES and SLE SDK repositories are added to the repository list and enabled.

The defined repositories can be listed with:

```
[root@bright82 ~]# zypper lr
```

and the head node can be updated with:

```
[root@bright82 ~]# zypper refresh
[root@bright82 ~]# zypper update
```

### 5.2.2 Registering A Software Image With SUSE

The SUSEConnect command can be used to register a SUSE12 software image. If the head node on which the software image resides has no direct connection to the internet, then the HTTP\_PROXY and HTTPS\_PROXY environment variables can be set to access the internet via a proxy. Running the command with the help option, "--help", provides further information about the command and its options.

The default software image default-image can be registered by running the following on the head node:

```
[root@bright82~]# chroot /cm/images/default-image \
SUSEConnect -e <-mail address> -r regcode-sles= \
<activation code> -u https://scc.suse.com #for SLES12
```

The e-mail address is the address used to register the subscription with Novell. When logged in on the Novell site, the activation code or registration code can be found at the products overview page after selecting "SUSE Linux Enterprise Server".

When running the registration command, warnings about the /sys or /proc filesystems can be ignored. The command tries to query hardware information via these filesystems, but these are empty filesystems in a software image, and only fill up on the node itself after the image is provisioned to the node.

Instead of registering the software image, the SLES repositories can be enabled for the default-image software image with:

```
[root@bright82 ~]# cp /etc/zypp/repos.d/* /cm/images/default-image/etc/zypp/repos.d/
[root@bright82 ~]# cp /etc/zypp/credentials.d/* /cm/images/default-image/etc/zypp\
/credentials.d/
[root@bright82 ~]# cp /etc/zypp/service.d/* /cm/images/default-image/etc/zypp\
/service.d/
```

The copied files should be reviewed. Any unwanted repositories, unwanted service files, and unwanted credential files, must be removed.

The repository list of the default-image software image can be viewed with the chroot option, -R, as follows:

```
[root@bright82 ~]# zypper -R /cm/images/default-image lr
```

and the software image can be updated with:

```
[root@bright82 ~]# export PBL_SKIP_BOOT_TEST=1
[root@bright82 ~]# zypper -R /cm/images/default-image refresh
[root@bright82 ~]# zypper -R /cm/images/default-image update
[root@bright82 ~]# zypper -R /cm/images/default-image clean --all
```

# 6

## Changing The Network Parameters Of The Head Node

### 6.1 Introduction

After a cluster physically arrives at its site, the administrator often has to change the network settings to suit the site. Details on this are given in section 3.2.1 of the *Administrator Manual*. However, it relies on understanding the material leading up to that section.

This chapter is therefore a quickstart document—conveniently a mere 3 pages—explaining how to change basic IPv4 network settings while assuming no prior knowledge of Bright Cluster Manager and its network configuration interface.

### 6.2 Method

A cluster consists of a head node, say `bright82` and one or more regular nodes. The head node of the cluster is assumed to face the internal network (the network of regular nodes) on one interface, say `eth0`. The external network leading to the internet is then on another interface, say `eth1`. This is referred to as a *type 1* configuration in this manual (section 3.3.7).

Typically, an administrator gives the head node a static external IP address before actually connecting it up to the external network. This requires logging into the physical head node with the vendor-supplied root password. The original network parameters of the head node can then be viewed and set. For example for `eth1`:

```
# cmsh -c "device interfaces bright82; get eth1 dhcp"
yes
```

Here, `yes` means the interface accepts DHCP server-supplied values.

Disabling DHCP acceptance allows a static IP address, for example `192.168.1.176`, to be set:

```
# cmsh -c "device interfaces bright82; set eth1 dhcp no"
# cmsh -c "device interfaces bright82; set eth1 ip 192.168.1.176; commit"
# cmsh -c "device interfaces bright82; get eth1 ip"
192.168.1.176
```

Other external network parameters can be viewed and set in a similar way, as shown in table 6.1. A reboot implements the networking changes.

### 6.3 Terminology

A reminder about the less well-known terminology in the table:

- `netmaskbits` is the netmask size, or prefix-length, in bits. In IPv4's 32-bit addressing, this can be up to 31 bits, so it is a number between 1 and 31. For example: networks with 256 ( $2^8$ ) addresses (i.e.

Table 6.1: External Network Parameters And How To Change Them On The Head Node

Network Parameter	Description	Operation	Command Used
IP*	IP address of head node on eth1 interface	view set	cmsh -c "device interfaces bright82; get eth1 ip" cmsh -c "device interfaces bright82; set eth1 ip <i>address</i> ; commit"
baseaddress*	base IP address (network address) of network	view set	cmsh -c "network get externalnet baseaddress" cmsh -c "network; set externalnet baseaddress <i>address</i> ; commit"
broadcastaddress*	broadcast IP address of network	view set	cmsh -c "network get externalnet broadcastaddress" cmsh -c "network; set externalnet broadcastaddress <i>address</i> ; commit"
netmaskbits	netmask in CIDR notation (number after "/", or prefix length)	view set	cmsh -c "network get externalnet netmaskbits" cmsh -c "network; set externalnet netmaskbits <i>bitsize</i> ; commit"
gateway*	gateway (default route) IP address	view set	cmsh -c "network get externalnet gateway" cmsh -c "network; set externalnet gateway <i>address</i> ; commit"
nameservers*,**	nameserver IP addresses	view set	cmsh -c "partition get base nameservers" cmsh -c "partition; set base nameservers <i>address</i> ; commit"
searchdomains**	name of search domains	view set	cmsh -c "partition get base searchdomains" cmsh -c "partition; set base searchdomains <i>hostname</i> ; commit"
timeservers**	name of timeservers	view set	cmsh -c "partition get base timeservers" cmsh -c "partition; set base timeservers <i>address</i> ; commit"

\* If *address* is set to 0.0.0.0 then the value offered by the DHCP server on the external network is accepted  
\*\* Space-separated multiple values are also accepted for these parameters when setting the value for *address* or *hostname*.



with host addresses specified with the last 8 bits) have a netmask size of 24 bits. They are written in CIDR notation with a trailing “/24”, and are commonly spoken of as “slash 24” networks.

- **baseaddress** is the IP address of the network the head node is on, rather than the IP address of the head node itself. The **baseaddress** is specified by taking **netmaskbits** number of bits from the IP address of the head node. Examples:
  - A network with 256 ( $2^8$ ) host addresses: This implies the first 24 bits of the head node’s IP address are the network address, and the remaining 8 bits are zeroed. This is specified by using “0” as the last value in the dotted-quad notation (i.e. zeroing the last 8 bits). For example: 192.168.3.0
  - A network with 128 ( $2^7$ ) host addresses: Here **netmaskbits** is 25 bits in size, and only the last 7 bits are zeroed. In dotted-quad notation this implies “128” as the last quad value (i.e. zeroing the last 7 bits). For example: 192.168.3.128.

When in doubt, or if the preceding terminology is not understood, then the values to use can be calculated using the head node’s **sipcalc** utility. To use it, the IP address in CIDR format for the head node must be known.

When run using a CIDR address value of 192.168.3.130/25, the output is (some output removed for clarity):

```
# sipcalc 192.168.3.130/25
```

```
Host address      - 192.168.3.130
Network address   - 192.168.3.128
Network mask      - 255.255.255.128
Network mask (bits) - 25
Broadcast address - 192.168.3.255
Addresses in network - 128
Network range     - 192.168.3.128 - 192.168.3.255
```

Running it with the **-b** (binary) option may aid comprehension:

```
# sipcalc -b 192.168.3.130/25
```

```
Host address      - 11000000.10101000.00000011.10000010
Network address   - 11000000.10101000.00000011.10000000
Network mask      - 11111111.11111111.11111111.10000000
Broadcast address - 11000000.10101000.00000011.11111111
Network range     - 11000000.10101000.00000011.10000000 -
                   11000000.10101000.00000011.11111111
```



# Third Party Software

In this chapter, several third party software packages included in the Bright Cluster Manager repository are described briefly. For all packages, references to the complete documentation are provided.

## 7.1 Modules Environment

RHEL and derivatives, and SLES Bright Cluster Manager package name: `env-modules`

Ubuntu package name: `cm-modules`

The *modules environment* package is installed by default on the head node. The home page for the software is at <http://modules.sourceforge.net/>). The software allows a user of a cluster to modify the shell environment for a particular application, or even for a particular version of an application. Typically, a module file defines additions to environment variables such as `PATH`, `LD_LIBRARY_PATH`, and `MANPATH`.

Cluster users use the `module` command to load or remove modules from their environment. The `module(1)` man page has more details about the command, and aspects of the modules environment that are relevant for administrators are discussed in section 2.2 of the *Administrator Manual*. Also discussed there is `Lmod`, the Lua-based alternative to the Tcl-based traditional modules environment package.

The modules environment from a user's perspective is covered in section 2.3 of the *User Manual*.

## 7.2 Shorewall

Package name: `shorewall`

### 7.2.1 The Shorewall Service Paradigm

Bright Cluster Manager provides the Shoreline Firewall (more commonly known as "Shorewall") package from the Bright repository. The package provides firewall and gateway functionality on the head node of a cluster.

Shorewall is a flexible and powerful high-level interface for the netfilter packet filtering framework. Netfilter is a standard part of Linux kernels. As its building blocks, Shorewall uses `iptables` and `iptables6` commands to configure netfilter. All aspects of firewall and gateway configuration are handled through the configuration files located in `/etc/shorewall`.

Shorewall IPv4 configuration is managed with the `shorewall` command, while IPv6 configuration is managed via the `shorewall6` command. IPv4 filtering and IPv6 filtering are treated as separate services in Shorewall. For convenience, only IPv4 Shorewall is described from here onward, because IPv6 management is largely similar.

After modifying Shorewall configuration files, Shorewall must be restarted to have the new configuration take effect. From the shell prompt, this can be carried out with:

```
service shorewall restart
```

In Bright Cluster Manager 8.2, Shorewall is managed by CMDaemon, in order to handle the automation of cloud node access. Restarting Shorewall can thus also be carried out within the services sub-mode (section 3.11 of the *Administrator Manual*), on the head node. For example a head node bright82 the cmsh session to carry out a restart of shorewall might be:

```
[bright82->device[bright82]->services[shorewall]]% restart
restart Successfully restarted service shorewall on: bright82
```

System administrators who need a deeper understanding of how Shorewall is implemented should be aware that Shorewall does not really run as a daemon process. The command to restart the service therefore does not stop and start a shorewall daemon. Instead it carries out the configuration of netfilter through implementing the iptables configuration settings, and then exits. It exits without leaving a shorewall process up and running, even though `service shorewall status` shows it is running.

### 7.2.2 Shorewall Zones, Policies, And Rules

In the default setup, Shorewall provides gateway functionality to the internal cluster network on the first network interface (eth0). This network is known as the nat zone to Shorewall. The external network (i.e. the connection to the outside world) is assumed to be on the second network interface (eth1). This network is known as the net zone in Shorewall.

Letting Bright Cluster Manager take care of the network interfaces settings is recommended for all interfaces on the head node (section 3.2 of the *Administrator Manual*). The file `/etc/shorewall/interfaces` is generated by the cluster management daemon, and any extra instructions that cannot be added via Bright View or cmsh can be added outside of the file section clearly demarcated as being maintained by CMDaemon.

Shorewall is configured by default (through `/etc/shorewall/policy`) to deny all incoming traffic from the net zone, except for the traffic that has been explicitly allowed in `/etc/shorewall/rules`. Providing (a subset of) the outside world with access to a service running on a cluster, can be accomplished by creating appropriate rules in `/etc/shorewall/rules`. By default, the cluster responds to ICMP ping packets. Also, during cluster installation, the following ports are open by default, but can be set to be blocked by the administrator (figure 3.32):

- SSH
- HTTP
- HTTPS
- port 8081, which allows access to the cluster management daemon.

### 7.2.3 Clear And Stop Behavior In `service` Options, `bash` Shell Command, And `cmsh` Shell

To remove all rules, for example for testing purposes, the `clear` option should be used from the Unix shell. This then allows all network traffic through:

```
shorewall clear
```

Administrators should be aware that in the Linux distributions supported by Bright Cluster Manager, the `service shorewall stop` command corresponds to the unix shell `shorewall stop` command, and not to the unix shell `shorewall clear` command. The `stop` option for the service and shell blocks network traffic but allows a pre-defined minimal safe set of connections, and is not the same as completely removing Shorewall from consideration. The stop options discussed so far should not be confused with the equivalent stop option in the cmsh shell.

This situation is indicated in the following table:

*Correspondence Of Stop And Clear Options In Shorewall Vs cmsh*

iptables rules	Service	Unix Shell	cmsh shell
keep a safe set:	service shorewall stop	shorewall stop	<i>no equivalent</i>
clear all rules:	<i>no equivalent</i>	shorewall clear	stop shorewall

### 7.2.4 Further Shorewall Quirks

#### Standard Distribution Firewall Should Be Disabled

Administrators should also be aware that RHEL and its derivatives run their own set of high-level iptables setup scripts if the standard distribution firewall is enabled. To avoid conflict, the standard distribution firewall in RHEL7 and its derivatives, Firewalld, must stay disabled, because Bright Cluster Manager requires Shorewall for regular functioning. Shorewall can be configured to set up whatever iptables rules are installed by the standard distribution script instead.

#### Shorewall Stopped Outside Of Bright Cluster Manager Considered Harmful

System administrators wishing to stop Shorewall should note that Bright Cluster Manager by default has the autostart setting (section 3.11 of the *Administrator Manual*) set to on. With such a value, CM-Daemon attempts to restart a stopped Shorewall if the service has been stopped from outside of cmsh or Bright View.

Stopping Shorewall outside of cmsh or Bright View is considered harmful, because it can trigger a failover. This is because stopping Shorewall blocks the failover prevention monitoring tests. These tests are the status ping and backup ping (both based on ICMP packet connections), and the CMDaemon status (based on REST calls) (section 14.4.2 of the *Administrator Manual*). In most cases, with default settings, Shorewall is not restarted in time, even when autostart is on, so that a failover then takes place.

A failover procedure is quite a sensible option when Shorewall is stopped from outside of cmsh or Bright View, because besides the failover monitoring tests failing, other failures also make the head node pretty useless. The blocking of ports means that, amongst others, workload managers and NFS shares are also unable to connect. Ideally, therefore, Shorewall should not be stopped outside cmsh or Bright View in the first place.

Full documentation on the specifics of Shorewall is available at <http://www.shorewall.net>.

## 7.3 Compilers

Bright Computing provides convenient RPM and .deb packages for several compilers that are popular in the HPC community. All of those may be installed through yum, zypper, or apt (section 11.2 of the *Administrator Manual*) but (with the exception of GCC) require an installed license file to be used.

### 7.3.1 GCC

Package name: gcc-recent for RHEL and derivatives, and SLES. cm-gcc for Ubuntu

The GCC suite that the distribution provides is also present by default.

### 7.3.2 Intel Compiler Suite

Package names:

*Packages In The Intel Compiler Suite Versions For RHEL And Derivatives, SLES, And Ubuntu*

2018	2019
intel-compiler-common-2018	intel-compiler-common-2019
intel-cc-2018	intel-cc-2019

intel-daal-2018	intel-daal-2019
intel-daal-2018-32	intel-daal-2019-32
intel-fc-2018	intel-fc-2019
intel-gdb-2018	intel-gdb-2019
intel-ipp-2018	intel-ipp-2019
intel-ipp-2018-32	intel-ipp-2019-32
intel-ipp-2018-devel	intel-ipp-2019-devel
intel-ipp-2018-devel-32	intel-ipp-2019-devel-32
intel-itac-2018	intel-itac-2019
intel-mkl-2018	intel-mkl-2019
intel-mkl-2018-32	intel-mkl-2019-32
intel-mpi-2018	intel-mpi-2019
intel-openmp-2018	intel-openmp-2019
intel-openmp-2018-32	intel-openmp-2019-32
intel-tbb-2018	intel-tbb-2019

The Intel compiler packages are provided as part of a suite.

- Intel® Parallel Studio XE 2018 provides a 2018 version of the suite
- Intel® Parallel Studio XE 2019 provides a 2019 version of the suite

Bright Cluster Manager 8.2 supports the 2018 and 2019 versions of the Intel compiler suites. They are supported for RHEL and derivatives, SLES, and Ubuntu, and are available for x86\_64.

Typically the compiler suite includes the Intel Fortran (indicated by `fc`) and Intel C++ compilers (part of the C compiler package, indicated by `cc`). 32-bit compilers are included in the `intel-cc-<year>` and `intel-fc-<year>` packages.

For the other packages, a 32-bit version is sometimes available separately. The 32-bit packages have package names ending in “-32”

Both the 32-bit and 64-bit versions can be invoked through the same set of commands. The modules environment (section 2.2 of the *Administrator Manual*) provided when installing the packages can be loaded accordingly, to select one of the two versions. For the C++ and Fortran compilers the 64-bit and 32-bit modules are called as modules beginning with `intel/compiler/64` and `intel/compiler/32` respectively.

The Intel compiler can be accessed by loading the compiler modules under `intel/compiler/64` or `intel/compiler/32`. The following commands can be used to run the Intel compilers:

- `icc`: Intel C/C++ compiler
- `ifort`: Intel Fortran 90/95 compiler

Optional packages are:

- `intel-ipp`: Integrated Performance Primitives
- `intel-daal`: Data Analytics Acceleration Library
- `intel-gdb`: The GNU Project Debugger For Intel Architecture
- `intel-mpi`: Multifabric MPI Library
- `intel-mkl`: Math Kernel Library

- `intel-itac`: Trace Analyzer And Collector
- `intel-tbb`: Threading Building Blocks

A short summary of a package can be shown using, for example: `yum info intel-fc-<year>`.

The compiler packages require a license, obtainable from Intel, and placed in `/cm/shared/licenses/intel`.

Full documentation for the Intel compilers is available at <http://software.intel.com/en-us/intel-compilers/>.

In the following example the license file is copied into the appropriate location, the C/C++ compiler is installed, and a modules environment (section 2.2 of the *Administrator Manual*) is loaded for use in this session by the root user. Furthermore, the modules environment is added for regular root user use with `module initadd`:

### Example

```
[root@bright82~]# cp <license file> /cm/shared/licenses/intel/
[root@bright82~]# yum install intel-cc-2019
(installation text output skipped)
[root@bright82~]# module load intel/compiler/64/2019/19.0.2
[root@bright82~]# module initadd intel/compiler/64/2019/19.0.2
```

How to load modules for use and regular use by non-root users is explained in section 2.2.3 of the *Administrator Manual*.

### 7.3.3 PGI High-Performance Compilers

Package name: `pgi`

The PGI compiler package contains the PGI C++ and Fortran 77/90/95 compilers.

- `pgcc`: PGI C compiler
- `pgc++`: PGI C++ compiler
- `pgf77`: PGI Fortran 77 compiler
- `pgf90`: PGI Fortran 90 compiler
- `pgf95`: PGI Fortran 95 compiler
- `pgdbg`: PGI debugger

The package can be installed with, for example:

```
yum install pgi
```

The license file for PGI can be placed at:

```
/cm/shared/licenses/pgi/license.dat
```

The PGI module environment can be loaded with:

```
module load shared pgi
```

Further documentation for the PGI High-Performance Compilers is available at:

```
http://www.pgroup.com/resources/docs.htm
```

### 7.3.4 FLEXlm License Daemon

Package name: flexlm

Bright Cluster Manager provides the latest free version of FLEXlm (version 9.5). However, Intel provides a more recent version, which is needed for more recent compilers.

The free version is described in this section.

For the Intel and PGI compilers a FLEXlm license must be present in the `/cm/shared/licenses` tree.

For workstation licenses, i.e. a license which is only valid on the head node, the presence of the license file is typically sufficient.

However, for floating licenses, i.e. a license which may be used on several machines, possibly simultaneously, the FLEXlm license manager, `lmgrd`, must be running.

The `lmgrd` service serves licenses to any system that is able to connect to it through the network. With the default firewall configuration, this means that licenses may be checked out from any machine on the internal cluster network. Licenses may be installed by adding them to `/cm/shared/licenses/lmgrd/license.dat`. Normally any FLEXlm license starts with the following line:

```
SERVER hostname MAC port
```

Only the first FLEXlm license that is listed in the `license.dat` file used by `lmgrd` may contain a `SERVER` line. All subsequent licenses listed in `license.dat` should have the `SERVER` line removed. This means in practice that all except for the first licenses listed in `license.dat` start with a line:

```
DAEMON name /full/path/to/vendor-daemon
```

The `DAEMON` line must refer to the vendor daemon for a specific application. For PGI the vendor daemon (called `pgroupd`) is included in the `pgi` package. For Intel the vendor daemon (called `INTEL`) must be installed from the `flexlm-intel`.

Installing the `flexlm` package adds a system account `lmgrd` to the password file. The account is not assigned a password, so it cannot be used for logins. The account is used to run the `lmgrd` process. The `lmgrd` service is not configured to start up automatically after a system boot, but can be configured to do so with:

```
chkconfig lmgrd on
```

The `lmgrd` service is started manually with:

```
service lmgrd start
```

The `lmgrd` service logs its transactions and any errors to `/var/log/lmgrd.log`.

## 7.4 CUDA For GPUs

The optional CUDA packages should be deployed in order to take advantage of the computational capabilities of NVIDIA GPUs. The packages may already be in place, and ready for deployment on the cluster, depending on the particular Bright Cluster Manager software that was obtained. If the CUDA packages are not in place, then they can be picked up from the Bright Computing repositories, or a local mirror.

### 7.4.1 Installing CUDA

#### CUDA Packages Available

At the time of writing of this section (September 2021) CUDA 10.1, 10.2, 11.0, 11.1, 11.2, 11.3 and 11.4 packages exist in the YUM, zypper, and APT repositories of Bright Computing. The available versions are updated typically in the next subversion release of Bright Cluster Manager after the upstream changes are made available. The latest packages available can be viewed at <https://support.brightcomputing.com/packages-dashboard/>.



**CUDA packages that the cluster administrator manages:** At the time of writing, the packages that the cluster administrator can install or remove for Bright Cluster Manager are:

Package	Type	Description
cuda10.1-toolkit cuda10.2-toolkit cuda11.0-toolkit† cuda11.1-toolkit† cuda11.2-toolkit† cuda11.3-toolkit†	} shared	CUDA math libraries and utilities
cuda10.2-visual-tools cuda11.0-visual-tools† cuda11.1-visual-tools† cuda11.2-visual-tools† cuda11.3-visual-tools†	} shared	CUDA visual toolkit
cuda10.1-sdk cuda10.2-sdk cuda11.0-sdk† cuda11.1-sdk† cuda11.2-sdk† cuda11.3-sdk†	} shared	CUDA software development kit
cuda-driver	local	CUDA Tesla GPU driver and libraries.
cuda-dcgm	local	CUDA Data Center GPU Manager (DCGM). This includes the dcgmi CLI tool.
cuda-xorg**	local	CUDA X.org driver and libraries

† not available in SLES12

\*\* optional, not used in Ubuntu

The packages of type `shared` in the preceding table should be installed on the head nodes of a cluster using CUDA-compatible GPUs. The packages of type `local` should be installed to all nodes that access the GPUs. In most cases this means that the `cuda-driver` and `cuda-dcgm` packages should be installed in a software image (section 2.1.2 of the *Administrator Manual*).

If a head node also accesses GPUs, then the `cuda-driver` and `cuda-dcgm` packages should be installed on it, too.

For packages of type `shared`, the particular CUDA version that is run on the node can be selected via a modules environment command:

### Example

```
module add shared cuda11.1/toolkit
```

**CUDA packages that the cluster administrator normally does not manage:** As an aside, there are also the CUDA DCGM packages:

Package	Type	Description
cuda-dcgm-libs	local	NVIDIA DCGM libraries, installed by default
cuda-dcgm-devel	local	NVIDIA DCGM development files, not installed by default
cuda-dcgm-nvvs	local	NVIDIA DCGM validation suite, not installed by default

The preceding DCGM packages are installed in Bright Cluster Manager, because CMDaemon uses them to manage NVidia Tesla GPUs. Tesla drivers normally work for the latest CUDA version, and may not therefore not (yet) support the latest GeForce GPUs.

**CUDA package that the cluster administrator may wish to install for CUDA programming:** CUB is a CUDA programming library that developers may wish to access. It is provided by the package `cm-cub-cuda`, from the Machine Learning (`cm-ml`) repository.

#### CUDA package installation basic sanity check:

- The NVIDIA GPU hardware should be detectable by the kernel, otherwise the GPUs cannot be used by the drivers. Running the `lspci` command on the device with the GPU before the CUDA package driver installation is a quick check that should make it clear if the NVIDIA hardware is detected in the first place:

##### Example

(running `lspci` on `node001` which is where the GPU should be)

```
[root@node001]# lspci | grep NVIDIA
00:07.0 3D controller: NVIDIA Corporation GK110BGL [Tesla K40c] (rev a1)
```

If the hardware is not detected by the kernel already, then the administrator should reassess the situation.

- Only after CUDA package installation has taken place, and after rebooting the node with the GPU, are GPU details visible using the `sysinfo` command:

##### Example

(running `sysinfo` on `node001`, which is where the GPU is, via `cmsh` on the head node)

```
[root@bright82 ~]# cmsh
[bright82]% device use node001
[bright82->device[node001]]% sysinfo | grep GPU
Number of GPUs
GPU Driver Version          418.40.04
GPU0 Name                   NVIDIA Tesla K40c
GPU0 Power Limit            235 W
GPU0 Serial                 0321915051810
GPU0 BIOS                   80.80.3E.00.02
```

#### CUDA package installation guidelines for compilation with login nodes:

- CUDA compilation should take place on a node that uses NVidia GPUs during compilation.
  - Using a workload manager to allocate this task to GPU nodes is recommended.

- Cross compilation of CUDA software is generally not a best practice due to resource consumption, which can even lead to crashes.
  - If, despite this, cross compilation with a CPU is done, then the `cuda-driver` package should be installed on the node on which the compilation is done, and the GPU-related services on the node, such as:
    - \* `cuda-driver.service`
    - \* `nvidia-persistenced.service`
    - \* `cuda-dcgm.service`
 should be disabled.

### CUDA Package Dependencies

The CUDA packages have additional dependencies that may require access to repositories besides the main repository in order to resolve them automatically. For example, for Red Hat, a subscription (section 5.1.2) is needed to the `rhel-x86_64-server-optional-6` channel for RHEL6.

In particular, the `freeglut`, `freeglut-devel`, and `xorg-x11-util-macros` packages are required. The installation ISO/DVD that Red Hat provides contains packages from the main repository, and does not contain these packages. These packages are provided with a Bright Cluster Manager installation ISO/DVD for Red Hat. Updates must however come from a subscription to the Red Hat supplementary/optional channels. Packages that are needed for a working Bright cluster, and which are provided by the Bright Cluster Manager installation ISO/DVD, but which are not provided in the Red Hat installation DVD, are discussed in general in section 11.6.2 of the *Administrator Manual*, where the problems that such package dependencies can cause when creating a software image for a cluster with `cm-create-image` are discussed.

As a separate issue, one of the dependencies of the `cuda-driver` package is the `freeglut-devel` package, so it should be installed on a node that accesses a GPU. If the CUDA SDK source is to be compiled on the head node (with the head node not accessing a GPU, and with the `cuda-driver` package not installed) then the `freeglut`, `freeglut-devel`, and `libXi-devel` packages should be installed on the head node.

The `cuda-driver` package is used to compile the kernel drivers which manage the GPU. Therefore, when installing `cuda-driver` with `yum`, several other X11-related packages are installed too, due to package dependencies.

The `cuda*-sdk` packages can be used to compile libraries and tools that are not part of the CUDA toolkit, but used by CUDA software developers, such as the `deviceQuery` binary (section 7.4.3).

The `cuda-xorg` package is optional, and contains the driver and libraries for an X server

### Example

For example, on a cluster where (some of) the nodes access GPUs, but the head node does not access a GPU, the following commands can be issued on the head node to install the CUDA 8.0 packages using YUM:

```
[root@mycluster ~]# yum install cuda80-toolkit cuda80-sdk
[root@mycluster ~]# yum --installroot=/cm/images/default-image install cuda-driver cuda-dcgm
```

The `--installroot` command installs to the image used by the nodes. Here the image used by the nodes is assumed to be `default-image`. To ensure the software is installed from the image to the nodes, the `imageupdate` command can be run from within `cmsh` for the appropriate nodes.

```
[root@mycluster ~]# cmsh
[mycluster]% device
[mycluster->device]% imageupdate -n node0[01-10] -w
```

### Compiling And Loading CUDA Drivers On The Fly

The `cuda-driver` package provides an `init` script which is executed at boot-time to load the CUDA driver. Because the CUDA driver depends on the running kernel, the script compiles the CUDA driver on the fly, and subsequently loads the module into the running kernel, and creates the `nvidia*` devices (`/dev/nvidia0`, `/dev/nvidia1`...).

The actions of compiling the `cuda-driver`, loading the module, and creating the `nvidia*` devices, can also be carried out during normal running by manually running the `init` script.

Loading the CUDA driver causes a number of diagnostic kernel messages to be logged:

#### Example

```
[root@mycluster ~]# /etc/init.d/cuda-driver start
Compiling nvidia driver.. loading.. create device(s)..      [ OK ]
[root@mycluster ~]# dmesg
...
nvidia-nvlink: Nvlink Core is being initialized, major device number 241
[drm] Initialized nvidia-drm 0.0.0 20150116 for 0000:82:00.0 on minor 1
NVRM: loading NVIDIA UNIX x86_64 Kernel Module 361.93.03 Tue Sep 27 22:40:25 PDT 2016
nvidia-uvm: Loaded the UVM driver in 8 mode, major device number 240
nvidia 0000:82:00.0: irq 200 for MSI/MSI-X
```

Versions of Red Hat 7 and beyond, and derived versions, as well as versions of SLES version 12 and beyond, use `systemd` instead of an `init`-based system. For these the equivalent starting command is:

#### Example

```
[root@mycluster ~]# systemctl start cuda-driver
```

If there is a failure in compiling the CUDA module, it is usually indicated by a message saying “Could not make module”, “NVRM: API mismatch:”, or “Cannot determine kernel version”. Such a failure typically occurs because compilation is not possible due to missing the correct kernel development package from the distribution. Section 7.4.2 explains how to check for, and install, the appropriate missing package.

### 7.4.2 Installing Kernel Development Packages

This section can be skipped if there is no CUDA compilation problem.

Typically, a CUDA compilation problem (section 7.4.1) is due to a missing or mismatched `kernel` package and `kernel-devel` package.

To check the head node and software images for the installation status of the `kernel-devel` package, the Bright Cluster Manager utility `kernel-devel-check` is used (section 11.3.5 of the *Administrator Manual*).

Alternatively, if a standard kernel is in use by the image, then simply upgrading CUDA, the standard kernel, and `kernel-devel`, to their latest versions may be a good tactic to fix a CUDA compilation problem, because the `kernel` and `kernel-devel` package versions become synchronized during such an upgrade.

### 7.4.3 Verifying CUDA

An extensive method to verify that CUDA is working is to run the `verify_cudaX.sh` script, located in the CUDA SDK directory.

This script first copies the CUDA SDK source to a local directory under `/tmp` or `/local1`. It then builds CUDA test binaries and runs them. It is possible to select which of the CUDA test binaries are run. These binaries clutter up the disk and are not intended for use as regular tools, so the administrator is urged to remove them after they are built and run.

A help text showing available script options is displayed when “verify\_cudaX.sh -h” is run. The script can be run as follows on the head or regular node (some output elided):

### Example

```
[root@node001 ~]# module load shared cuda10.1/toolkit
[root@node001 ~]# cd $CUDA_SDK
[root@node001 10.1.105]# ./verify_cuda10.1.sh
Copy cuda10.1 sdk files to "/tmp/cuda10.1" directory.

make clean

make (may take a while)

Run all tests? (y/N)? y

Executing: /tmp/cuda10.1/bin/x86_64/linux/release/alignedTypes

[/tmp/cuda10.1/bin/x86_64/linux/release/alignedTypes] - Starting...
GPU Device 0: "Tesla K40c" with compute capability 3.5

[Tesla K40c] has 15 MP(s) x 192 (Cores/MP) = 2880 (Cores)
> Compute scaling value = 1.00
> Memory Size = 49999872
Allocating memory...
Generating host input data array...
Uploading input data to GPU memory...
Testing misaligned types...
uint8...
Avg. time: 1.760188 ms / Copy throughput: 26.455141 GB/s.
      TEST OK
uint16...
...
...

All cuda10.1 just compiled test programs can be found in the
"/tmp/cuda10.1/bin/x86_64/linux/release/" directory
They can be executed from the "/tmp/cuda10.1" directory.

The "/tmp/cuda10.1" directory may take up a lot of disk space.
Use "rm -rf /tmp/cuda10.1" to remove the data.
```

Another method to verify that CUDA is working, is to build and use the deviceQuery command on a node accessing one or more GPUs. The deviceQuery command lists all CUDA-capable GPUs that a device can access, along with several of their properties (some output elided):

### Example

```
[root@node001 ~]# module load shared cuda10.1/toolkit
[root@node001 ~]# cd $CUDA_SDK
[root@node001 10.1.105]# cd 1_Uutilities/deviceQuery
[root@node001 deviceQuery]# make
...
mkdir -p ../../bin/x86_64/linux/release
cp deviceQuery ../../bin/x86_64/linux/release
[root@node001 deviceQuery]# ./deviceQuery
```

```

./deviceQuery Starting...

  CUDA Device Query (Runtime API) version (CUDA static linking)

Detected 1 CUDA Capable device(s)

Device 0: "Tesla K40c"
  CUDA Driver Version / Runtime Version      10.1 / 10.1
  CUDA Capability Major/Minor version number: 3.5
  Total amount of global memory:             11441 MBytes (11996954624 bytes)
  (15) Multiprocessors, (192) CUDA Cores/MP: 2880 CUDA Cores
  GPU Max Clock rate:                       745 MHz (0.75 GHz)
  Memory Clock rate:                        3004 Mhz
  ...
deviceQuery, CUDA Driver = CUDART, CUDA Driver Version = 10.1, CUDA Runtime Version = 10.1, NumDevs
= 1
Result = PASS

```

The CUDA user manual has further information on how to run compute jobs using CUDA.

**Further information on CUDA verification:** More on verification can be found in the *NVIDIA CUDA INSTALLATION GUIDE FOR LINUX* at [https://docs.nvidia.com/cuda/pdf/CUDA\\_Installation\\_Guide\\_Linux.pdf](https://docs.nvidia.com/cuda/pdf/CUDA_Installation_Guide_Linux.pdf).

#### 7.4.4 Verifying OpenCL

CUDA also contains an OpenCL compatible interface. To verify that OpenCL is working, or failing, the `verify_opengl.sh` script can be run (some output elided):

##### Example

```

[root@cuda-test ~]# module load shared cuda90/toolkit
[root@cuda-test ~]# cd $CUDA_SDK
[root@cuda-test 9.0.176]# ./verify_opengl.sh
Copy opengl files to "/tmp/opengl" directory.

make clean
make (may take a while)
Run all tests? (y/N)? y
Executing: /tmp/opengl/OpenCL/bin/linux/release/oclBandwidthTest

[oclBandwidthTest] starting...
/tmp/opengl/OpenCL/bin/linux/release/oclBandwidthTest Starting...

...

All opengl just compiled test programs can be found in the
"/tmp/opengl/OpenCL/bin/linux/release/" directory
They can be executed from the "/tmp/opengl/OpenCL" directory.

The "/tmp/opengl" directory may take up a lot of diskspace.
Use "rm -rf /tmp/opengl" to remove the data.

```

#### 7.4.5 Configuring The X server

The X server can be configured to use a CUDA GPU. To support the X server, the `cuda-driver`, and `cuda-xorg` packages need to be installed.

The following file pathname lines need to be added to the Files section of the X configuration file:

```
ModulePath "/usr/lib64/xorg/modules/extensions/nvidia"
ModulePath "/usr/lib64/xorg/modules/extensions"
ModulePath "/usr/lib64/xorg/modules"
```

The following dynamic module loading lines need to be added to the Module section of the X configuration:

```
Load      "glx"
```

The following graphics device description lines need to be replaced in the Device section of the X configuration:

```
Driver      "nvidia"
```

The default configuration file for X.org is `/etc/X11/xorg.conf`.

### Example

```
Section "ServerLayout"
    Identifier      "Default Layout"
    Screen          0  "Screen0"  0 0
    InputDevice     "Keyboard0"  "CoreKeyboard"
EndSection

Section "Files"
    ModulePath      "/usr/lib64/xorg/modules/extensions/nvidia"
    ModulePath      "/usr/lib64/xorg/modules/extensions"
    ModulePath      "/usr/lib64/xorg/modules"
EndSection

Section "Module"
    Load            "glx"
EndSection

Section "InputDevice"
    Identifier      "Keyboard0"
    Driver           "kbd"
    Option           "XkbModel"  "pc105"
    Option           "XkbLayout" "us"
EndSection

Section "Device"
    Identifier      "Videocard0"
    Driver           "nvidia"
    BusID            "PCI:14:0:0"
EndSection

Section "Screen"
    Identifier      "Screen0"
    Device           "Videocard0"
    DefaultDepth     24
    SubSection       "Display"
        Viewport     0 0
        Depth         24
    EndSubSection
EndSection
```

### 7.4.6 Further NVIDIA Configuration Via The Cluster Manager

After the installation and verification has been carried out for CUDA drivers, further configuration as part of CMDaemon management can be carried out, as explained in section 3.13.3 of the *Administrator Manual*.

## 7.5 AMD GPU Driver Installation

AMD GPUs require drivers to be installed in order to work. The DKMS system, which is used to compile kernel modules that are not part of the mainline kernel, is used for creating AMD GPU kernel modules.

### 7.5.1 AMD GPU Driver Installation For RHEL/CentOS

For RHEL/CentOS 7.4 the following procedure can be followed:

The default-image is first cloned to an image that is to be the AMD GPU image, for example am:

#### Example

```
root@bright82:~# cmsh
[bright82]% softwareimage
[bright82->softwareimage]% clone default-image am
[bright82->softwareimage*[am*]]% commit
[bright82->softwareimage[am]]%
[notice] bright82: Started to copy: /cm/images/default-image -> /cm/images/am (4117)
[bright82->softwareimage[am]]% quit
```

To install the packages, the description in <https://github.com/RadeonOpenCompute/ROCm> at the time of writing (May 2018) is followed. The installation must be done in the image, which for RHEL/CentOS image uses a chroot into the image, and uses a bind mount to have some special filesystem directories (/proc, /sys, and similar) be available during the package installation. This is needed for the DKMS installation.

Bind mounting the filesystems and then chrooting is a little tedious, so the `cm-chroot-sw-img` utility (page 442 of the *Administrator Manual*) is used to automate the job.

The following session output illustrates the procedure for CentOS, with much text elided:

```
root@bright82 ~# cm-chroot-sw-img /cm/images/am/

mounted /cm/images/default-image/dev
mounted /cm/images/default-image/dev/pts
mounted /cm/images/default-image/proc
mounted /cm/images/default-image/sys
mounted /cm/images/default-image/run
...
```

The Software Collections package (<https://wiki.centos.org/SpecialInterestGroup/SCLO>) is installed, so that the `devtoolset-7` package can be installed, and the DKMS system installed:

```
[root@am:/]# yum install centos-release-scl
...
[root@am:/]# yum install devtoolset-7
...
[root@am:/]# scl enable devtoolset-7 bash
[root@am:/]# yum install -y dkms kernel-headers-`uname -r`
```

In the image, an `rocm.repo` configuration file should be created with the following values:

#### Example



```
[root@am:/]# cat /etc/yum.repos.d/rocm.repo
[ROCM]
name=ROCM
baseurl=http://repo.radeon.com/rocm/yum/rpm
enabled=1
gpgcheck=0
```

The rocm-dkms package can then be installed, the chroot exited, and the bind mounts then automatically unmount:

```
[root@am:/]# yum install rocm-dkms
...
[root@am:/]# exit

umounted /cm/images/default-image/dev/pts
umounted /cm/images/default-image/dev
umounted /cm/images/default-image/proc
umounted /cm/images/default-image/sys
umounted /cm/images/default-image/run
```

The nodes that are to use the driver should then be set to use the new image, and should be rebooted:

### Example

```
root@bright82 ~# cmsh
[bright82]% device use node001
[bright82->device[node001]]% set softwareimage am
[bright82->device*[node001*]]% commit
[bright82->device[node001]]% reboot node001
```

Normal nodes without the AMD GPU also boot up without crashing if they are set to use this image, but will not be able to run OpenCL programs.

### 7.5.2 AMD GPU Driver Installation For Ubuntu

For Ubuntu 16.04 the following procedure can be followed.

As for the Centos/RHEL case, the procedure begins with cloning the default-image to an image that is to be the AMD GPU image, such as, for example, am.

```
root@bright82:~# cmsh
[bright82]% softwareimage
[bright82->softwareimage]% clone default-image am
[bright82->softwareimage*[am*]]% commit
[bright82->softwareimage[am]]%
[notice] bright82: Started to copy: /cm/images/default-image -> /cm/images/am (117)
[bright82->softwareimage[am]]% quit
```

To install the packages, the description in <https://github.com/RadeonOpenCompute/ROCM> at the time of writing (May 2018) is followed. The installation must be done in the image, which for an Ubuntu image uses a chroot into the image, and uses a bind mount to have the /proc, /sys, and other special directories be available during the package installation (section 11.4 of the *Administrator Manual*). The following session output illustrates the procedure, with much text elided, with the help of the cm-chroot-sw-img utility (page 442 of the *Administrator Manual*):

```
root@bright82:~# cm-chroot-sw-img /cm/images/am/
...
root@bright82:/# wget -q0 - http://repo.radeon.com/rocm/apt/debian/rocm.gpg.key | apt-key add -
OK
```

```

root@bright82:/# sh -c 'echo deb [arch=amd64] http://repo.radeon.com/rocm/apt/debian/ xenial\
main > /etc/apt/sources.list.d/rocm.list'
root@bright82:/# cat /etc/apt/sources.list.d/rocm.list
deb [arch=amd64] http://repo.radeon.com/rocm/apt/debian/ xenial main
root@bright82:/# apt update
...
root@bright82:/# apt install rocm-dkms
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  cpp-5 g++-5 g++-5-multilib g++-multilib gcc-5 gcc-5-base gcc-5-multilib gcc-multilib...
...
25 upgraded, 51 newly installed, 0 to remove and 253 not upgraded.
Need to get 435 MB of archives.
After this operation, 1,920 MB of additional disk space will be used.
Do you want to continue? [Y/n]
...
Loading new amdgpu-1.8-118 DKMS files...
First Installation: checking all kernels...
Building only for 4.4.0-72-generic
Building for architecture x86_64
Building initial module for 4.4.0-72-generic
Done.
Forcing installation of amdgpu
...
amdgpu:
...

depmod....

Backing up initrd.img-4.4.0-72-generic to /boot/initrd.img-4.4.0-72-generic.old-dkms
Making new initrd.img-4.4.0-72-generic
(If next boot fails, revert to initrd.img-4.4.0-72-generic.old-dkms image)
update-initramfs....

DKMS: install completed.
Setting up rocm-dkms (1.8.118) ...
KERNEL=="kfd", MODE="0666"
Processing triggers for initramfs-tools (0.122ubuntu8.8) ...
update-initramfs: Generating /boot/initrd.img-4.4.0-72-generic
W: mdadm: /etc/mdadm/mdadm.conf defines no arrays.
cp: cannot stat '/etc/iscsi/initiatorname.iscsi': No such file or directory
root@bright82:/# exit

```

The nodes that are to use the driver should then be set to use the new image, and should be rebooted.

```

[bright82->device[node001]]% set softwareimage am
[bright82->device*[node001*]]% commit
[bright82->device[node001]]% reboot node001

```

Normal nodes without the AMD GPU also boot up without crashing if they are set to use this image, but are not be able to run OpenCL programs.

### 7.5.3 AMD GPU Driver Installation For SLED/SLES

The driver can be installed in SLES12SP3 as follows:

1. The default image is cloned to a new image that is to have the driver, for example amdgpupro:

```
bright82:~ # cmsg
[bright82]% softwareimage
[bright82->softwareimage]% clone default-image amdgpupro
[bright82->softwareimage*[amdgpupro*]]% commit
[notice] bright82: Started to copy: /cm/images/default-image -> /cm/images/amdgpupro
[bright82->softwareimage[amdgpupro]]% exit
```

2. The new software image should then be chrooted into:

```
bright82:~ # chroot /cm/images/amdgpupro
bright82:/ #
```

3. The instructions that AMD provides on installing the AMDGPU-Pro driver should be followed.

At the time of writing (May 2018) there are release notes at:

<https://support.amd.com/en-us/kb-articles/Pages/Radeon-Software-for-Linux-Release-Notes.aspx>

which point to the driver tar.xz package at:

<https://www2.ati.com/drivers/linux/sled-sles/amdgpu-pro-18.10-577045.tar.xz>

It is simplest to use a regular browser to pick it up this tar.xz file, because JavaScript is expected at that URL. The file can be placed in the amdgpupro image directory and extracted as follows (some output elided):

```
bright82:/ # tar xvJf amdgpu-pro-18.10-577045.tar.xz
amdgpu-pro-18.10-577045/
amdgpu-pro-18.10-577045/repodata/
...
amdgpu-pro-18.10-577045/RPMS/noarch/wayland-protocols-amdgpu-devel-1.13-577045.noarch.rpm
```

A session that follows the installation instructions, at

<https://support.amd.com/en-us/kb-articles/Pages/Installation-Instructions-for-amdgpu-Graphics-Stacks.aspx>

at the time of writing (May 2018), is (some output elided):

```
bright82:/ # cd amdgpu-pro-18.10-577045
bright82:/amdgpu-pro-18.10-577045 # ./amdgpu-install
[amdgpu-pro-local]
Name=AMD amdgpu Pro local repository
baseurl=file:///var/opt/amdgpu-pro-local
enabled=1
gpgcheck=0
```

New repository or package signing key received:

...

Do you want to reject the key, trust temporarily, or trust always?

[r/t/a/? shows all options] (r):

Building repository 'Cluster Manager 8.1 - Base' cache .....[done]

```
...
(23/24) Installing: amdgpu-18.10-577045.x86_64 .....[done]
(24/24) Installing: amdgpu-pro-18.10-577045.x86_64 .....[done]
bright82:/amdgpu-pro-18.10-577045 #
```

For the `amdgpu-install` command, the administrator may need to use the `--opencl=pal` or `--opencl=rocm` options, depending on the hardware that is installed, as explained in the AMD installation instructions.

4. The chroot environment can now be exited:

```
bright82:/amdgpu-pro-18.10-577045 # exit
bright82:~ #
```

5. The software image for a node can now be set:

### Example

```
bright82:~ # cmsh
[bright82]% device use node001
[bright82->device[node001]]% set softwareimage amdgpupro
[bright82->device*[node001*]]% commit
[notice] bright82: Initial ramdisk for node node001 based on image amdgpupro is being
generated
[bright82->device[node001]]%
```

## 7.6 OFED Software Stack

This section explains how OFED packages are installed so that Bright Cluster Manager can use InfiniBand for data transfer during regular use—that is for computation runs, rather than for booting up or provisioning. The configuration of PXE booting over InfiniBand is described in section 5.1.3 of the *Administrator Manual*. The configuration of node provisioning over InfiniBand is described in section 5.3.3 of the *Administrator Manual*.

### 7.6.1 Choosing A Distribution Version, Or A Vendor Version, Ensuring The Kernel Matches, And Logging The Installation

By default, the Linux distribution OFED packages are matched to the distribution kernel version and installed on the cluster. This is the safest option in most cases, and also allows NFS over RDMA.

Bright Cluster Manager also packages the OFED software developed by the vendors, Intel True Scale (formerly QLogic) and Mellanox. These vendor OFED packages can be more recent than the distribution packages, which means that they can provide support for more recent hardware and firmware, as well as more features.

For the vendor OFED packages to work, the OFED firmware as provided by the manufacturer should in general be recent, to ensure software driver compatibility.

The Bright Cluster Manager vendor OFED packages can be selected and installed during the initial cluster installation (figure 3.15), replacing the default distribution OFED stack. The stack can also be installed later on, after the cluster is set up.

If there is no OFED kernel modules package available for the kernel in use, then the Bright Computing OFED install script tries to build the package from the source package provided by the vendors Mellanox or Intel True Scale. However, very recent kernels may not yet be supported by the source package. If a build fails for such a kernel, then the OFED software stack will fail to install, and nothing is changed on the head node or the software image. OFED hardware manufacturers resolve build

problems with their software shortly after they become aware of them, but in the meantime a supported kernel must be used.

When updating kernels on the head or the regular nodes, the updated Bright Cluster Manager OFED software stack must be reinstalled (if there are packages already available for the kernel) or rebuilt (if there are no such packages provided).

If the Bright Cluster Manager OFED software stack is installed during the cluster installation procedure itself (section 3.3.8), then some basic information is logged to `/var/log/cmfirstboot.log`, which is the general first boot log.

If the Bright Cluster Manager OFED software stack is not installed during the cluster installation procedure itself, then it can be installed later when the cluster is up and running. A successful installation of the Bright Cluster Manager OFED software stack (section 7.6.2) onto a running cluster includes the running of an installation script after the Bright Cluster Manager OFED package installation. The vendor and version number installed can then be found in `/etc/cm-ofed`. Further installation details can be found in `/var/log/cm-ofed.log`.

### 7.6.2 Mellanox and Intel True Scale OFED Stack Installation Using The Bright Computing Repository

Package names: `mlnx-ofed41`, `mlnx-ofed42`, `mlnx-ofed43`, `mlnx-ofed44`, `mlnx-ofed45`, `mlnx-ofed46`, `mlnx-ofed47`, `intel-truescale-ofed`

The Mellanox or Intel True Scale OFED stacks are installed and configured by Bright Cluster Manager in an identical way as far as the administrator is concerned. In this section (section 7.6.2):

*<vendor-ofedVersion>*

is used to indicate where the administrator must carry out a substitution. Depending on the vendor and version used, the substitution is one of the following:

- for the Intel True Scale stack, `intel-truescale-ofed` is used as the substitution. Installation only works for RHEL7 kernels up to version 3.10.693 at the time of writing (November 2019). Default kernels later than this, are thus not expected to work in RHEL7. The Intel release notes for True Scale, at [https://downloadmirror.intel.com/27579/eng/OFED\\_HostSW\\_ReleaseNotes\\_J96109\\_01\\_v744018.pdf](https://downloadmirror.intel.com/27579/eng/OFED_HostSW_ReleaseNotes_J96109_01_v744018.pdf) at the time of writing, can be consulted for updates on the situation. Information on what other distributions are supported and to what extent can also be found there.

Intel OPA (section 7.7) is an evolutionary development of True Scale that is supported by Intel for newer kernels.

- for the Mellanox stacks, the substitutions are:
  - `mlnx-ofed41` for the Mellanox version 4.1 stack
  - `mlnx-ofed42` for the Mellanox version 4.2 stack
  - `mlnx-ofed43` for the Mellanox version 4.3 stack
  - `mlnx-ofed44` for the Mellanox version 4.4 stack
  - `mlnx-ofed45` for the Mellanox version 4.5 stack
  - `mlnx-ofed46` for the Mellanox version 4.6 stack
  - `mlnx-ofed47` for the Mellanox version 4.7 stack

These stacks are currently supported by the Bright Cluster Manager 8.2-supported distributions (RHEL and derivatives, and SLES) according to the compatibility matrix at <https://www.mellanox.com/support/mlnx-ofed-matrix>.

For convenience, a table derived from that URL, showing the partial relevant content on 18th November 2019, is reproduced here:

Stack Version	Distribution	Versions
4.1	RHEL	6.2, 6.3, 6.5, 6.6, 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4
	CentOS	6.2, 6.3, 6.5, 6.6, 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4
	SLES	12, 12SP1, 12SP2, 12SP3
	Ubuntu	16.04
4.2	RHEL	6.3, 6.6, 6.8, 6.9, 7.2, 7.3, 7.4
	CentOS	6.3, 6.6, 6.8, 6.9, 7.2, 7.3, 7.4
	SLES	12SP2, 12SP3
	Ubuntu	16.04
4.3	RHEL	6.3, 6.5, 6.6, 6.7, 6.8, 6.9, 7.2, 7.3, 7.4, 7.4 ALT (Pegas 1.0/.1.1)
	CentOS	6.3, 6.5, 6.6, 6.7, 6.8, 6.9, 7.2, 7.3, 7.4
	SLES	12SP2, 12SP3
	Ubuntu	16.04
4.4	RHEL	6.3, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 7.1, 7.2, 7.3, 7.4, 7.4 ALT (Pegas 1.0), 7.5, 7.5 ALT (Pegas 1.1)
	CentOS	6.3, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 7.1, 7.2, 7.3, 7.4, 7.5
	SLES	12SP1, 12SP2, 12SP3
	Ubuntu	16.04.3, 16.04.4
4.5	RHEL/CentOS	6.3, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 7.2, 7.3, 7.4, 7.4 ALT (Pegas 1.0), 7.5, 7.6, 7.6 ALT (Pegas 1.2)
	SLES	12SP1, 12SP2, 12SP3, 12SP4
	Ubuntu	16.04.3, 16.04.4, 18.0.4, 18.0.4.1
4.6	RHEL/CentOS	6.3, 6.8, 6.9, 6.10, 7.2, 7.3, 7.4, 7.5, 7.6, 7.6 ALT (Pegas 1.2), 8.0 (Beta)
	SLES	12SP1, 12SP2, 12SP3
	Ubuntu	16.04.3, 16.04.4, 18.0.4.1, 18.04.2
4.7	RHEL/CentOS	6.9, 6.10, 7.2, 7.4, 7.5, 7.6, 7.6 ALT (Pegas 1.2), 7.7, 8.0, 8.1 (Beta)
	SLES	12SP1, 12SP2, 12SP3, 12SP4, 12SP5 (Beta)
	Ubuntu	16.04.3, 16.04.4, 18.0.4.1, 18.04.2, 18.04.3

Thus, for example, a `yum install` command indicated by:

```
yum install <vendor-ofedVersion>
```

means that the installation of the Bright Computing OFED package is executed with one of these corresponding `yum install` commands:

```
yum install mlnx-ofed41
```

or

```
yum install mlnx-ofed42
```

```

or
    yum install mlnx-ofed43
or
    yum install mlnx-ofed44
or
    yum install mlnx-ofed45
or
    yum install mlnx-ofed46
or
    yum install mlnx-ofed47
or
    yum install intel-truescale-ofed

```

### Installing The OFED Stack Provided By The Bright Computing Repository Vendor Package

Running the package manager command associated with the distribution (yum install, zypper up, apt install), unpacks and installs or updates several packages and scripts. For example:

```
yum install <vendor-ofedVersion>
```

However, it does not carry out the installation and configuration of the driver itself due to the fundamental nature of the changes it would carry out. The script:

```
<vendor-ofedVersion>-install.sh
```

can be used after the package manager installation to carry out the installation and configuration of the driver itself. The script can be run on the nodes as follows:

- On the head node, the default distribution OFED software stack can be replaced with the vendor OFED software stack made available from the Bright Computing repository, by using the script's head option, -h:

```
[root@bright82~]# /cm/local/apps/<vendor-ofedVersion>/current/bin/<vendor-ofedVersion>-ins\
tall.sh -h
```

A reboot is recommended after the script completes the install.

- For a software image, for example default-image, used by the regular nodes, the default distribution OFED software stack can be replaced with the vendor OFED software stack made available from the Bright Computing repository, by using the script's software image option, -s:

```
[root@bright82~]# /cm/local/apps/<vendor-ofedVersion>/current/bin/<vendor-ofedVersion>-ins\
tall.sh -s default-image
```

A reboot updates the software image on the regular node.

If the distribution kernel is updated on any of these head or regular nodes after the vendor OFED stack has been installed, then the vendor OFED kernel modules made available from the Bright Computing repository must be recompiled and reinstalled. This can be done by running the installation scripts again. This replaces the kernel modules, along with all the other OFED packages again.

The OFED Stack provided by Bright Computing can be removed by appending the -r option to the appropriate -h or -s option. Removing the packages from a head node or software image can lead to package dependency breakage, and software not working any more. So using the "-r" option should be done with caution.

### Upgrading Kernels When The OFED Stack Has Been Provided By The Bright Computing Repository Vendor Package—Reinstallation Of The OFED Stack

For all distributions, as explained in the preceding text, a vendor OFED stack is installed and configured via the script <vendor-ofedVersion>-install.sh. OFED reinstallation may be needed if the kernel is upgraded.

**In Ubuntu:** if the OFED stack is installed from the distribution or vendor OFED .deb packages, then the DKMS (Dynamic Kernel Module System) framework makes upgraded vendor OFED kernel modules available at a higher preference than the distribution OFED kernel modules for a standard distribution kernel. If there is a kernel upgrade that causes unexpected behavior from the vendor OFED package, then the cluster administrator can still configure the distribution OFED for use by setting the distribution OFED kernel module as the preferred kernel module. So no kernel-related packages need to be excluded from vendor OFED upgrades or kernel upgrades. Typically, Ubuntu clusters can have a package update (`apt upgrade`) carried out, with no explicit changes needed to take care of the OFED stack.

**For RHEL and derivatives, and SLES:** if the OFED stack is installed from the vendor OFED RPM packages, then the script customizes the vendor OFED stack for the existing kernel, and replaces the distribution stack. However, updating the kernel afterwards, without updating the stack along with it, could lead to unexpected behavior due to the customization. Kernel and kernel development updates are therefore prevented from taking place by a package management system block. Updating the kernel, kernel development, and OFED stack in such a configuration therefore requires that the administrator manually overrides the block so that the OFED stack can be handled with consideration.

The following procedure can thus be followed to update and install the kernel packages and OFED stack:

1. Overriding the block (not needed for Ubuntu):

- In Red Hat-based systems, The `/etc/yum.conf` file must be edited. In that file, in the line that starts with `exclude`, the `kernel` and `kernel-devel` packages need to be removed, so that they are no longer excluded from updates.
- In SUSE, the `kernel-default` and `kernel-default-devel` packages must be unlocked. The command:

```
zypper remove-lock kernel-default kernel-default-devel
```

unlocks them so that they can take part in updates again.

2. Updating the kernel and kernel development packages:

- `yum update`—or for SUSE `zypper up`—updates the packages on the head node.
- To update the packages on the regular nodes the procedure outlined in section 11.3.3 of the *Administrator Manual* is followed:

- The packages on the regular node image (for example, `default-image`) are updated according to distribution:

- \* in Red Hat-based systems as follows:

```
yum --installroot=/cm/images/default-image update
```

- \* or in SLES as follows:

```
zypper --root=/cm/images/default-image up
```

- \* or in Ubuntu as follows, using the `cm-chroot-sw-img` tool (page 442 of the *Administrator Manual*):

```
root@bright82:~# cm-chroot-sw-img /cm/images/default-image
root@bright82:~# apt update; apt upgrade      #upgrade takes place in image
...
root@bright82:~# exit                          #get out of chroot
```

- The `kernelversion` setting for the regular node image, which in this example is the default `default-image`, can be updated as follows:



**Example**

```
[root@bright82 ~]# cmsh
[bright82]% softwareimage
[bright82->softwareimage]% use default-image
[bright82->softwareimage[default-image]]% set kernelversion 3.10.0-327.3.1.el7.x86_64
[bright82->softwareimage[default-image*]]% commit
```

This ensures that the updated kernel is used after reboot. Tab-completion in the `set kernelversion` line prompts for the right kernel from available options.

3. A reboot of the head and regular nodes installs the new kernel.
4. Configuring and installing the vendor OFED stack driver for the new kernel is done by running the script `<vendor-ofedVersion>-install.sh` as before, as follows:

- For a stack that is on the head node, the compilation should be done together with the `-h` option:

```
[root@bright82~]# /cm/local/apps/<vendor-ofedVersion>/current/bin/<vendor-ofedVersion>-install.sh -h
```

- For a software image used by the regular nodes, for example `default-image`, the compilation should be done together with the `-s` option:

```
[root@bright82~]# /cm/local/apps/<vendor-ofedVersion>/current/bin/<vendor-ofedVersion>-install.sh -s default-image
```

These configuration and installation steps for the vendor OFED driver are typically not needed for Ubuntu.

**7.7 Intel OPA Software Stack**

The Intel Omni-Path Architecture (OPA) Software Stack is available for RHEL7 and derivatives, and SLES 12.

**7.7.1 Installation**

After the head node has been installed, the Intel OPA Software Stack can be installed by executing the following commands on the head node:

```
[root@bright82 ~]# yum install intel-opa
```

The `yum` command installs the package containing the OPA stack itself, as well as the installation scripts required for installing and configuring the kernel drivers. These are automatically placed under a subdirectory named after the OPA stack version.

**7.7.2 Configuration And Deployment**

The drivers must then be configured for the running kernel, and the OPA stack deployed on the head node. If the subdirectory for the OPA stack version is called `<version>`, then the following commands can be executed to carry out the configuration and deployment:

For the head node:

```
/cm/local/apps/intel-opa/<version>/bin/intel-opa-install.sh -h
```

For the software images, the OPA stack can be configured and deployed for each software image as follows:

```
/cm/local/apps/intel-opa/<version>/bin/intel-opa-install.sh -s <name of software image>
```

The OPA MTU size is not changed by Bright Cluster Manager during installation. An Intel recommendation at the time of writing (October 2017) in [https://www.intel.com/content/dam/support/us/en/documents/network-and-i-o/fabric-products/Intel\\_OP\\_Performance\\_Tuning\\_UG\\_H93143\\_v3\\_0.pdf](https://www.intel.com/content/dam/support/us/en/documents/network-and-i-o/fabric-products/Intel_OP_Performance_Tuning_UG_H93143_v3_0.pdf), in section 6.2 is:

*OPA on the other hand can support MTU sizes from 2048B (2K) up to 8192B (8KB) for verbs or PSM 2 traffic. Intel recommends you use the 8KB MTU default for RDMA requests of 8KB or more.*

## 7.8 Lustre

This section covers integrating Bright Cluster Manager with Lustre, a parallel distributed filesystem which can be used for clusters.

After a short architectural overview of Lustre, (section 7.8.1), steps to set up a Lustre filesystem to work with Bright Cluster Manager are described (sections 7.8.2 to 7.8.4).

Further details on Lustre, including the Lustre manual, can be found at <https://wiki.whamcloud.com>.

### 7.8.1 Architecture

There are four components to a Lustre filesystem:

1. One management service (MGS)
2. One metadata target (MDT) on the metadata server (MDS)
3. Multiple object storage target (OSTs), on an object storage server (OSS)
4. Clients that access and use the data on the Lustre filesystem

The management services run on the metadata server, and hold information for all Lustre filesystems running in a cluster. Metadata values, like filenames, directories, permissions, and file layout are stored on the metadata target. The file data values themselves are stored on the object storage targets.

This section describes how to install and run Lustre so that it works with a Bright Cluster Manager running on one head node and four regular nodes. Lustre itself will be set up entirely on the regular nodes. The components will be implemented as follows:

- mycluster: The Head Node
- mds001: Lustre Server running both the MGS and MDS. Contains the MDT
- oss001: Lustre Server running OSS. Contains one OST
- oss002: Lustre Server running OSS. Contains another OST
- lclient001: Lustre Client

The examples in this section (7.8) are for an installation of Lustre 2.6 onto a cluster running on CentOS 6.6.

### 7.8.2 Preparation

To prepare the Lustre integration, a head node is installed by the administrator. The head node uses close-to-default Bright Cluster Manager settings.

An exception to the default settings is for the disk layout, for the nodes which are to contain an OST or MDT. These nodes need an extra partition for their storage. The non-head nodes are installed later on in the procedure.

Most of the configuration will be done on the head node by creating and configuring disk images for the servers. After each node is booted and running, some additional configuration needs to be done via `cmsh`, and also on the node itself via the regular operating system.

### 7.8.3 Server Implementation

The Lustre servers, MDS, and OSSs, run on a patched kernel. The patched kernel, kernel modules, and software can be installed with RPM packages. The Lustre server software can also be compiled from source, but the kernel needs to be patched and recreated. Lustre supports one kernel version per Lustre version.

To use Lustre with Bright Cluster Manager, a Lustre server image and a Lustre client image are installed onto the head node so that they can provision the Lustre nodes.

#### Creating The Lustre Server Image

To create a Lustre server image, a clone is made of an existing software image, for example from default-image. In cmsh a clone image is created by the administrator as follows:

#### Example

```
[root@mycluster ~]# cmsh
[mycluster]% softwareimage
[mycluster->softwareimage]% clone default-image lustre-server-image
[mycluster->softwareimage*[lustre-server-image*]]% commit
```

It is best to first check which version of Lustre can be used for a particular distribution against the Lustre Support Matrix at:

<https://wiki.whamcloud.com/display/PUB/Lustre+Support+Matrix>

After choosing a Lustre version from the Lustre Support Matrix, the appropriate distribution and platform can be chosen. For CentOS and Scientific Linux (SL), Red Hat packages can be used.

Download links for Lustre releases, which include the kernel, module, lustre and lustre-osd-ldiskf packages, can be found at:

<https://wiki.whamcloud.com/display/PUB/Lustre+Releases>

For the session described here, the packages can be downloaded from:

[https://downloads.whamcloud.com/public/lustre/lustre-2.6.0/el6/server/RPMS/x86\\_64/](https://downloads.whamcloud.com/public/lustre/lustre-2.6.0/el6/server/RPMS/x86_64/)

Download links for Lustre tools, including the e2fsprogs package, can be found at:

<https://wiki.whamcloud.com/display/PUB/Lustre+Tools>

The packages that should be picked up are:

- kernel: Lustre-patched kernel (MDS/MGS/OSS only)
- lustre-modules: Lustre kernel modules (client and server for the Lustre-patched kernel and EL6 only)
- kmod-lustre: Lustre kernel modules (client and server for the Lustre-patched kernel and EL7 only)
- lustre: Lustre user space tools (client and server for the Lustre-patched kernel)
- lustre-osd-ldiskfs: Backing filesystem kernel module (MDS/MGS/OSS only and EL6 only)
- lustre-osd-ldiskfs-mount: Backing filesystem kernel module (MDS/MGS/OSS)
- kmod-lustre-osd-ldiskfs: Backing filesystem kernel module (MDS/MGS/OSS and EL7 only)

- `e2fsprogs`: Backing filesystem creation and repair tools (MDS/MGS/OSS only)
- `e2fsprogs-libs`: Backing filesystem creation and repair tools libraries (MDS/MGS/OSS)
- `e2fsprogs-devel`: Backing filesystem creation and repair tools development (MDS/MGS/OSS and EL6 only)

The `e2fsprogs` package requires the `libss`, `libcom_err`, and `libcom_err-devel` packages, also available from the same location as `e2fsprogs`. All three packages should be installed on the system if they are not already there.

In most cases, the `e2fsprogs` package from the distribution is already installed, so the package only has to be upgraded. If the Lustre kernel version has a lower version number than the already-installed kernel, then the Lustre kernel needs to be installed with the `--force` option. Warning and error messages that may display about installing packages in a software image can be ignored.

The packages can be placed by the administrator into a subdirectory of the `lustre-server-image`. They can then be installed within the image by using the `rpm` command within `chroot`:

### Example

```
[root@mycluster ~]# mkdir /cm/images/lustre-server-image/root/lustre
[root@mycluster ~]# cp kernel-* lustre-* e2fsprogs-* \
  /cm/images/lustre-server-image/root/lustre/
[root@mycluster ~]# chroot /cm/images/lustre-server-image
[root@mycluster /]# cd /root/lustre
[root@mycluster lustre]# rpm -Uvh \
  e2fsprogs-1.42.12.wc1-7.el6.x86_64.rpm \
  e2fsprogs-libs-1.42.12.wc1-7.el6.x86_64.rpm \
  e2fsprogs-devel-1.42.12.wc1-7.el6.x86_64.rpm \
  libcom_err-1.42.12.wc1-7.el6.x86_64.rpm \
  libss-1.42.12.wc1-7.el6.x86_64.rpm
[root@mycluster lustre]# rpm -ivh --force \
  kernel-2.6.32-431.20.3.el6_lustre.x86_64.rpm
[root@mycluster lustre]# rpm -ivh \
  lustre-2.6.0-2.6.32_431.20.3.el6_lustre.x86_64.x86_64.rpm \
  lustre-modules-2.6.0-2.6.32_431.20.3.el6_lustre.x86_64.x86_64.rpm \
  lustre-osd-ldiskfs-2.6.0-2.6.32_431.20.3.el6_lustre.x86_64.x86_64.rpm
[root@mycluster lustre]# exit
[root@mycluster ~]# rm -r /cm/images/lustre-server-image/root/lustre
```

The kernel version is set to the Lustre kernel version for the Lustre server image:

### Example

```
[root@mycluster ~]# cd /cm/images/lustre-server-image/boot
[root@mycluster boot]# ls -1 vmlinuz-*
/boot/vmlinuz-2.6.32-431.20.3.el6_lustre.x86_64
/boot/vmlinuz-2.6.32-504.8.1.el6.x86_64
[root@mycluster boot]# cmsg
[mycluster]% softwareimage
[mycluster->softwareimage]% use lustre-server-image
[mycluster->softwareimage[lustre-server-image]]% set kernelversion \
  2.6.32-431.20.3.el6_lustre.x86_64
[mycluster->softwareimage*[lustre-server-image*]]% commit
```

### Creating The Lustre Server Category

A node category is cloned. For example, default to lustre-server. The software image is set to the Lustre server image, the installbootrecord option is enabled, and the roles option is cleared:

#### Example

```
[root@mycluster ~]# cmsh
[mycluster]% category
[mycluster->category]% clone default lustre-server
[mycluster->category*[lustre-server*]]% set softwareimage lustre-server\
-image
[mycluster->category*[lustre-server*]]% set installbootrecord yes
[mycluster->category*[lustre-server*]]% clear roles
[mycluster->category*[lustre-server*]]% commit
```

The command `set installbootrecord yes` installs a Master Boot Record on a node. It enables a node to boot from the local drive instead of from the network. The BIOS on the node also has to be configured to boot from the local drive instead of the network. After this change, `cmsh` will keep showing a restart-required flag (section 5.5.2 of the *Administrator Manual*) for those nodes. The flag normally only clears during a boot from the network, so in this case it has to be cleared manually using the `--reset` option:

```
[mycluster->[device]]% foreach -c lustre-server (open --reset)
```

### Creating Lustre Server Nodes

The MDS node is created with `cmsh`:

#### Example

```
[root@mycluster ~]# cmsh
[mycluster]% device
[mycluster->[device]]% add physicalnode mds001 10.141.16.1
[mycluster->[device*[mds001*]]]% set category lustre-server
[mycluster->[device*[mds001*]]]% commit
```

One or more OSS nodes are created with `cmsh`:

#### Example

```
[root@mycluster ~]# cmsh
[mycluster]% device
[mycluster->[device]]% add physicalnode oss001 10.141.32.1
[mycluster->[device*[oss001*]]]% set category lustre-server
[mycluster->[device*[oss001*]]]% commit
```

For nodes based on EL6 the Lustre `initrd` file needs to be regenerated, after the first boot and initial installation. To regenerate the `initrd` image file, for the nodes in the `lustre-server` category, :

```
[root@mycluster ~]# cmsh
[mycluster]% device
[mycluster->device]% pexec -c lustre-server "mv \
/boot/initrd-2.6.32-431.20.3.el6_lustre.x86_64.orig \
/boot/initrd-2.6.32-431.20.3.el6_lustre.x86_64.old"
[mycluster->device]% pexec -c lustre-server "mkinitrd \
/boot/initrd-2.6.32-431.20.3.el6_lustre.x86_64.orig \
2.6.32-431.20.3.el6_lustre.x86_64"
```

Warning and error messages that display about write errors or broken pipes can be ignored.

### Creating The Lustre Metadata Target

On the metadata server a metadata target must be created. To create the metadata target, a raw block device without partitioning should be used. The device can also be an external storage device or a redundant storage device, or both.

Setting up a RAID mode capable of dealing with device failure is strongly recommended for block devices to be used as metadata targets, since Lustre itself does not support any redundancy at filesystem level. The metadata server also acts as a management server.

To format a metadata target, `mkfs.lustre` is used. For example, the following formats `/dev/sdb`, and sets the Lustre filesystem name to `lustre00`:

#### Example

```
[root@mds001 ~]# mkfs.lustre --fsname lustre00 --mdt --mgs /dev/sdb
```

The filesystem is mounted and the entry added to `/etc/fstab`:

#### Example

```
[root@mds001 ~]# mkdir /mnt/mdt
[root@mds001 ~]# mount -t lustre /dev/sdb /mnt/mdt
[root@mds001 ~]# echo "/dev/sdb /mnt/mdt lustre rw,_netdev 0 0" >> /etc/fstab
```

### Creating The Lustre Object Storage Target

On the object storage server one or multiple object storage target(s) can be created. To create the object storage target, a raw block device without partitioning should be used. The device can also be an external storage device or a redundant storage device, or both.

Setting up a RAID mode capable of dealing with device failure is strongly recommend for block devices to be used as object storage targets, since Lustre itself does not support any redundancy at filesystem level.

The `mkfs.lustre` command can be used to format an object storage target. For example, a Lustre filesystem can be formatted on `/dev/sdb` as follows:

#### Example

```
[root@oss001 ~]# mkfs.lustre --fsname lustre00 --ost --index=0 --mgsgnode=10.141.16.1@tcp0 /dev/sdb
```

With the options used here, the command also sets the:

- filesystem name to `lustre00`
- OST index number to 0
- management node to `10.141.16.1`
- network type to TCP/IP

Specifying the OST index at format time simplifies certain debugging and administrative tasks.

After formatting the filesystem, it can be mounted, and an entry can be added to `/etc/fstab`:

#### Example

```
[root@oss001 ~]# mkdir /mnt/ost01
[root@oss001 ~]# mount -t lustre /dev/sdb /mnt/ost01
[root@oss001 ~]# echo "/dev/sdb /mnt/ost01 lustre rw,_netdev 0 0" >> /etc/fstab
```

After mounting the OST(s) the Lustre clients can mount the Lustre filesystem.

### 7.8.4 Client Implementation

There are several ways to install a Lustre client.

The client kernel modules and client software can be built from source. Alternatively, if the client has a supported kernel version, the `lustre-client` RPM package and `lustre-client-modules` RPM package can be installed. The `lustre-client-modules` package installs the required kernel modules.

If the client does not have a supported kernel, then a Lustre kernel, Lustre modules, and Lustre user space software can be installed with RPM packages.

In the following example the previously created server-image is simply cloned by the administrator, since it already contains all necessary components.

#### Creating The Lustre Client Image

A clone software image is created using `cmsh` on the head node.

##### Example

```
[root@mycluster ~]# cmsh
[mycluster]% softwareimage
[mycluster->softwareimage]% clone lustre-server-image lustre-client-image
[mycluster->softwareimage*[lustre-client-image*]]% commit
```

To configure the `lnet` kernel module to use TCP/IP interface `eth1`, the string `"options lnet networks=tcp(eth1)"` is added to the `/etc/modprobe.conf` file of the client image:

```
[root@mycluster ~]# echo "options lnet networks=tcp(eth1)" >> /cm/image\
s/lustre-client-image/etc/modprobe.conf
```

To specify that a Lustre node uses both a TCP/IP interface and an InfiniBand interface, the string `"options lnet networks=tcp0(eth0),o2ib(ib0)"` is appended to the `/etc/modprobe.conf` file of the client image:

```
[root@mycluster ~]# echo "options lnet networks=tcp0(eth0),o2ib(ib0)" >\
> /cm/images/lustre-client-image/etc/modprobe.d/lustre.conf
```

#### Creating The Lustre Client Category

A node category is cloned. For example: `default` is cloned to a new category `lustre-client`. The software image in this category is set to the Lustre client image, `lustre-client`:

##### Example

```
[root@mycluster ~]# cmsh
[mycluster]% category
[mycluster->category]% clone default lustre-client
[mycluster->category*[lustre-client*]]% set softwareimage lustre-client-image
[mycluster->category*[lustre-client*]]% commit
```

#### Configuring The Lustre Mount On The Client For A Category

The Lustre client category can then be configured to mount the Lustre filesystem. Some text in the display here is elided:

##### Example

```
[root@mycluster ~]# cmsh
[mycluster]% category
[mycluster->category]% use lustre-client
[mycluster->category[lustre-client]]% fsmounts
[mycl...fsmounts]% add /mnt/lustre00
[myc...fsmounts*[mnt/lustre00*]]% set device 10.141.16.1@tcp0:/lustre00
[myc...fsmounts*[mnt/lustre00*]]% set filesystem lustre
[myc...fsmounts*[mnt/lustre00*]]% set mountoptions rw,_netdev
[myc...fsmounts*[mnt/lustre00*]]% commit
```

The configured `fsmounts` device is the MGS, which in the example has the IP address `10.141.16.1`, and a network type of TCP/IP.

### Creating Lustre Client Nodes

A client node is created as follows:

#### Example

```
[root@mycluster ~]# cmlsh
[mycluster]% device
[mycluster->device]% add physicalnode lclient001 10.141.48.1
[mycluster->device*[lclient001*]]% set category lustre-client
[mycluster->device*[lclient001*]]% commit
```

The Lustre client is booted and checked to see if the Lustre filesystem is mounted. The stripe configuration of the filesystem can be checked with `lfs getstripe`, and it can be set with `lfs setstripe`:

#### Example

```
[root@lclient001 ~]# lfs getstripe /mnt/lustre00
[root@lclient001 ~]# lfs setstripe -s 1M -i -1 -c -1 /mnt/lustre00
```

The `lfs setstripe` command in the example sets the filesystem to use 1MB blocks, the start OST is chosen by the MDS, and data is striped over all available OSTs.



# 8

## Burning Nodes

The *burn framework* is a component of Bright Cluster Manager 8.2 that can automatically run test scripts on specified nodes within a cluster. The framework is designed to stress test newly built machines and to detect components that may fail under load. Nodes undergoing a burn session with the default burn configuration, lose their filesystem and partition data for all attached drives, and revert to their software image on provisioning after a reboot.

### 8.1 Test Scripts Deployment

The framework requires power management to be running and working properly so that the node can be power cycled by the scripts used. In modern clusters power management is typically achieved by enabling a baseboard management controller such as IPMI, iLO, or Redfish. Details on power management are given in Chapter 4 of the *Administrator Manual*.

The framework can run any executable script. The default test scripts are mostly bash shell scripts and Perl scripts. Each test script has a directory in `/cm/shared/apps/cmburn` containing the script. The directory and test script must have the same name. For example: `/cm/shared/apps/cmburn/disktest/disktest` is the default script used for testing a disk. More on the contents of a test script is given in section 8.3.2.

### 8.2 Burn Configurations

A *burn configuration* is an XML file stored in the CMDaemon database that specifies the burn tests and the order in which they run. Within the burn configuration the tests are normally grouped into sequences, and several sequences typically make up a phase. Phases in turn are grouped in either a pre-install section or post-install section. A simple example of such a burn configuration could therefore look like:

#### Example

```
<?xml version="1.0"?>
<burnconfig>

  <mail>
    <address>root@master</address>
    <address>some@other.address</address>
  </mail>

  <pre-install>

    <phase name="01-hwinfo">
      <test name="hwinfo"/>
      <test name="hwdiff"/>
    </phase>
  </pre-install>
</burnconfig>
```

```

    <test name="sleep" args="10"/>
  </phase>

  <phase name="02-disks">
    <test name="disktest" args="30"/>
    <test name="mce_check" endless="1"/>
  </phase>

</pre-install>

<post-install>

  <phase name="03-hpl">
    <test name="hpl"/>
    <test name="mce_check" endless="1"/>
  </phase>

  <phase name="04-compile">
    <test name="compile" args="6"/>
    <test name="mce_check" endless="1"/>
  </phase>

</post-install>

</burnconfig>

```

### 8.2.1 Mail Tag

The optional `<mail>` tag pair can add a sequence of e-mail addresses, with each address enclosed in an `<address>` tag pair. These addresses receive burn failure and warning messages, as well as a notice when the burn run has completed.

### 8.2.2 Pre-install And Post-install

The pre-install part of a burn configuration is configured with the `<pre-install>` tag pair, and run from inside a node-installer environment. This environment is a limited Linux environment and allows some simpler tests to run before loading up the full Linux node environment.

Similarly, the post-install part of a burn configuration uses the `<post-install>` tag pair to run from inside the full Linux node environment. This environment allows more complex tests to run.

### 8.2.3 Post-burn Install Mode

The optional `<post-burn-install>` tag pair allows the administrator to specify the install mode (section 5.4.4 of the *Administrator Manual*) after burn. The tag pair can enclose a setting of AUTO, FULL, MAIN, or NOSYNC. The default setting is the install mode that was set before burn started.

### 8.2.4 Phases

The phases sections must exist. If there is no content for the phases, the phases tags must still be in place (“must exist”). Each phase must have a unique name and must be written in the burn configuration file in alphanumerical order. By default, numbers are used as prefixes. The phases are executed in sequence.

### 8.2.5 Tests

Each phase consists of one or more test tags. The tests can optionally be passed arguments using the `args` property of the burn configuration file (section 8.2). If multiple arguments are required, they should be a space separated list, with the (single) list being the `args` property.

Tests in the same phase are run simultaneously.

Most tests test something and then end. For example, the disk test tests the performance of all drives and then quits.

Tests which are designed to end automatically are known as *non-endless* tests.

Tests designed to monitor continuously are known as *endless tests*. Endless tests are not really endless. They end once all the non-endless tests in the same phase are ended, thus bringing an end to the phase. Endless tests typically test for errors caused by the load induced by the non-endless tests. For example the `mce_check` test continuously keeps an eye out for Machine Check Exceptions while the non-endless tests in the same phase are run.

A special test is the final test, `memtest86`, which is part of the default burn run, as configured in the XML configuration `default-destructive`. It does run endlessly if left to run. To end it, the administrator can deal with its output at the node console or can power reset the node. It is usually convenient to remove `memtest86` from the default XML configuration in larger clusters, and to rely on the HPL and `memtester` tests instead, for uncovering memory hardware errors.

## 8.3 Running A Burn Configuration

Burn configurations can be viewed and executed from `cmsh`.

### 8.3.1 Burn Configuration And Execution In `cmsh`

#### Burn Configuration File Settings

From `cmsh`, the burn configurations can be accessed from partition mode as follows:

#### Example

```
[bright82]% partition use base
[bright82->partition[base]]% burnconfigs
[bright82->partition[base]->burnconfigs]% list
```

Name (key)	Description	XML
default-destructive	Standard burn test.	<2614 bytes>
long-hpl	Run HPL test for a long+	<829 bytes>

The values of a particular burn configuration (`default-destructive` in the following example) can be viewed as follows:

#### Example

```
[bright82->partition[base]->burnconfigs]% use default-destructive
[bright82->partition[base]->burnconfigs[default-destructive]]% show
```

Parameter	Value
Description	Standard destructive burn test. Beware, wipes the disks!
Name	default-destructive
Revision	
XML	<2614 bytes>

The `set` command can be used to modify existing values of the burn configuration, that is: Description, Name, and XML. XML is the burn configuration file itself. The `get xml` command can be used to view the file, while using `set xml` opens up the default text editor, thus allowing the burn configuration to be modified.

A new burn configuration can also be added with the `add` command. The new burn configuration can be created from scratch with the `set` command. However, an XML file can also be imported to the new burn configuration by specifying the full path of the XML file to be imported:

#### Example

```
[bright82->partition[base]->burnconfigs]% add boxburn
[bright82->partition[base]->burnconfigs*[boxburn*]]% set xml /tmp/im.xml
```

The burn configuration can also be edited when carrying out burn execution with the burn command.

### Executing A Burn

A burn as specified by the burn configuration file can be executed in cmsh using the burn command of device mode.

**Burn commands:** The burn commands can modify these properties, as well as execute other burn-related operations.

The burn commands are executed within device mode, and are:

- burn start
- burn stop
- burn status
- burn log

The burn help text that follows lists the detailed options. Next, operations with the burn commands illustrate how the options may be used along with some features.

```
[head1->device[node005]]% burn
Name:      burn - Node burn control

Usage:     burn [OPTIONS] status
           burn [OPTIONS] start
           burn [OPTIONS] stop
           burn [OPTIONS] log

Options:   -n, --nodes <node>
           List of nodes, e.g. node001..node015,node020..node028,node030
           or ~/some/file/containing/hostnames

           -g, --group <group>
           Include all nodes that belong to the node group, e.g. testnodes or test01,test03

           -c, --category <category>
           Include all nodes that belong to the category, e.g. default or default,gpu

           -r, --rack <rack>
           Include all nodes that are located in the given rack, e.g rack01
           or rack01..rack04

           -h, --chassis <chassis>
           Include all nodes that are located in the given chassis, e.g chassis01
           or chassis03..chassis05

           -e, --overlay <overlay>
           Include all nodes that are part of the given overlay, e.g overlay1
           or overlayA,overlayC

           -m, --image <image>
```

```

    Include all nodes that have the given image, e.g default-image or
    default-image,gpu-image

-t, --type <type>
    Type of devices, e.g node or virtualnode,cloudnode

-i, --intersection
    Calculate the intersection of the above selections

-u, --union
    Calculate the union of the above selections

-l, --role role
    Filter all nodes that have the given role

-s, --status <status>
    Only run command on nodes with specified status, e.g. UP, "CLOSED|DOWN",
    "INST.*"

--config <name>
    Burn with the specified burn configuration. See in partition burn configurations
    for a list of valid names

--file <path>
    Burn with the specified file instead of burn configuration

--later
    Do not reboot nodes now, wait until manual reboot

--edit
    Open editor for last minute changes

--no-drain
    Do not drain the node from WLM before starting to burn

--no-undrain
    Do not undrain the node from WLM after burn is complete

-p, --path
    Show path to the burn log files. Of the form: /var/spool/burn/<mac>.

-v, --verbose
    Show verbose output (only for burn status)

--sort <field1>[,<field2>,...]
    Override default sort order (only for burn status)

-d, --delimiter <string>
    Set default row separator (only for burn status)

-d, --delay <seconds>
    Wait <seconds> between executing two sequential power commands. This option is
    ignored for the status command

```

Examples:

```
burn --config default-destructive start -n node001
```

**Burn command operations:** Burn commands allow the following operations, and have the following features:

- **start, stop, status, log:** The basic burn operations allow a burn to be started or stopped, and the status of a burn to be viewed and logged.

- The “burn start” command always needs a configuration file name. In the following it is boxburn. The command also always needs to be given the nodes it operates on:

```
[bright82->device]% burn --config boxburn -n node007 start
Power reset nodes
[bright82->device]%
ipmi0 ..... [ RESET ] node007
Fri Nov 3 ... [notice] bright82: node007 [ DOWN ]
[bright82->device]%
Fri Nov 3 ... [notice] bright82: node007 [ INSTALLING ] (node installer started)
[bright82->device]%
Fri Nov 3 ... [notice] bright82: node007 [ INSTALLING ] (running burn in tests)
...
```

- The “burn stop” command only needs to be given the nodes it operates on, for example:

```
[bright82->device]% burn -n node007 stop
```

- The “burn status” command:

- \* may be given the nodes for which the status is to be found, for example:

```
[bright82->device]% burn status -n node005..node007
Hostname Burn name Status New burn on PXE Phase ...
-----
node005 no burn results available no ...
node006 currently not burning no ...
node007 boxburn Burning yes 02-disks ...
```

*each line of output is quite long, so each line has been rendered truncated and ellipsized.*

*The ellipsis marks in the 5 preceding output lines align with the lines that follow.*

*That is, the lines that follow are the endings of the preceding 5 lines:*

```
...Warnings Tests
...-----
...0
...0
...0 /var/spool/burn/c8-1f-66-f2-61-c0/02-disks/disktest (S,171),\
/var/spool/burn/c8-1f-66-f2-61-c0/02-disks/kmon (S),\
/var/spool/bu+
```

- The “burn log” command displays the burn log for specified node groupings. Each node with a boot MAC address of <mac> has an associated burn log file.

- Advanced options include the following:

- `-n|--nodes`, `-g|--group`, `-c|--category`, `-r|--rack`, `-h|--chassis`, `-e|--overlay`, `-t|--type`, `-i|--intersection`, `-u|--union`, `-r|--role`, `-s|--status`: Burn commands can be executed over various node groupings.
- `--config <burn configuration>`, `--file <path>`: The burn configuration file can be set as one of the XML burn configurations listed in partition mode, or it can be set as the path of the XML file from the file system
- `-l|--later`: This option disables the immediate power reset that occurs on running the “burn start” or “burn stop” command on a node. This allows the administrator to power down manually, when preferred.
- `-e|--edit`: The burn configuration file can be edited with the `-e` option for the “burn start” command. This is an alternative to editing the burn configuration file in partition mode.
- `--no-drain`, `--no-undrain`: The node is not drained before burning, or not undrained after burning
- `-l|--later`: This option disables the immediate power reset that occurs on running the “burn start” or “burn stop” command on a node. This allows the administrator to power down manually, when preferred.
- `-p|--path`: This shows the burn log path, by default (section 8.4) on the head node under a directory named after the mac address `/var/spool/burn/<mac>`.

#### Example

```
[bright82->device]% burn -p -n node001..node003 log
node001: /var/spool/burn/fa-16-3e-60-1d-c7
node002: /var/spool/burn/fa-16-3e-8a-d8-0e
node003: /var/spool/burn/fa-16-3e-af-38-cd
```

**Burn command output examples:** The `burn status` command has a compact one-line output per node:

#### Example

```
[bright82->device]% burn -n node001 status
node001 (00000000a000) - W(0) phase 02-disks 00:02:58 (D:H:M) FAILED, mce_check (SP), \
disktest (SF,61), kmon (SP)
```

The fields in the preceding output example are:

Description	Value	Meaning Here
The node name	node001	
The node tag	(00000000a000)	
Warnings since start of burn	(0)	
The current phase name	02-disks	Burn configuration phase being run is 02-disks
Time since phase started	00:02:58 (D:H:M)	2 hours 58 minutes
State of current phase	FAILED	Failed in 02-disks
burn test for MCE	mce_check (SP)	Started and Passed
burn test for disks	disktest (SF,61)	Started and Failed 61 is the speed, and is custom information
burn test kernel log monitor	kmon (SP)	Started and Passed

Each test in a phase uses these letters to display its status:

Letter	Meaning
S	started
W	warning
F	failed
P	passed

The “burn log” command output looks like the following (some output elided):

```
[bright82->device]% burn -n node001 log
Thu ... 2012: node001 - burn-control: burn framework initializing
Thu ... 2012: node001 - burn-control: e-mail will be sent to: root@master
Thu ... 2012: node001 - burn-control: finding next pre-install phase
Thu ... 2012: node001 - burn-control: starting phase 01-hwinfo
Thu ... 2012: node001 - burn-control: starting test /cm/shared/apps/cmburn/hwinfo
Thu ... 2012: node001 - burn-control: starting test /cm/shared/apps/cmburn/sleep
Thu ... 2012: node001 - sleep: sleeping for 10 seconds
Thu ... 2012: node001 - hwinfo: hardware information
Thu ... 2012: node001 - hwinfo: CPU1: vendor_id = AuthenticAMD
...
Thu ... 2012: node001 - burn-control: test hwinfo has ended, test passed
Thu ... 2012: node001 - burn-control: test sleep has ended, test passed
Thu ... 2012: node001 - burn-control: all non-endless test are done, terminating endless tests
Thu ... 2012: node001 - burn-control: phase 01-hwinfo passed
Thu ... 2012: node001 - burn-control: finding next pre-install phase
Thu ... 2012: node001 - burn-control: starting phase 02-disks
Thu ... 2012: node001 - burn-control: starting test /cm/shared/apps/cmburn/disktest
```



```

Thu ... 2012: node001 - burn-control: starting test /cm/shared/apps/cmburn/mce_check
Thu ... 2012: node001 - burn-control: starting test /cm/shared/apps/cmburn/kmon
Thu ... 2012: node001 - disktest: starting, threshold = 30 MB/s
Thu ... 2012: node001 - mce_check: checking for MCE's every minute
Thu ... 2012: node001 - kmon: kernel log monitor started
Thu ... 2012: node001 - disktest: detected 1 drives: sda
...
Thu ... 2012: node001 - disktest: drive sda wrote 81920 MB in 1278.13
Thu ... 2012: node001 - disktest: speed for drive sda was 64 MB/s -> disk passed
Thu ... 2012: node001 - burn-control: test disktest has ended, test FAILED
Thu ... 2012: node001 - burn-control: all non-endless test are done, terminating endless tests
Thu ... 2012: node001 - burn-control: asking test /cm/shared/apps/cmburn/kmon/kmon t o terminate
Thu ... 2012: node001 - kmon: kernel log monitor terminated
Thu ... 2012: node001 - burn-control: test kmon has ended, test passed
Thu ... 2012: node001 - burn-control: asking test /cm/shared/apps/cmburn/mce_check/mce_check\
to terminate
Thu ... 2012: node001 - mce_check: terminating
Thu ... 2012: node001 - mce_check: waiting for mce_check to stop
Thu ... 2012: node001 - mce_check: no MCE's found
Thu ... 2012: node001 - mce_check: terminated
Thu ... 2012: node001 - burn-control: test mce_check has ended, test passed
Thu ... 2012: node001 - burn-control: phase 02-disks FAILED
Thu ... 2012: node001 - burn-control: burn will terminate

```

The output of the `burn log` command is actually the messages file in the burn directory, for the node associated with a MAC-address directory `<mac>`. The burn directory is at `/var/spool/burn/` and the messages file is thus located at:

```
/var/spool/burn/<mac>/messages
```

The tests have their log files in their own directories under the MAC-address directory, using their phase name. For example, the pre-install section has a phase named `01-hwinfo`. The output logs of this test are then stored under:

```
/var/spool/burn/<mac>/01-hwinfo/
```

### 8.3.2 Writing A Test Script

This section describes a sample test script for use within the burn framework. The script is typically a shell or Perl script. The sample that follows is a Bash script, while the `hp1` script is an example in Perl.

Section 8.1 describes how to deploy the script.

#### Non-endless Tests

The following example test script is not a working test script, but can be used as a template for a non-endless test:

#### Example

```

#!/bin/bash

# We need to know our own test name, amongst other things for logging.
me=`basename $0`

# This first argument passed to a test script by the burn framework is a
# path to a spool directory. The directory is created by the framework.

```

```
# Inside the spool directory a sub-directory with the same name as the
# test is also created. This directory ($spooldir/$me) should be used
# for any output files etc. Note that the script should possibly remove
# any previous output files before starting.
spooldir=$1

# In case of success, the script should touch $passedfile before exiting.
passedfile=$spooldir/$me.passed

# In case of failure, the script should touch $failedfile before exiting.
# Note that the framework will create this file if a script exits without
# creating $passedfile. The file should contain a summary of the failure.
failedfile=$spooldir/$me.failed

# In case a test detects trouble but does not want the entire burn to be
# halted $warningfile _and_ $passedfile should be created. Any warnings
# should be written to this file.
warningfile=$spooldir/$me.warning

# Some short status info can be written to this file. For instance, the
# stresscpu test outputs something like 13/60 to this file to indicate
# time remaining.
# Keep the content on one line and as short as possible!
statusfile=$spooldir/$me.status

# A test script can be passed arguments from the burn configuration. It
# is recommended to supply default values and test if any values have
# been overridden from the config file. Set some defaults:
option1=40
option2=some_other_value

# Test if option1 and/or option2 was specified (note that $1 was to
# spooldir parameter):
if [ ! x$2 = "x" ]; then
    option1=$2
fi
if [ ! x$3 = "x" ]; then
    option2=$3
fi

# Some scripts may require some cleanup. For instance a test might fail
# and be
# restarted after hardware fixes.
rm -f $spooldir/$me/*.out &>/dev/null

# Send a message to the burn log file, syslog and the screen.
# Always prefix with $me!
blog "$me: starting, option1 = $option1 option2 = $option2"

# Run your test here:
run-my-test
if [ its_all_good ]; then
    blog "$me: w00t, it's all good! my-test passed."
    touch $passedfile
    exit 0
```

```

elif [ was_a_problem ]; then
    blog "$me: WARNING, it did not make sense to run this test. You don't have special device X."
    echo "some warning" >> $warningfile # note the append!
    touch $passedfile
    exit 0
else
    blog "$me: Aiii, we're all gonna die! my-test FAILED!"
    echo "Failure message." > $failedfile
    exit 0
fi

```

### Endless Tests

The following example test script is not a working test, but can be used as a template for an endless test.

#### Example

```

#!/bin/bash

# We need to know our own test name, amongst other things for logging.
me=`basename $0`

# This first argument passed to a test script by the burn framework is a
# path to a spool directory. The directory is created by the framework.
# Inside the spool directory a sub-directory with the same name as the
# test is also created. This directory ($spooldir/$me) should be used
# for any output files etc. Note that the script should possibly remove
# any previous output files before starting.
spooldir=$1

# In case of success, the script should touch $passedfile before exiting.
passedfile=$spooldir/$me.passed

# In case of failure, the script should touch $failedfile before exiting.
# Note that the framework will create this file if a script exits without
# creating $passedfile. The file should contain a summary of the failure.
failedfile=$spooldir/$me.failed

# In case a test detects trouble but does not want the entire burn to be
# halted $warningfile _and_ $passedfile should be created. Any warnings
# should be written to this file.
warningfile=$spooldir/$me.warning

# Some short status info can be written to this file. For instance, the
# stresscpu test outputs something like 13/60 to this file to indicate
# time remaining.
# Keep the content on one line and as short as possible!
statusfile=$spooldir/$me.status

# Since this in an endless test the framework needs a way of stopping it
# once all non-endless test in the same phase are done. It does this by
# calling the script once more and passing a "-terminate" argument.
if [ "$2" == "-terminate" ]; then
    blog "$me: terminating"

    # remove the lock file the main loop is checking for
    rm $spooldir/$me/running

```

```

blog "$me: waiting for $me to stop"
# wait for the main loop to die
while [ -d /proc/`cat $spooldir/$me/pid` ]
do
    sleep 1
done
blog "$me: terminated"

else
    blog "$me: starting test, checking every minute"

    # Some scripts may require some cleanup. For instance a test might fail
    # and be restarted after hardware fixes.
    rm -f $spooldir/$me/*.out &>/dev/null

    # create internal lock file, the script will remove this if it is
    # requested to end
    touch $spooldir/$me/running

    # save our process id
    echo $$ > "$spooldir/$me/pid"

    while [ -e "$spooldir/$me/running" ]
    do

        run-some-check
        if [ was_a_problem ]; then
            blog "$me: WARNING, something unexpected happened."
            echo "some warning" >> $warningfile # note the append!
        elif [ failure ]; then
            blog "$me: Aiii, we're all gonna die! my-test FAILED!"
            echo "Failure message." > $failedfile
        fi
        sleep 60

    done

    # This part is only reached when the test is terminating.
    if [ ! -e "$failedfile" ]; then
        blog "$me: no problem detected"
        touch $passedfile
    else
        blog "$me: test ended with a failure"
    fi
fi

```

### 8.3.3 Burn Failures

Whenever the burn process fails, the output of the `burn log` command shows the phase that has failed and that the burn terminates.

#### Example

```

Thu ... 2012: node001 - burn-control: phase 02-disks FAILED
Thu ... 2012: node001 - burn-control: burn will terminate

```

Here, `burn-control`, which is the parent of the disk testing process, keeps track of the tests that pass and fail. On failure of a test, `burn-control` terminates all tests.

The node that has failed then requires intervention from the administrator in order to change state. The node does not restart by default. The administrator should be aware that the state reported by the node to `CMDaemon` remains burning at this point, even though it is not actually doing anything.

To change the state, the burn must be stopped with the `burn stop` command in `cmsh`. If the node is restarted without explicitly stopping the burn, then it simply retries the phase at which it failed.

Under the burn log directory, the log of the particular test that failed for a particular node can sometimes suggest a reason for the failure. For retries, old logs are not overwritten, but moved to a directory with the same name, and a number appended indicating the try number. Thus:

### Example

First try, and failing at 02-disks tests:

```
cd /var/spool/burn/48:5b:39:19:ff:b3
ls -ld 02-disks*/
drwxr-xr-x 6 root root 4096 Jan 10 16:26 02-disks
```

2nd try, after failing again:

```
ls -ld 02-disks*/
drwxr-xr-x 6 root root 4096 Jan 10 16:49 02-disks
drwxr-xr-x 6 root root 4096 Jan 10 16:26 02-disks.1
```

3rd try, after failing again:

```
ls -ld 02-disks*/
drwxr-xr-x 6 root root 4096 Jan 10 16:59 02-disks
drwxr-xr-x 6 root root 4096 Jan 10 16:49 02-disks.1
drwxr-xr-x 6 root root 4096 Jan 10 16:26 02-disks.2
```

## 8.4 Relocating The Burn Logs

A burn run can append substantial amounts of log data to the default burn spool at `/var/spool/burn`. To avoid filling up the head node with such logs, they can be appended elsewhere.

### 8.4.1 Configuring The Relocation

The 3-part procedure that can be followed is:

1. The `BurnSpoolDir` setting can be set in the `CMDaemon` configuration file on the head node, at `/cm/local/apps/cmd/etc/cmd.conf`. The `BurnSpoolDir` setting tells `CMDaemon` where to look for burn data when the burn status is requested through `cmsh`.

- `BurnSpoolDir="/var/spool/burn"`

`CMDaemon` should be restarted after the configuration has been set. This can be done with:

```
service cmd restart
```

2. The `burnSpoolHost` setting, which matches the host, and `burnSpoolPath` setting, which matches the location, can be changed in the node-installer configuration file on the head node, at `/cm/node-installer/scripts/node-installer.conf`. These have the following values by default:

- `burnSpoolHost = master`
- `burnSpoolPath = /var/spool/burn`

These values define the NFS-mounted spool directory.

The `burnSpoolHost` value should be set to the new DNS host name, or to an IP address. The `burnSpoolPath` value should be set to the new path for the data.

- Part 3 of the procedure adds a new location to export the burn log. This is only relevant if the spool directory is being relocated within the head node. If the spool is on an external fileserver, the existing burn log export may as well be removed.

The new location can be added to the head node as a path value, from a writable filesystem export name. The writable filesystem export name can most easily be added using Bright View, via the clickpath:

Devices→Head Nodes→Edit→Settings→Filesystem exports→Add

Adding a new name like this is recommended, instead of just modifying the path value in an existing Filesystem exports name. This is because changing things back if the configuration is done incorrectly is then easy. By default, the existing Filesystem exports for the burn directory has the name:

- `/var/spool/burn@internalnet`

and has a path associated with it with a default value of:

- `/var/spool/burn`

When the new name is set in Filesystem exports, the associated path value can be set in agreement with the values set earlier in parts 1 and 2.

If using `cmsh` instead of Bright View, then the change can be carried out from within the `fsexports` submode. Section 3.10.1 of the *Administrator Manual* gives more detail on similar examples of how to add such filesystem exports.

### 8.4.2 Testing The Relocation

To test the changes, it is wise to first try a single node with a short burn configuration. This allows the administrator to check that install and post-install tests can access the spool directories. Otherwise there is a risk of waiting hours for the pre-install tests to complete, only to have the burn abort on the post-install tests. The following short burn configuration can be used:

#### Example

```
<burnconfig>
<pre-install>
<phase name="01-hwinfo">
<test name="hwinfo"/>
<test name="sleep" args="10"/>
</phase>
</pre-install>
<post-install>
<phase name="02-mprime">
<test name="mprime" args="2"/>
<test name="mce_check" endless="1"/>
<test name="kmon" endless="1"/>
</phase>
</post-install>
</burnconfig>
```

To burn a single node with this configuration, the following could be run from the device mode of `cmsh`:

### Example

```
[bright82->device]% burn start --config default-destructive --edit -n node001
```

This makes an editor pop up containing the default burn configuration. The content can be replaced with the short burn configuration. Saving and quitting the editor causes the node to power cycle and start its burn.

The example burn configuration typically completes in less than 10 minutes or so, depending mostly on how fast the node can be provisioned. It runs the `mprime` test for about two minutes.





# Installing And Configuring SELinux

## 9.1 Introduction

Security-Enhanced Linux (SELinux) can be enabled on selected nodes. On a standard Linux operating system where SELinux is enabled, it is typically initialized in the kernel during the execution of the `init` script inside the `initrd` when booting from a hard drive. However, in the case of nodes provisioned by Bright Cluster Manager, via PXE boot, the SELinux initialization occurs at the very end of the node installer phase.

SELinux is disabled by default because its security policies are typically customized to the needs of the organization using it. The administrator is therefore the one who must decide on appropriate access control security policies. When creating such custom policies special care should be taken that the `cmd` process is executed in, ideally, an unconfined context.

Before enabling SELinux on a cluster, the administrator is advised to first check that the Linux distribution used offers enterprise support for SELinux-enabled systems. This is because support for SELinux should be provided by the distribution in case of issues.

Enabling SELinux is only advised by Bright Cluster Manager if the internal security policies of the organization absolutely require it. This is because it requires custom changes from the administrator. If something is not working right, then the effect of these custom changes on the installation must also be taken into consideration, which can sometimes be difficult.

## 9.2 Enabling SELinux on RHEL6

RedHat-based systems come with a default targeted policy which confines only some selected (“targeted”) system services.

### 9.2.1 Regular Nodes

There are two ways to enable SELinux on regular nodes for RHEL6:

1. by configuring the node to boot a local disk.
2. using the node installer to set up SELinux during PXE boot

In both cases, before the regular node is provisioned, the `/cm/images/<image>/etc/selinux/config` file must be properly configured. This means configuring appropriate values for the `SELINUX` and `SELINUXTYPE` directives.

#### **SELinux, With Booting Off A Local Disk**

SELinux can be enabled on a regular node by first provisioning it via PXE, and then setting the `installbootrecord` property (section 5.4.10 of the *Administrator Manual*). The node will subsequently boot via the local hard drive, instead of from the network.

The downside to this method is that if the software image is updated, the filesystem of the node is not updated after a reboot.

### SELinux with PXE booting

The other, and recommended, way to enable SELinux on a regular node is to have the node installer initialize the SELinux environment after provisioning the node. That is, the node installer loads the initial policy and applies proper security contexts to the filesystem.

To make the node installer initialize SELinux, the content of the `/cm/node-installer/scripts/node-installer.conf` file (located on the head node) must be edited. The value of the `SELinuxInitialize` directive should be changed from `false` to `true`. When the node is rebooted with this setting, SELinux initializes via the node installer after provisioning has been completed, and before the node installer finishes its execution.

## 9.2.2 Head Node

In order to enable SELinux on the head node in RHEL6:

- The `/etc/selinux/config` file must be edited (according to the organizational requirements) in the same way as for regular nodes.
- An `/.autorelabel` file should be created on the head node's filesystem.
- The kernel parameters ("`security=selinux selinux=1`") must be manually added to the `/boot/grub/menu.lst` file.
- The head node must then be restarted.

## 9.3 Additional Considerations

### 9.3.1 Provisioning The `/.autorelabel` File Tag

It is advised that the `/cm/images/<image>/.autorelabel` file only get transferred to the regular nodes during a FULL node installation. I.e., it should not be transferred during the AUTO node installation. This can be achieved by appending the following entry to the `excludelistsyncinstall` property of the node category:

```
no-new-files: - /.autorelabel
```

Why this is done is explained in section 9.4.

### 9.3.2 SELinux Warnings During Regular Node Updates

When software images are updated (section 11.4 of the *Administrator Manual*), messages such as the following may be displayed:

```
SELinux: Could not downgrade policy file /etc/selinux/targeted/policy/\  
policy.24, searching for an older version.  
SELinux: Could not open policy file <= /etc/selinux/targeted/policy/po\  
licy.24: No such file or directory
```

These messages are displayed if the SELinux status cannot be retrieved. For a default image, the SELinux status is disabled by default, in which case the messages can safely be ignored.

## 9.4 Filesystem Security Context Checks

Ensuring that the files present on the node have correct security contexts applied to them is an important part of enforcing a security policy.

In the case of the head nodes, the filesystem security context check is performed by the default system startup scripts. This is, by default, performed only if the presence of the `/.autorelabel` file on the root filesystem is detected.

In the case of the regular nodes the process is significantly different. For these, by default, it is the node installer that is responsible for the correctness of security contexts on the filesystem of the nodes.

If the regular node has undergone full provisioning, then if the `/.autorelabel` file exists on the node's local filesystem, the security contexts of all eligible filesystems of that node are restored by the node installer. This behavior is analogous to what the startup subsystem scripts would normally do. However, since the node installer removes the `/.autorelabel` file after performing the context restore, the operating system startup script does not detect it once the system boot continues.

If the node has undergone a sync provisioning (e.g. installed in AUTO mode), then after enabling SELinux, the node installer will only restore the security context on the files which were modified during provisioning and on files which were generated by the node installer itself. This is typically significantly faster than performing a full filesystem security context restore on all eligible filesystems.

The behavior described above can be altered using the `/cm/node-installer/script/node-installer.conf` configuration file. For example, it is always possible to force a full filesystem security context restore in the AUTO install mode, or to leave the context checking to the operating system's startup scripts.





# Other Licenses, Subscriptions, Or Support Vendors

Bright Cluster Manager comes with enough software to allow it to work with no additional commercial requirements other than its own. However, Bright Cluster Manager integrates with some other products that have their own separate commercial requirements. The following table lists commercial software that requires a separate license, subscription, or support vendor, and an associated URL where more information can be found.

Software	URL
<b>Workload managers</b>	
PBS Pro	<a href="http://www.pbsworks.com">http://www.pbsworks.com</a>
MOAB	<a href="http://www.adaptivecomputing.com">http://www.adaptivecomputing.com</a>
LSF	<a href="http://www.ibm.com/systems/platformcomputing/products/lsf/">http://www.ibm.com/systems/platformcomputing/products/lsf/</a>
UGE	<a href="http://www.univa.com">http://www.univa.com</a>
<b>Distributions</b>	
Suse	<a href="http://www.suse.com">http://www.suse.com</a>
Red Hat	<a href="http://www.redhat.com">http://www.redhat.com</a>
<b>Compilers</b>	
Intel	<a href="https://software.intel.com/en-us/intel-sdp-home">https://software.intel.com/en-us/intel-sdp-home</a>
PGI High-performance	<a href="http://www.pgroup.com/">http://www.pgroup.com/</a>
<b>Miscellaneous</b>	

*...continues*

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Software	URL
Amazon AWS	<a href="http://aws.amazon.com">http://aws.amazon.com</a>

# B

## Hardware Recommendations

The hardware suggestions in section 3.1 are for a minimal cluster, and are inadequate for larger clusters.

For larger clusters, hardware suggestions and examples are given in this section. The section assumes that OpenStack, which has its own resource requirements, is not running.

The memory used depends significantly on CMDaemon, which is the main Bright Cluster Manager service component, and on the number of processes running on the head node or regular node. The number of processes mostly depends on the number of metrics and health checks that are run.

Hard drive storage mostly depends on the number of metrics and health checks that are managed by CMDaemon.

### B.1 Heuristics For Requirements

Normal system processes run on the head and regular node if the cluster manager is not running, and take up their own RAM and drive space.

#### B.1.1 Heuristics For Requirements For A Regular Node

A calculation of typical regular node requirements can be made as follows:

##### Regular Node Disk Size

For disked nodes, a disk size of around 16 GB is the minimum needed. 128GB should always be fine at the time of writing (May 2018). The disk size should be large enough to hold the entire regular node image that the head node supplies to it, which typically is around 5GB, along with swap, log files and other local overhead for the jobs that will run on the regular node.

##### Regular Node Memory Size

The total RAM required is roughly the sum of:

RAM used for non – Bright system processes + 50MB + (number of nodes × 10kB).

#### B.1.2 Heuristics For Requirements For A Head Node

A calculation of typical head node requirements can be made as follows:

##### Head Node Disk Size

The disk size required is roughly the sum of:

space needed by operating system without cluster manager + 5GB per regular node image + (100kB × number of metrics and health checks × number of devices)

A device means any item seen as a device by CMDaemon. A list of devices can be seen by `cmsh` under its device node. Examples of devices are: regular nodes, cloud nodes, switches, head nodes, GPU units, and PDUs.

### Head Node Memory Size

The total RAM required is roughly the sum of:

RAM used for normal system process + 100MB + (number of nodes × 1.8MB)

This assumes less than 100 metrics and health checks are being measured, which is a default for systems that are just head nodes and regular nodes. Beyond the first 100 metrics and health checks, each further 100 extra take about 1MB extra per device.

## B.2 Observed Head Node Resources Use, And Suggested Specification

### B.2.1 Observed Head Node Example CMDaemon And MySQL Resources Use

CMDaemon and MySQL have the following approximate default resource usage on the head node as the number of nodes increases:

Number of nodes	CMDaemon + MySQL RAM/GB	CMDaemon RAM/GB	Disk Use/GB
1000	16	2	10
2000	32	4	20
5000	64	10	50

### B.2.2 Suggested Head Node Specification For Significant Clusters

For clusters with more than 1000 nodes, a head node is recommended with at least the following specifications:

- 24 cores
- 128 GB RAM
- 512 GB SSD

The extra RAM is useful for caching the filesystem, so scrimping on it makes little sense.

Handy for speedy retrievals is to place the monitoring data files, which are by default located under `/var/spool/cmd/monitoring/`, on an SSD.

A dedicated `/var` or `/var/lib/mysql` partition for clusters with greater than 2500 nodes is also a good idea.