

Bright Cluster Manager 7.1

Cloudbursting Manual

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Preface

Welcome to the *Cloudbursting Manual* for Bright Cluster Manager 7.1.

0.1 About This Manual

This manual is aimed at helping cluster administrators install, understand, configure, and manage the cloud capabilities of Bright Cluster Manager. The administrator is expected to be reasonably familiar with the *Administrator Manual*.

0.2 About The Manuals In General

Regularly updated versions of the Bright Cluster Manager 7.1 manuals are available on updated clusters by default at `/cm/shared/docs/cm`. The latest updates are always online at <http://support.brightcomputing.com/manuals>.

- The *Installation Manual* describes installation procedures for the basic cluster.
- 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 *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 *Hadoop Deployment Manual* describes how to deploy Hadoop with Bright Cluster Manager.
- The *UCS Deployment Manual* describes how to deploy the Cisco UCS server with Bright Cluster Manager.

If the manuals are downloaded and kept in one local directory, then in most pdf viewers, clicking on a cross-reference in one manual that refers to a section in another manual opens and displays that section in the second manual. Navigating back and forth between documents is usually possible with keystrokes or mouse clicks.

For example: `<Alt>-<Backarrow>` in Acrobat Reader, or clicking on the bottom leftmost navigation button of xpdf, both navigate back to the previous document.

The manuals constantly evolve to keep up with the development of the Bright Cluster Manager environment and the addition of new hardware and/or applications. The manuals also regularly incorporate customer feedback. Administrator and user input is greatly valued at Bright Computing. So any comments, suggestions or corrections will be very gratefully accepted at manuals@brightcomputing.com.

0.3 Getting Administrator-Level Support

If the reseller from whom Bright Cluster Manager was bought offers direct support, then the reseller should be contacted.

Otherwise the primary means of support is via the website <https://support.brightcomputing.com>. This allows the administrator to submit a support request via a web

form, and opens up a trouble ticket. It is a good idea to try to use a clear subject header, since that is used as part of a reference tag as the ticket progresses. Also helpful is a good description of the issue. The followup communication for this ticket goes via standard e-mail. Section 10.2 of the *Administrator Manual* has more details on working with support.

1

Introduction

In weather, a cloudburst is used to convey the idea that a sudden flood of cloud contents takes place. In cluster computing, the term *cloudbursting* conveys the idea that a flood of extra cluster capacity is made available when needed from a cloud computing services provider such as Amazon.

Bright Cluster Manager implements cloudbursting for two scenarios:

1. A “Cluster-On-Demand”, or a “pure” cloud cluster (chapter 2). In this scenario, the entire cluster can be started up on demand from a state of non-existence. All nodes, including the head node, are instances running in a coordinated manner entirely inside the cloud computing service.
2. A “Cluster Extension”, or a “hybrid” cloud cluster (chapter 3). In this scenario, the head node is kept outside the cloud. Zero or more regular nodes are also run outside the cloud. When additional capacity is required, the cluster is extended via cloudbursting to make additional nodes available from within the cloud.

Chapters 2 and 3 deal with GUI configuration of the two cloudbursting scenarios.

Chapter 4 looks at cloudbursting configuration using command line tools.

Chapter 5 discusses some miscellaneous aspects of cloudbursting.

Chapter 6 describes the concepts, including networking, behind setting up a “private” cloud cluster on a virtual private network using the Amazon VPC infrastructure.

2

Cluster-On-Demand Cloudbursting

Requirements

If the cloud provider is Amazon, then Cluster-On-Demand cloudbursting (the case of starting up a “pure” cloud cluster) requires:

- an Amazon account
- registration on the Bright Computing Customer Portal website at <http://www.brightcomputing.com/Customer-Login.php>
- a Bright Cluster Manager product key. The key is obtained at the Customer Portal website specifically for a Cluster-On-Demand setup, from the `Burst!` menu. This key is later activated when the license is installed (section 2.2) on the head node. The head node and regular nodes in this case are in the cloud.

Steps

The following steps are then carried out to start up the head node and regular nodes of the cloud cluster:

- a head node instance is launched from a browser, using the Amazon management console (section 2.1)
- the head node instance is logged into via `ssh` and the cluster is configured (section 2.2)
- the regular nodes are started up from the head node using `cmsh` or `cmgui` to power them up (section 2.4)

These steps are now covered in more detail.

2.1 Cluster-On-Demand: Launching The Head Node From The Cloud Provider

Launching a head node from within Amazon is covered in this section.

2.1.1 Getting To The “Launch Instance” Button

The Amazon management console can be logged into from <https://console.aws.amazon.com/console/> by using the e-mail address and password of the Amazon account (figure 2.1).

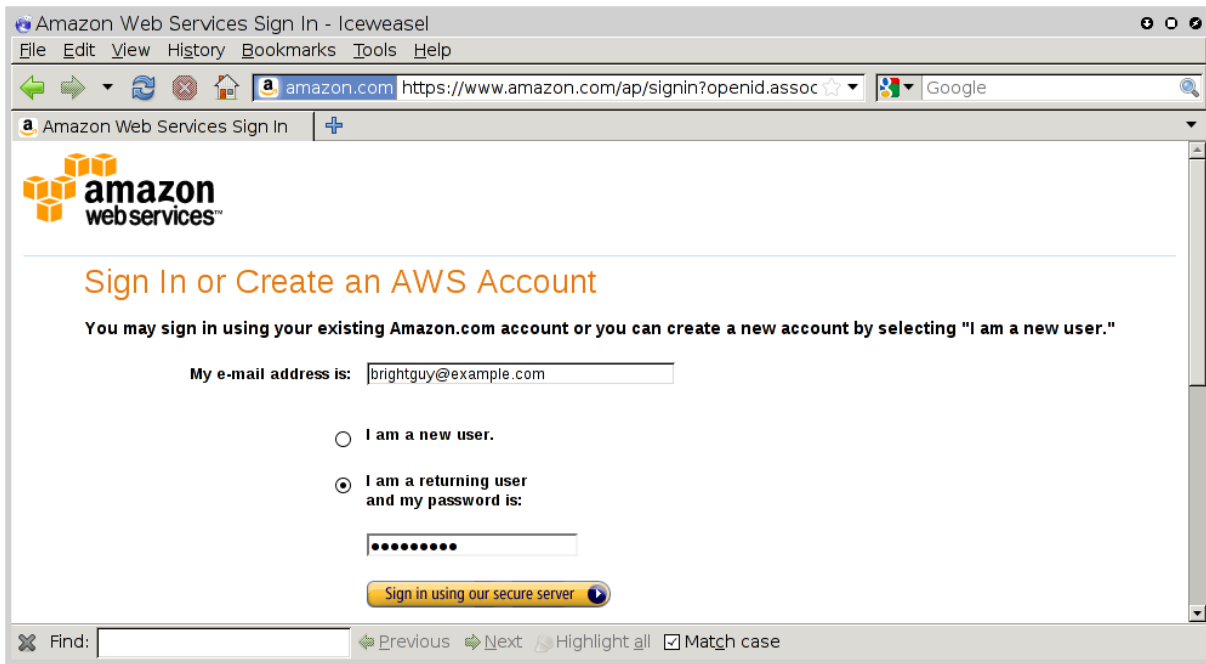


Figure 2.1: Logging Into The Amazon Management Console

By default, on login, the management console displays a list of accessible Amazon web services (figure 2.2).

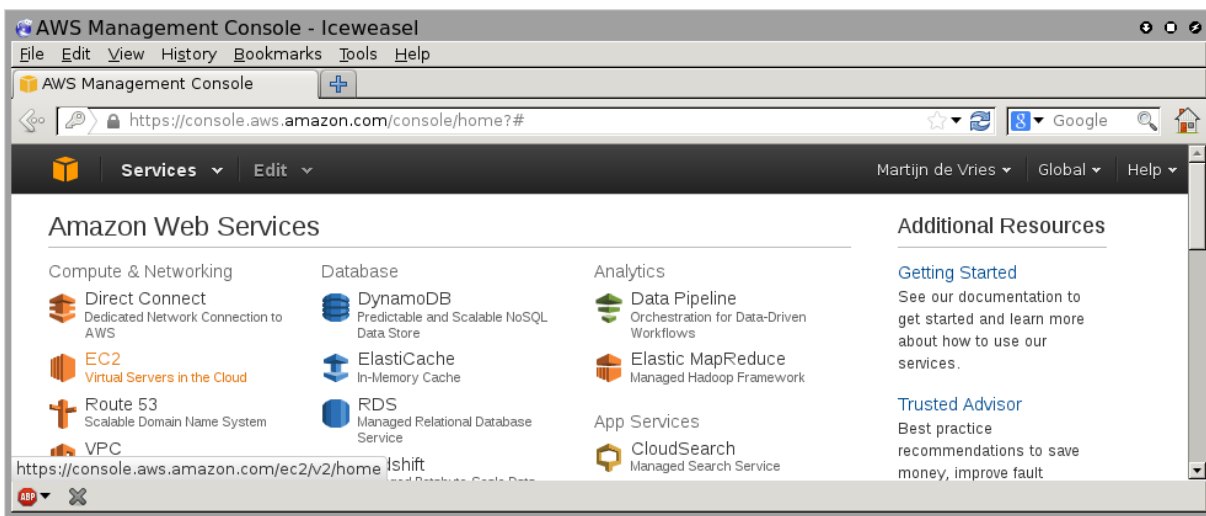


Figure 2.2: Amazon Management Console: Accessible Services

To set up the Cluster-On-Demand cluster, the EC2 service within the Compute & Networking grouping should be clicked. This brings up the EC2 Dashboard, which is also the top link of a resource tree that is displayed in a Navigation pane (figure 2.3).

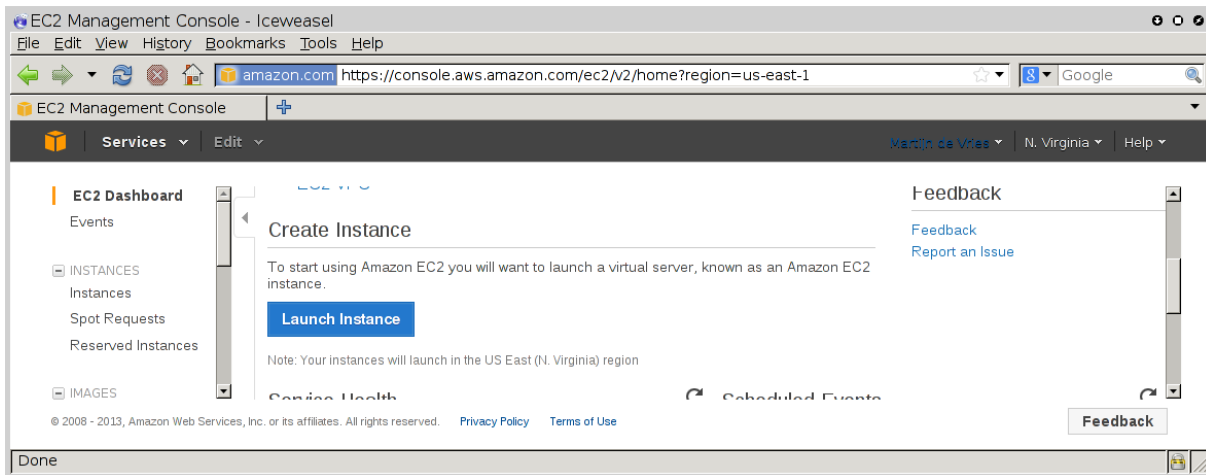


Figure 2.3: The EC2 Dashboard With The “Launch Instance” Button

In the main pane of the dashboard is the `Launch Instance` button. Clicking it starts up Amazon’s Launch Instance Wizard. Amazon documentation for the wizard is at <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/launching-instance.html>.

Using the wizard to launch a head node instance is described next.

2.1.2 Launching The Head Node Instance

To start a Cluster-On-Demand cluster, a head node instance must first be launched. This can be done as follows:

- **Step 1:** Choose an Amazon Machine Image (AMI): The first step in the wizard offers a choice of `Select` buttons to launch an instance from an AMI image (figure 2.4).

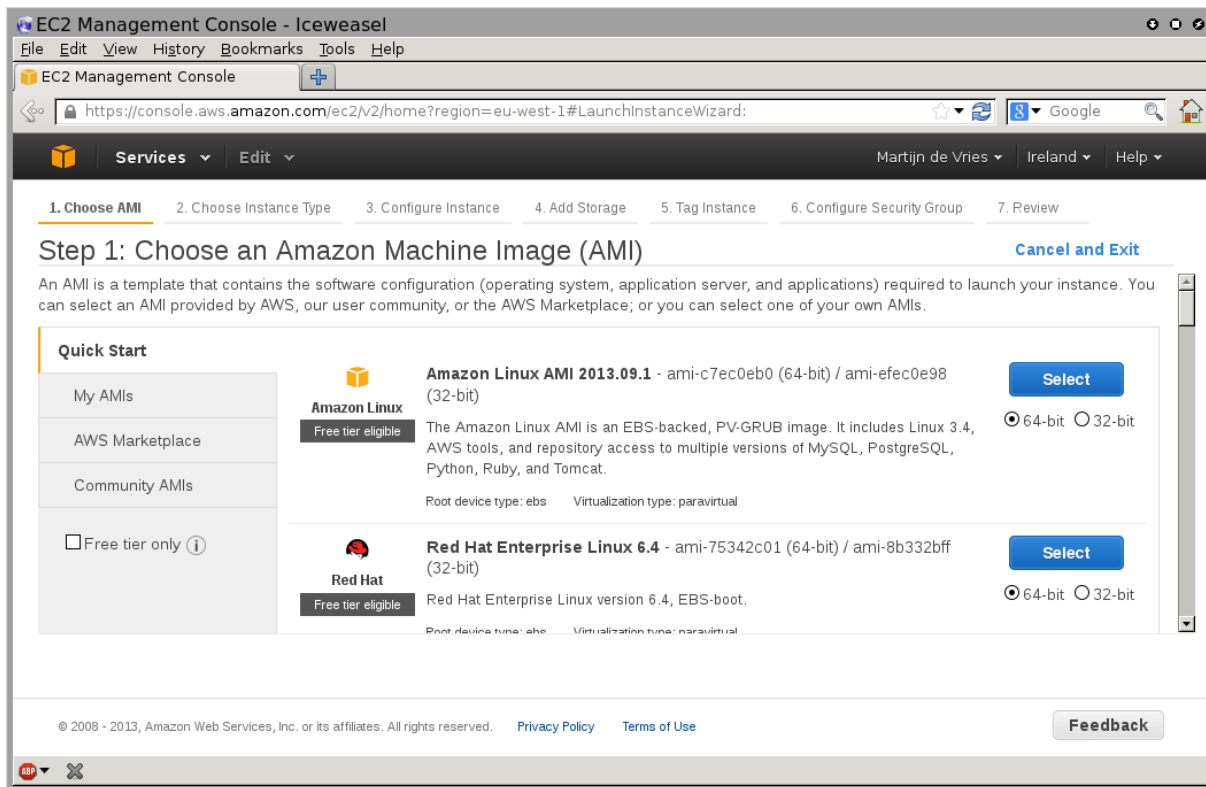


Figure 2.4: EC2: Choosing An AMI, Step 1

The default AMIs can be ignored. Clicking on the `Community AMIs` link in the left navigation pane brings up a new display of community AMIs. Entering a search text of “`brightheadnode`” then shows only the AMIs appropriate for a Bright Cluster Manager head node instance in a Cluster-On-Demand cluster. These are:

1. An AMI that uses standard XEN paravirtualization technology. This is available for all regions. If this image is used, hardware virtualization extensions acceleration is not implemented, even if available in the underlying cloud node hardware.
2. An AMI with `hvm` in the name. This is available for some regions. It is intended for use in regions that support HVM (Hardware Virtual Machines). HVM requires that the CPU used has the Intel VT or AMD-V virtualization extensions, to implement hardware acceleration for virtualized machines. At the time of checking (April 2013):
 - Regions supporting HVM are `eu-west-1`, `us-east-1`, and `us-west-2`.
 - Instance types supporting HVM are the `m3.xlarge` instance type, and higher. Instance types (<http://aws.amazon.com/ec2/instance-types/>) are a way of characterizing machine specifications, such as whether it has more RAM, more cores, or HVM.

Updated details on the regions and instance types that Amazon EC2 supports can be found via the Amazon website, <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/instance-types.html>.

Clicking on the `Select` button for the appropriate XEN or HVM head node AMI then brings up the next step in the launch wizard:

- **Step 2: Choose an Instance Type:** This displays a *micro instance* by default (figure 2.5).

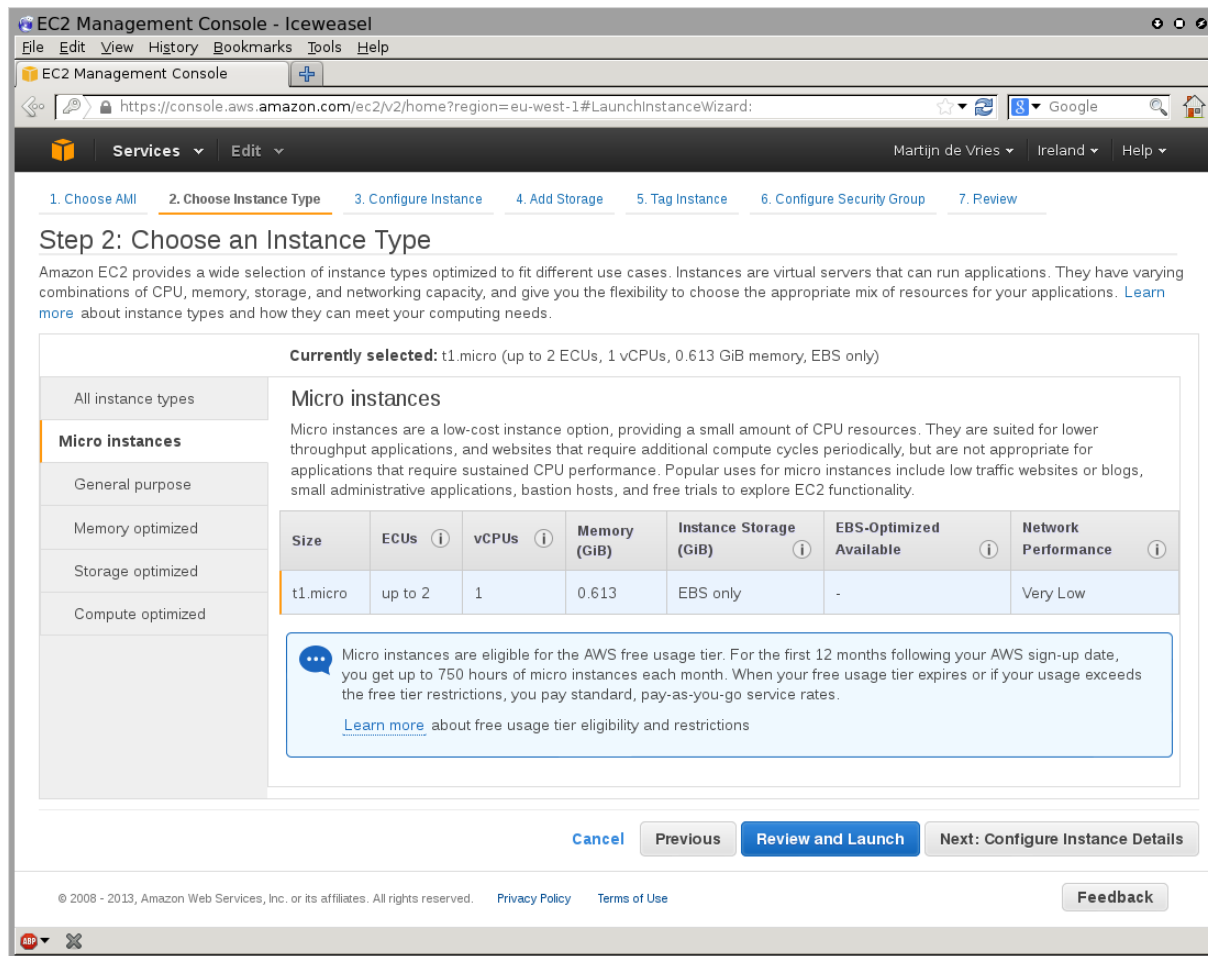


Figure 2.5: EC2: Choosing An AMI, Step 2

The `t1.micro` is the smallest and least powerful type of instance that a head node can run as, but is only useful for quite minor testing. It is likely to be overwhelmed when doing any significant work. A more reasonable node type to use for testing is therefore the `m1.small` type, which is available under the `General purpose` navigation option of this window.

Steps 3 to 6 that follow are optional and can be skipped, by going ahead to Step 7: Review Instance Launch.

- Step 3: Configure Instance Details: Among other instance options, this optional step allows the following to be set:
 - Purchasing option, for spot instances (section 5.3.1)
 - Network This is a choice of EC2-Classic or EC2-VPC instances (section 6.1.1)
 - Availability Zone, for if there is a preference for the location of the instance. Nodes within the same availability zone can connect with low latency and high bandwidth to each other. They are also isolated from other availability zones in the same region, which reduces the risk of network outages from another zone affecting them. By default, no preference is specified for the head node, nor for the cloud nodes later. This is because spot pricing can increase as nodes from an availability zone become scarce, which may conflict with the intention of the administrator. The default availability setting for a cloud account can be set in `cmsh` from within `cloud` mode:

Example

```
[bright71->cloud[Spare Capacity]]% set defaultavailabilityzone
```

- Shutdown behavior, to decide if the instance should be stopped (kept around) or terminated (removed).
- Step 4: Add Storage: Among other storage options, this optional step allows the following options to be set:
 - Size (GB): The size of storage to be added to the instance
 - Type: Whether the storage is EBS or ephemeral
 - Device: A device name, chosen from `/dev/sdb` onwards, since `/dev/sda` is already taken
 - Delete on Termination: Whether the device is deleted when the instance terminates

By default, the instance has a Type called `Root`, which is a special EBS volume. It has a default Size (GB) of 80, which can be edited.

For most instances other than `micro`, a certain amount of ephemeral storage is provided by Amazon for free, and can then be set for the root device in the Storage Device Configuration options of this screen. The EBS and ephemeral storage types are described in section 3.2.1.

- Step 5: Tag instance: This optional step allows the addition of metadata to an instance, via assignment of key-value pairs. A default key of `Name` is presented, and the administrator should put in a name for the instance as the associated value. The associated value can be arbitrary.
- Step 6: Configure Security Group: This optional step allows a *security group* to be defined. A security group is a configuration that defines how network access to the instance is allowed. By default all access to the instance is blocked, apart from SSH access.
 - Default: SSH inbound allowed. This means that `cmsh` can be used to control the Cluster-On-Demand cluster via SSH just like a regular cluster.

Inbound connections can be defined, based on protocol, packet type, port, and source in CIDR specification. For example, allowing inbound connections via TCP port 8081 from anywhere (0.0.0.0/0) allows `cmgui` to communicate via its custom protocol with the default CMDaemon back end on the head node.

The default security group setting should also be modified by the administrator at this point if a standalone `cmgui` is to be used to control the cluster (section 2.3). For regular use in a cluster-on-demand setup, lag is reduced if a standalone `cmgui` is used rather than running a `cmgui` originating from the head node via an `ssh -X` connection.

- Step 7: Review Instance Launch: The configuration so far can be reviewed. On clicking the Launch button, a pop-up dialog for "Select an existing key pair or create a new key pair" is displayed (figure 2.6).

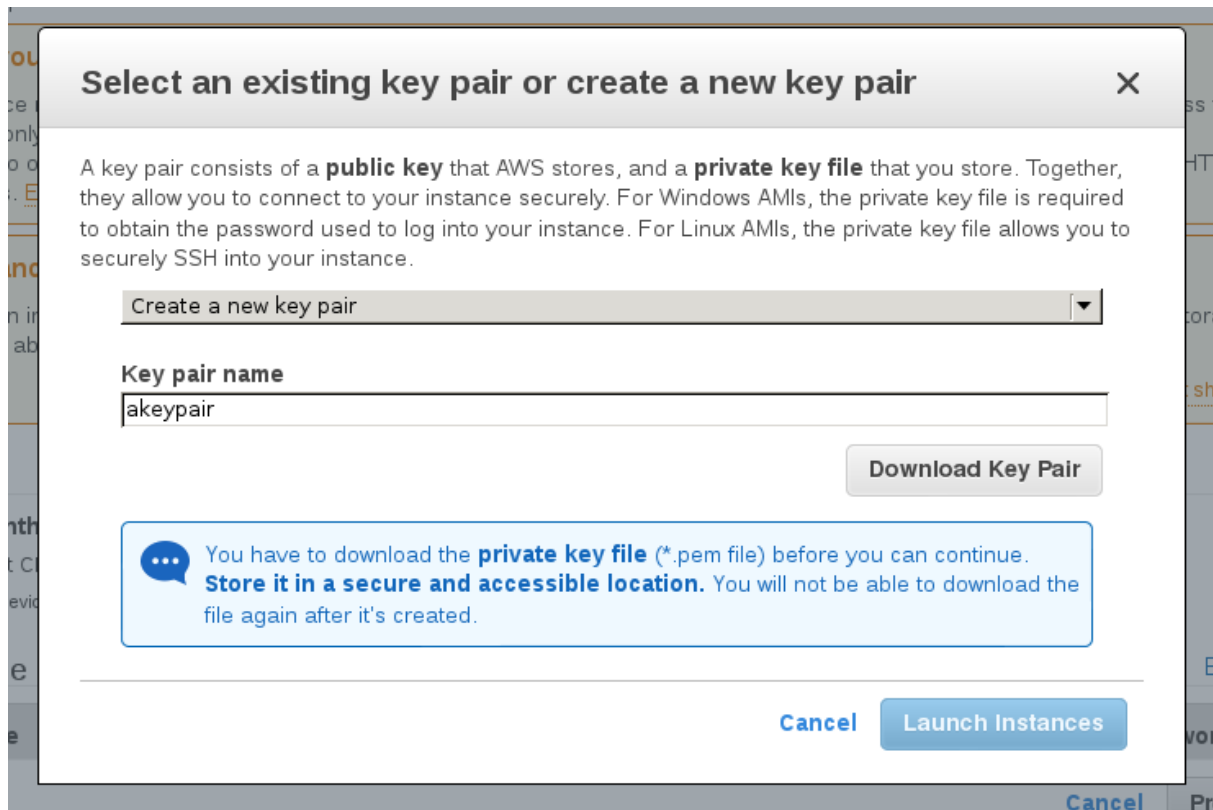


Figure 2.6: EC2: Choosing An AMI, Step 7 - Keypair generation/creation dialog

This dialog allows the creation and storage of a cryptographic key pair. It can alternatively allow an existing pair to be used from the “Select a key pair” selection. The private key of the key pair is used in order to allow SSH access to the head node instance when it is up and running.

After the instance is launched, the web session displays a window informing that the instance is being started up.

2.1.3 Managing A Head Node Instance With The AWS EC2 Management Console

A *newly-launched* head node instance, after it is fully up, is a fully-booted and running Linux instance, but it is not yet a fully-configured head node. That is, it is capable of running Bright Cluster Manager, but it is not yet running it, nor is it working with compute nodes at this point. The steps to make it a fully-configured head node are covered in section 2.2.

For now, the newly-launched head node instance can be watched and managed without Bright Cluster Manager in the following ways.

Status checking via instance selection from instances list:

Clicking the `Instances` menu resource item from the navigation pane opens up the “Instances” pane. This lists instances belonging to the account owner. An instance can be marked by ticking its checkbox. Information for the selected instance is then displayed in the lower main pane (figure 2.7).

The screenshot shows the Amazon EC2 Management Console interface. On the left is a navigation sidebar with categories like INSTANCES, IMAGES, ELASTIC BLOCK STORAGE, and NETWORK & SECURITY. The main area displays a list of EC2 instances. Below the list, the details for the selected instance 'examplecluster' are shown, including its AMI, zone, type, and various IDs.

	Name	Instance	AMI ID	Root Device	Type	State	Status	Alarm St.	Monitoring	Security G
<input checked="" type="checkbox"/>	examplecluster	i-907182f3	ami-0c2f8a65	ebs	t1.micro	running	init	none	basic	quicklaun
<input type="checkbox"/>	piotr-cluster-on-	i-a4d5b5d4	ami-0c2f8a65	ebs	m1.small	stopped		none	basic	quicklaun
<input type="checkbox"/>	us-east-1-direct	i-e17b6b91	ami-543baa3c	ebs	m1.large	stopped		none	basic	brightclou
<input type="checkbox"/>	us-east-1-direct	i-1e5fc46d	ami-e04cde89	ebs	t1.micro	stopped		none	basic	brightclou

1 EC2 Instance selected.

EC2 Instance: examplecluster (i-907182f3)

ec2-50-16-44-106.compute-1.amazonaws.com

Description | Status Checks | Monitoring | Tags

AMI:	brightheadnode-6.0-centos6-xen (ami-0c2f8a65)	Alarm Status:	none
Zone:	us-east-1d	Security Groups:	quicklaunch-2. view rules
Type:	t1.micro	State:	running
Scheduled Events:	No scheduled events	Owner:	137677339600
VPC ID:	-	Subnet ID:	-
Source/Dest. Check:		Virtualization:	paravirtual

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Figure 2.7: The EC2 Instances List

System (Amazon machine infrastructure) and instance (instance running under the infrastructure) reachabilities are similarly shown under the neighboring “Status Checks” tab (figure 2.8).

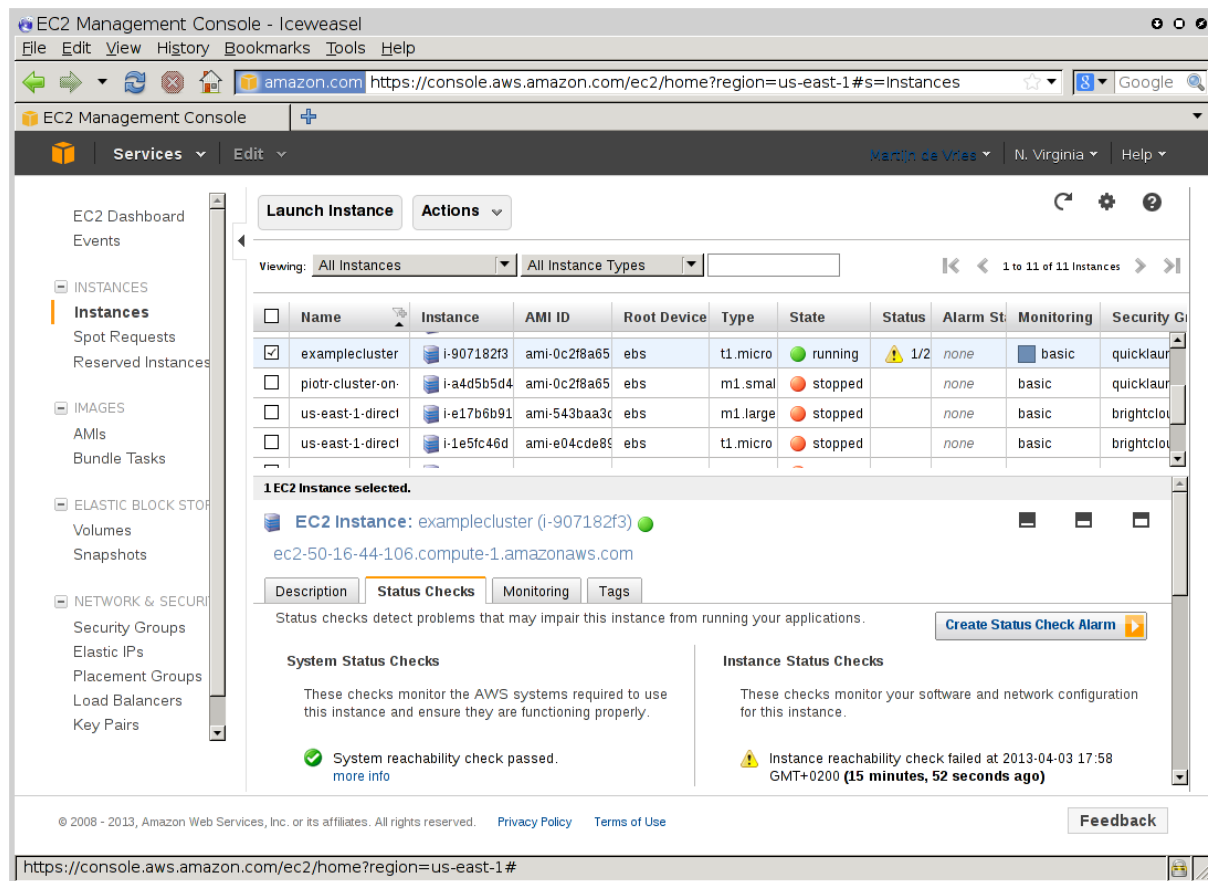


Figure 2.8: Reachability Status For An EC2 Instance

Acting on an instance from the AWS EC2 Management Console:

An instance can be marked by clicking on it. Clicking the **Actions** button near the top of the main center pane, or equivalently from a right-mouse-button click in the pane, brings up a menu of possible actions. These actions can be executed on the marked instance, and include the options to **Start**, **Stop** or **Terminate** the instance.

Connecting to an instance from the AWS EC2 Management Console:

A marked and running instance can have an SSH connection made to it. Clicking on the **Connect** button near the top of the main center pane displays a pop-up text that guides the user through the connection options for a running instance. These connection options are via:

- **a standalone SSH client**

There is further documentation on this at:

- <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/AccessingInstancesLinux.html> for Linux clients
- <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/putty.html> for PuTTY users

- **a browser-based Java SSH client, MindTerm**

There is further documentation on this at:

- <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/mindterm.html>

Most administrators should find the pop-up text enough, and the further documentation unnecessary.

The standalone SSH client help text displays instructions (figure 2.9) on how to run `ssh` from the command line to access the marked instance. If the launched head node is fully up then a login using those instructions succeeds.

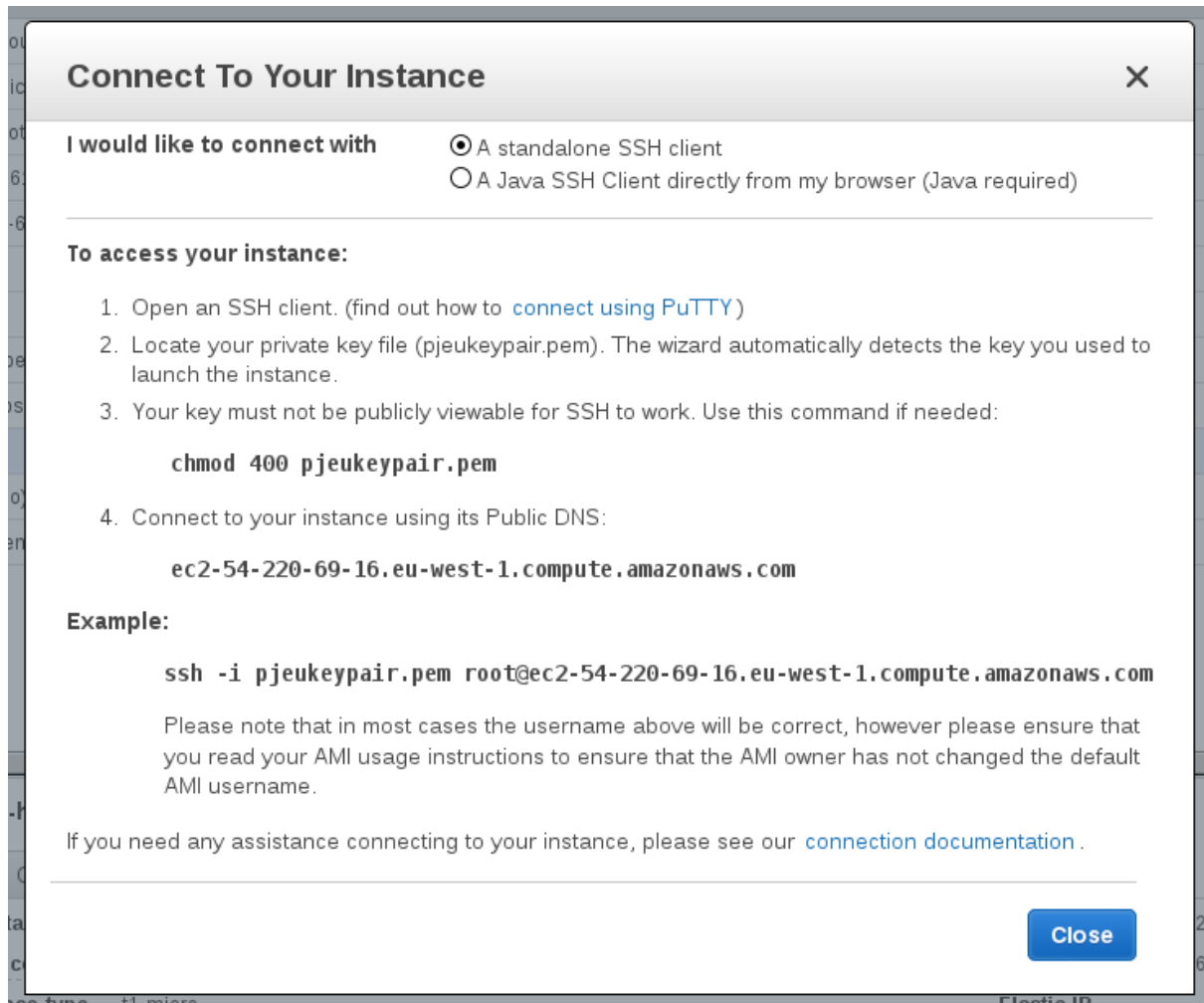


Figure 2.9: SSH Instructions To Connect To The Marked Instance

Viewing the head node console:

The head node takes about 2 minutes to start up. If, on following the instructions, an SSH connection cannot be made, then it can be worth checking the head node system log to check if the head node has started up correctly. The log is displayed on right-clicking on the “Actions” button and selecting the “Get System Log” menu item (figure 2.10). A successful start of the system generates a log with a tail similar to that of figure 2.10.

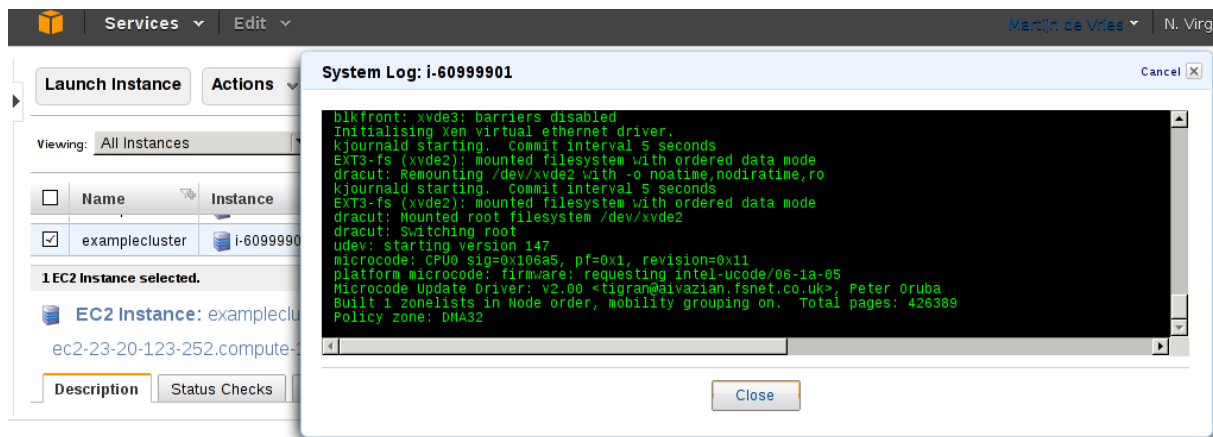


Figure 2.10: System Log Of The Checkboxed Instance

If the system and network are working as expected, then an SSH connection can be made to the head node to carry out the next step, which is the configuration of the head node and cluster.

2.2 Cluster-On-Demand: Head Node Login And Cluster Configuration

After the Amazon console manager has started up a head node instance, the head node instance and cluster must be configured. Logging into the head node via `ssh` allows this.

On logging in for the first time, the system suggests that the `bright-setup` script be run:

Example

```

pj@office:~$ ssh -i pjkeypair.pem root@ec2-176-34-160-197.eu-west-1.com\
pute.amazonaws.com
The authenticity of host 'ec2-176-34-160-197.eu-west-1.compute.amazonaw\
s.com (176.34.160.197)' can't be established.
RSA key fingerprint is 66:1e:f3:77:83:f8:3f:42:c1:b7:d2:d5:56:d8:c3:58.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'ec2-176-34-160-197.eu-west-1.compute.amazon\
aws.com,176.34.160.197' (RSA) to the list of known hosts.
Welcome to Bright Cluster Manager

```

```

Based on Scientific Linux 5
Cluster Manager ID: #999915

```

To set up your cluster, type

```
bright-setup
```

and follow the instructions

```

Creating DSA key for ssh
[root@headnode ~]#

```

Running the `bright-setup` script goes through several screens, some of which prompt for input. At some prompts, it is hinted that typing “I” gives further explanation about the input.

The screens go through the following issues:

- The license agreement.
- Amazon Web Services account information. This asks for the AWS Username, AWS Account ID, Access Key ID, and Secret Access Key. These are needed by Bright Cluster Manager to manage the cloud node instances.
- The installation of the Bright Computing product key (formatted like 868868-797099-979199-091301-134414). This is the cloud version of the `request-license` command in section 4.3 of the *Installation Manual*, and asks for:
 - The organization information for the license. This requires input for the fields: country, state, locality, organizational unit, unit and cluster name.
 - The values to be used for the head node machine name and its administrative password (used for the root and MySQL passwords).
- Optionally, setting up the secondary drives using Amazon’s EBS service.
- Optionally, setting up extra storage for `/home` using Amazon’s EBS service.
- Optionally, setting up extra storage for monitoring data (recommended for more than 500 nodes).
- Setting up cloud node instance types. Amazon instance types (<http://aws.amazon.com/ec2/instance-types/>) are choices presented from node specifications consisting of memory, storage, cores, GPUs, and others. The setting up of the instance type step is looped through if necessary to allow more than one instance type to be configured.
 - Setting up
 - * the number `<N>` of cloud compute nodes and
 - * their base name (the `cnode` part of the name if the nodes have the names `cnode001` to `cnode<N>`).
 - Setting up the amount of storage for the cloud compute node instance.

The default disk partitioning layout for nodes can be modified as described in Appendix D of the *Administrator Manual*. Using diskless nodes is also possible if the cloud compute node instance has enough RAM—about 2GB at the time of writing.

Setting these values causes the cloud node objects to be created in the CMDaemon database. Cloud nodes are not however actually started up at this stage. Starting up must be done explicitly, and is covered in section 2.4.

- Setting up the workload manager, along with the number of slots, and if the head node is to be used for compute jobs too.

After accepting the input, the `bright-setup` script runs through the configuration of the head node and the cloud nodes. Its progress is indicated by output similar to the following:

Example

```
[root@headnode ~]# bright-setup
Retrieving Amazon instance information
```

```
-----
|                               License agreements                               |
|-----|
The end user license agreement will be shown in a new screen. To exit
this screen, type 'q'. Press any key to continue
Do you agree with the license terms and conditions? (yes, no, show): yes
```

```

-----
|                               Amazon account information                               |
-----
AWS username (I for information): exampleuser@brightcomputing.com
AWS Account ID (I for information): 313234312222
Access Key ID (I for information): OUPOUASOUDSSSAOU
Secret Access Key (I for information): Aighei8EooLi1Dae8Nio5ohl4ieXiAiaiV

Verifying Amazon credentials

-----
|                               Bright License                               |
-----
Bright Product Key (I for information):
                                423112-231432-134234-132423-134221
    Country: US
    State: CA
    Locality: San Francisco
    Organization name: Bright Computing
    Organizational Unit: Development
    Cluster Name: demo-cluster

-----
|                               Head Node                               |
-----
Hostname: bright71
Administrative Password:
Verify password:
Do you want to create a second drive for more storage capacity?
(I for information) [YES|no] no
Extra storage for /home (I for information)? [NO|yes] n
Extra storage for monitoring data (I for information)? [NO|yes] n

-----
|                               Compute Nodes                               |
-----
Instance Type (I for information):
    m1.small
    m1.medium
    c1.medium
    m1.large
    t1.micro
    m2.xlarge
    m2.2xlarge
    m2.4xlarge
    c1.xlarge
    [t1.micro]
>
t1.micro
Node Count [2]:
2
Base name (I for information) [cnode]:
cnode
Instances of type t1.micro need to use EBS storage

```

Size of EBS (GB) [40]: 15

Do you want to configure more node types? [NO|yes]

no

```
-----
|                               Workload Management system                               |
-----
```

Which workload management system do you want to use? (I for information)?

slurm

sge

torque

[slurm]

>

slurm

Number of slots per node [8]:

8

Do you want to use the head node for compute jobs? [NO|yes]

no

The following information will be used to configure this head node:

Amazon information:

AWS username: exampleuser@brightcomputing.com

AWS Account ID: 313234312222

Access Key ID: OUPOUASOUDSSSAOU

Secret Access Key: Aighei8EooLilDae8Nio5ohl4ieXiAin5eeRoaiV

Bright Product Key: 423112-231432-134234-132423-134221

License information

Country: US

State: CA

Locality: San Francisco

Organization name: Bright Computing

Organizational Unit: Development

Cluster Name: demo-cluster

Hostname: bright71

Second drive size: no

Instance Type: t1.micro

Node Count: 2

Base name: cnode

Storage type: EBS

Size of storage: 15 GB

Workload management system: slurm

Number of slots: 8

Head node for compute jobs: no

The information to configure this head node has been collected, and shown above. The next phase will be to process this information. A new Bright license will be installed, the Bright Cluster Manager software will be initialized and the workload management software will be initialized

Do you want to continue? [YES|no]

yes

Starting to configure this head node

Successfully retrieved the license

Installed license

```

Initializing Bright Cluster Manager
Installing admin certificates
Configuring default scheduler, slurm
Set up finished

```

It is recommended that the system administrator log out and login again after the script has been run, in order to enable the new environment for the shell that the administrator is in. If the hostname was changed in the `bright-setup` script, for example, the name change shows up in the shell prompt only after the re-login.

Once there is a head in the cloud, the other cloud nodes can be started up.

2.3 Cluster-On-Demand: Connecting To The headnode Via `cmsh` or `cmgui`

Amazon provides a security group to each instance. By default, this configures network access so that only inbound SSH connections are allowed from outside the cloud. A new security group can be configured, or an existing one modified, using the `Edit details` button in figure 2.11. Security groups can also be accessed from the navigation menu on the left side of the EC2 Management Console.

2.3.1 Cluster-On-Demand: Access With A Remote, Standalone `cmgui`

The security group defined by Amazon for the head node can be modified by the administrator to allow remote connections to CMDaemon running on the head node (figure 2.11).

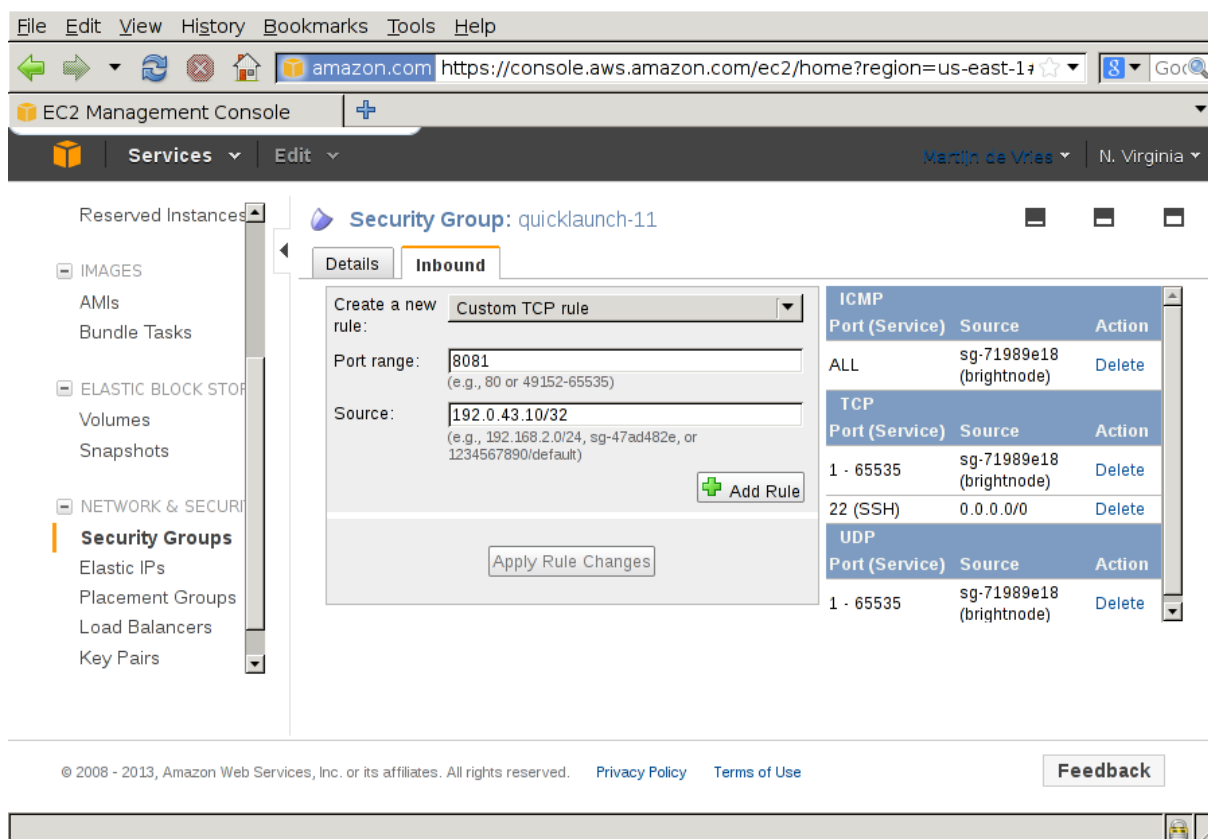


Figure 2.11: Security Group Network And Port Access Restriction

- To allow only a specific network block to access the instance, the network from which remote connections are allowed can be specified in CIDR format.
- Explicitly allowing inbound connections to port 8081 on the head node allows the standalone `cmgui` (section 2.4 of the *Administrator Manual*) to connect to the head node. This is because the

`cmgui` back end, which is `CMDaemon`, communicates via port 8081.

2.3.2 Cluster-On-Demand: Access With A Local `cmsh`

The security group created by Amazon by default already allows inbound SSH connections from outside the cloud to the instance running in the cloud, even if the incoming port 8081 is blocked. Launching a `cmsh` session within an SSH connection running to the head node is therefore possible, and works well.

2.3.3 Cluster-On-Demand: Access With A Local `cmgui`

It is possible to run an X-forwarded `cmgui` session from within an `ssh -X` connection that is already running to the head node. However, it suffers from significant X-protocol lag due to the various network encapsulation layers involved. The procedure described earlier for cluster-on-demand access with the remote, standalone `cmgui` from outside the cloud is therefore recommended instead for a more pleasant experience.

2.4 Cluster-On-Demand: Cloud Node Start-up

Cloud nodes must be explicitly started up. This is done by powering them up, assuming the associated cloud node objects exist. The cloud node objects are typically specified in the `bright-setup` script—in the preceding example the cloud node objects are `cnode001` and `cnode002`.

However, more cloud node objects can be created if needed after the `bright-setup` script has run. The maximum number that may be created is set by the license purchased.

Large numbers of cloud node objects can be created with Bright Cluster Manager as follows:

- In `cmgui` they are conveniently created with the Node Creation Wizard as described in section 3.3. Several of the steps described in that section are specific to Cluster Extension clusters. These steps are not needed for Cluster-On-Demand clusters, and therefore do not come up when the wizard is used in this case.
- In `cmsh` a large number of cloud node objects can conveniently be created with the “`foreach --clone`” command instead, as described in section 4.3.

After creation, individual cloud nodes can be powered up from within `cmgui` by a right-click on the cloud node resource item (figure 2.12).

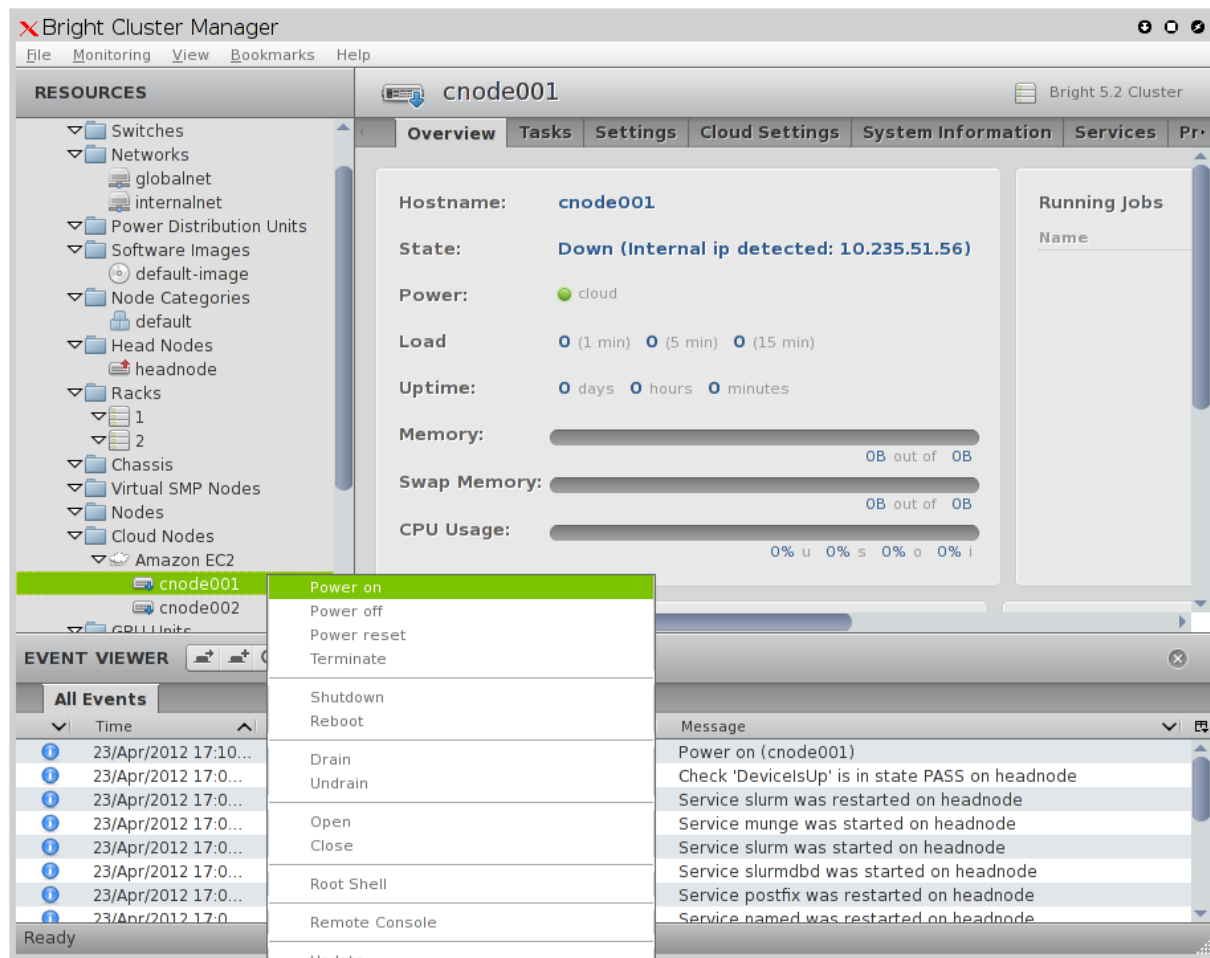


Figure 2.12: Powering on a cloud node with cmgui

As with regular non-cloud nodes, multiple cloud nodes can be powered up in cmgui by selecting them from the Overview tabbed pane. Switching to the Tasks tabbed pane and clicking on the power on button then powers them up.

As with regular non-cloud nodes, cloud nodes can also be powered up from within the device mode of cmsh. The initial power status (section 4.1 of the *Administrator Manual*) of cloud nodes is FAILED, because they cannot be communicated with. As they start up, their power status changes to OFF, and then to ON. Some time after that they are connected to the cluster and ready for use. The device status (as opposed to the power status) remains DOWN until it is ready for use, at which point it switches to UP:

Example

```
[head1->device]% power status
cloud ..... [ FAILED ] cnode001 (Cloud instance ID not set)
cloud ..... [ FAILED ] cnode002 (Cloud instance ID not set)
No power control ..... [ UNKNOWN ] head1
[head1->device]% power on -n cnode001
cloud ..... [ ON ] cnode001
[head1->device]% power status
cloud ..... [ OFF ] cnode001 (pending)
cloud ..... [ FAILED ] cnode002 (Cloud instance ID not set)
No power control ..... [ UNKNOWN ] head1
[head1->device]% power on -n cnode002
```

```

cloud ..... [  ON   ] cnode002
[head1->device]% power status
cloud ..... [  ON   ] cnode001 (running)
cloud ..... [ OFF   ] cnode002 (pending)
No power control ..... [ UNKNOWN ] head1
[head1->device]% !ping -c1 cnode001
ping: unknown host cnode001
[head1->device]% status
head1 ..... [  UP   ]
node001 ..... [  UP   ]
node002 ..... [ DOWN ]
[head1->device]% !ping -c1 cnode001
PING cnode001.cm.cluster (10.234.226.155) 56(84) bytes of data.
64 bytes from cnode001.cm.cluster (10.234.226.155): icmp_seq=1 ttl=63 t\
ime=3.94 ms

```

Multiple cloud nodes can be powered up at a time in `cmsh` with the “power on” command using ranges and other options (section 4.2.2 of the *Administrator Manual*).

2.4.1 IP Addresses In The Cluster-On-Demand Cloud

- The IP addresses assigned to cloud nodes on powering them up are arbitrarily scattered over the 10.0.0.0/8 network and its subnets
 - No pattern should therefore be relied upon in the addressing scheme of cloud nodes
- Shutting down and starting up head and regular cloud nodes can cause their IP address to change.
 - However, Bright Cluster Manager managing the nodes means that a regular cloud node re-establishes its connection to the cluster when it comes up, and will have the same node name as before.

Cluster Extension Cloudbursting

Cluster Extension cloudbursting (“hybrid” cloudbursting) in Bright Cluster Manager is the case when a cloud service provider is used to provide nodes that are in the cloud as an extension to the number of regular nodes in a cluster. The head node in a Cluster Extension configuration is always outside the cloud, and there may be some regular nodes that are outside the cloud too.

Requirements

Cluster Extension cloudbursting requires:

- **An activated cluster license.**

Some administrators skip on ahead to try out cloudbursting right away in a Cluster Extension configuration, without having made the license active earlier on. That will not work.

A check on the state of the license can be carried out with:

Example

```
[root@bright71 ~]# cmsh -c "main; licenseinfo"
```

```
License Information
```

```
-----
Licensee                /C=US/ST=NY/L=WS/O=Bright
                        Bitcoins/OU=Unit/CN=Bright 7.1 Cluster
Serial Number           19305
Start Time              Mon Dec 20 00:00:00 2015
End Time                Wed Jun 20 00:00:00 2018
Version                 7.1
Edition                 Advanced
Pre-paid Nodes          100
Max Pay-per-use Nodes   N/A
Max Hadoop Nodes        80
Max OpenStack           70
Node Count              4
...

```

If activation is indeed needed, then it is most likely a case of simply running the `request-license` command with the product key. Further details on activating the license are in section 4 of the *Administrator Manual*.

- **Registration of the product key.**

The product key must also be registered on the Bright Computing Customer Portal website at <http://www.brightcomputing.com/Customer-Login.php>. A Customer Portal account is needed to do this.

The product key is submitted at the Customer Portal website specifically for a Cluster Extension setup, from the `Burst!` menu. The customer portal account is then automatically associated with the license installed (section 2.2) on the head node. The key is also needed to activate the cluster license, if that has not been done before.

- **An Amazon account**, if the cloud provider is Amazon.
- **An open UDP port**.

By default, this is port 1194. It is used for the OpenVPN connection from the head node to the cloud and back. To use TCP, and/or ports other than 1194, the Bright Computing knowledgebase at <http://kb.brightcomputing.com> can be consulted using the keywords “openvpn port”.

Outbound ssh access from the head node is also useful, but not strictly required.

By default, Shorewall as provided by Bright Cluster Manager on the head node is configured to allow all outbound connections, but other firewalls may need to be considered too.

Steps

Cluster Extension cloudbursting uses a *cloud director*. A cloud director is a specially connected cloud node used to manage regular cloud nodes, and is described more thoroughly in section 3.2. Assuming the administrator has ownership of a cloud provider account, the following steps can be followed to launch Cluster Extension cloud nodes:

1. The cloud provider is logged into from `cmgui`, and a cloud director is configured (section 3.1).
2. The cloud director is started up (section 3.2).
3. The cloud nodes are provisioned from the cloud director (section 3.3).


The cloud nodes then become available for general use by the cluster.

Cluster Extension Cloudbursting With A Hardware VPN

Bright Cluster Manager recommends, and provides, OpenVPN by default for Cluster Extension cloudbursting VPN connectivity. If there is a wish to use a hardware VPN, for example if there is an existing hardware VPN network already in use at the deployment site, then Bright Cluster Manager can optionally be configured to work with the hardware VPN. The configuration details can be found in the Bright Computing knowledgebase at <http://kb.brightcomputing.com> by carrying out a search on the site using the keywords “cloudbursting without openvpn”.

3.1 Cluster Extension: Cloud Provider Login And Cloud Director Configuration

To access the Amazon cloud service from `cmgui`, the “Cloud Nodes” resource is selected, and the “Cloud Accounts” tabbed pane opened. This allows a cloud provider account to be edited or deleted from the available ones already there.

It also allows a new cloud account provider to be added and configured. This is done by clicking on the  button beside the text “Add a new cloud account”, which opens up the “Add Cloud Provider Wizard” window (figure 3.1).

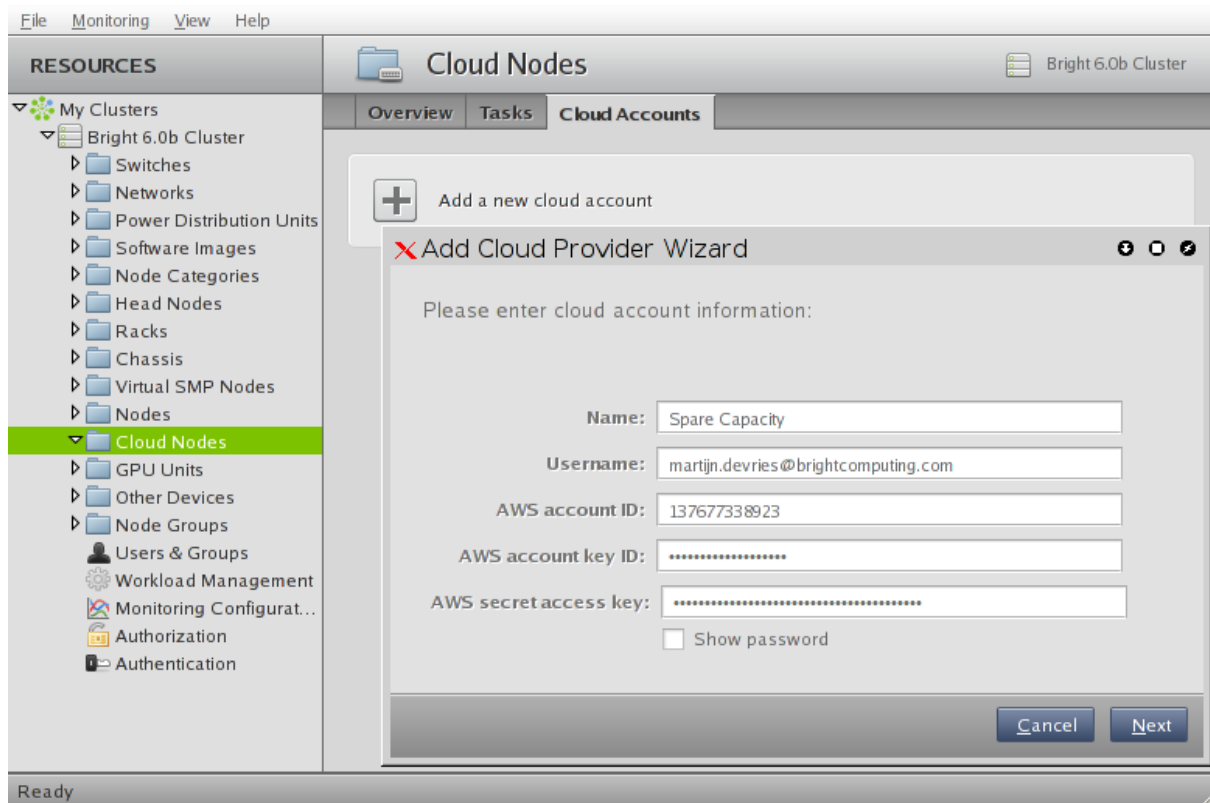


Figure 3.1: Logging Into A Cloud Provider With cmgui

In the first screen, the cloud account subscription information is added. The subscription information could be from Amazon or from another supported provider.

In the case of Amazon, the information is obtainable after signing up for Amazon Web Services (AWS) at <http://aws.amazon.com>. After sign-up, the Access Identifiers section of the subscription, at <http://aws-portal.amazon.com/gp/aws/developer/account/index.html?action=access-key>, provides the required information. If that URL does not work, then the Amazon documentation at <http://docs.amazonwebservices.com/fws/latest/GettingStartedGuide/index.html?AWScredentials.html> can be followed instead.

For Amazon, the fields to enter in the wizard are:

- The Name: A convenient, arbitrary value.
- The Username: The e-mail address associated with the AWS account.
- The AWS account ID: The AWS Account ID.
- The AWS account key ID: The AWS Access Key ID.
- The AWS secret access key ID: The AWS Secret Access Key.

The “show password” checkbox toggles the visibility of the sensitive input. Clicking the Next button submits the details, and inputs for the next screen are retrieved from Amazon.

The next screen (figure 3.2) displays options for the Amazon cloud service.

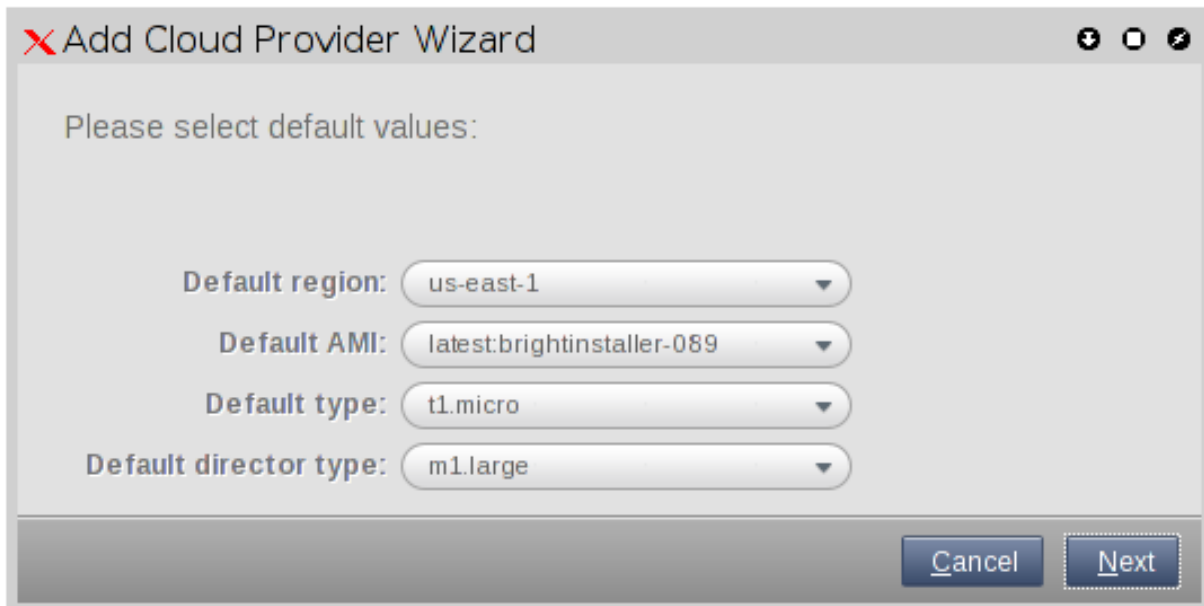


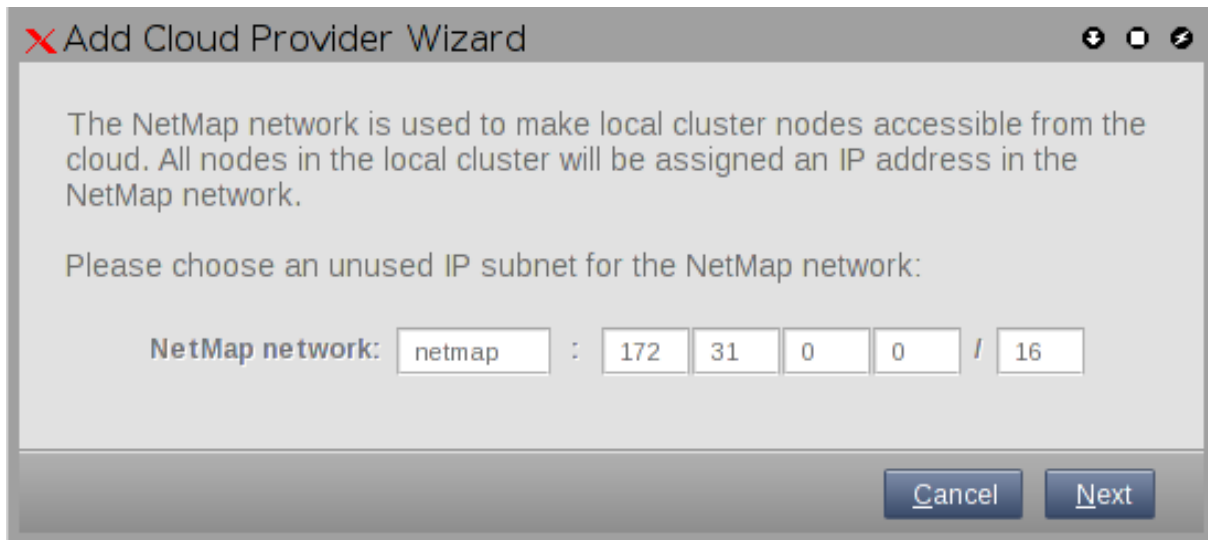
Figure 3.2: Selecting Options At The Cloud Provider With `cmgui`

In figure 3.2, the following options are shown:

- **Default region:** These are regions from which the service can be provided. Amazon, for example, offers a choice out of capacity on the East Coast of the USA, Western Europe, the Asia Pacific region and others.
- **Default AMI:** This is the Amazon Machine Instance image that Bright Computing provides. The node-installer from this image installs the cloud director and cloud nodes.
- **Default type:** A choice out of a selection of possible virtual machine types (<http://aws.amazon.com/ec2/instance-types/>) made available by Amazon for the cloud node. The choices presented are from node specifications consisting of memory, storage, cores, GPUs, and others. In `cmsh`, running `cmsh -c "cloud types"` also shows the types available.
- **Default director type:** A choice for the cloud director node, made from a selection of possible virtual machine types made available by Amazon. This virtual machine type usually needs to be more powerful than a regular cloud node, and is by default set to `m1.large`.

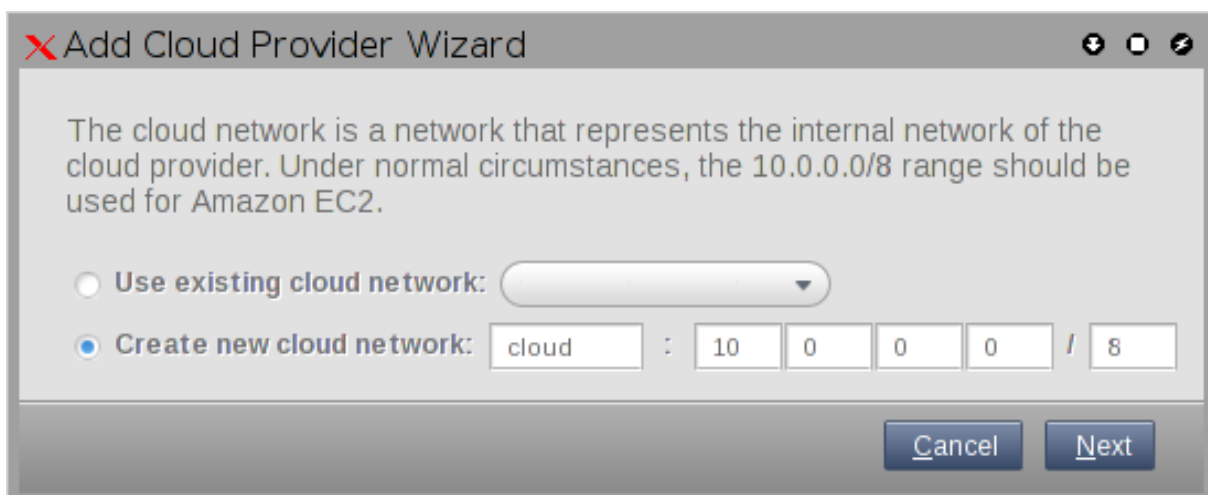
The default settings are normally a good choice. On clicking the `Next` button, the choices are processed.

The next screen (figure 3.3) displays the NetMap network name and addressing scheme. This is a network mapping that assigns extra IP addresses to local nodes to make them accessible from the cloud. The addressing scheme can be changed if needed to another unused subnet. By default it uses 172.30.0.0/16.

Figure 3.3: Setting The NetMap Network With `cmgui`

The default values are normally a good choice. On clicking the `Next` button, the values are processed.

The next screen (figure 3.4) displays the cloud network name and addressing scheme. This can be changed if needed, but for Amazon the 10.0.0.0/8 range is expected.

Figure 3.4: Setting The Cloud Network At The Cloud Provider With `cmgui`

On clicking the `Next` button, the configuration is processed.

The next screen (figure 3.5) displays a proposed Bright Cluster Manager tunnel network naming and addressing scheme for each checked cloud region. These can be changed if needed from the suggested defaults. For Amazon the `us-east-1` region shown in the figure has a default tunnel network value of 172.21.0.0/16.

Add Cloud Provider Wizard

For each of the cloud regions that will be used, a tunnel network needs to be defined. A tunnel network is used to make cloud nodes accessible within the cluster.

Please select the regions that will be used and choose an unused IP subnet for the tunnel network in each range:

Region	Tunnel network	IP range
<input type="checkbox"/> ap-northeast-1	ap-northeast-1	172 16 0 0 / 16
<input type="checkbox"/> ap-southeast-1	ap-southeast-1	172 17 0 0 / 16
<input type="checkbox"/> ap-southeast-2	ap-southeast-2	172 18 0 0 / 16
<input type="checkbox"/> eu-west-1	eu-west-1	172 19 0 0 / 16
<input type="checkbox"/> sa-east-1	sa-east-1	172 20 0 0 / 16
<input checked="" type="checkbox"/> us-east-1	us-east-1	172 21 0 0 / 16
<input type="checkbox"/> us-west-1	us-west-1	172 22 0 0 / 16
<input type="checkbox"/> us-west-2	us-west-2	172 23 0 0 / 16

Cancel Next

Figure 3.5: Setting The Tunnel Network For Regions With `cmgui`

On clicking the **Next** button, the configuration is processed.

The next screen (figure 3.6) displays a proposed Bright Cluster Manager tunnel interface name and IP address for the head node(s). A tunnel interface is defined for the head node for each tunnel network. By default, the address ending in `.255.254` is used, and appended to the first two parts of the dotted quad (for example, `172.21` for `us-east-1`), so that the suggested default IP address in this case becomes `172.21.255.254`. The default suggested device name is `tun0`.

These can be changed if needed from the suggested defaults.

Region	Head node interface	IP
us-east-1	tun0	172.21.255.254

Figure 3.6: Setting The Tunnel Network Interface For The Head Node(s) With `cmgui`

On clicking the `Next` button, the configuration is processed.

The next screen (figure 3.7) displays a proposed Bright Cluster Manager hostname and tunnel IP address for the cloud director node(s). By default, the suggested hostname is the region name with `-director` as the suffix. For example, `us-east1-director` for the region `us-east1`. By default, an address ending in `.255.251` is suggested for appending to the first two parts of the dotted quad (for example, the prefix `172.21` for `us-east-1`), so that the suggested default IP address in this case becomes `172.21.255.251`. The addresses ending in `252` and `253` may be required by head nodes that implement failover (Chapter 12 of the *Administrator Manual*).

These can be changed if needed from the suggested defaults, but should be consistent with the network address.

Region	Hostname	IP
us-east-1	us-east-1-director	172.21.255.251

Figure 3.7: Setting The Tunnel Network Interface For The Cloud Director(s) With `cmgui`

On clicking the `Next` button, the configuration is processed.

The next screen (figure 3.8) displays the proposed assignment of IP addresses in the NetMap network. These can be changed from the suggested defaults, but should be consistent with the addressing schemes already defined.

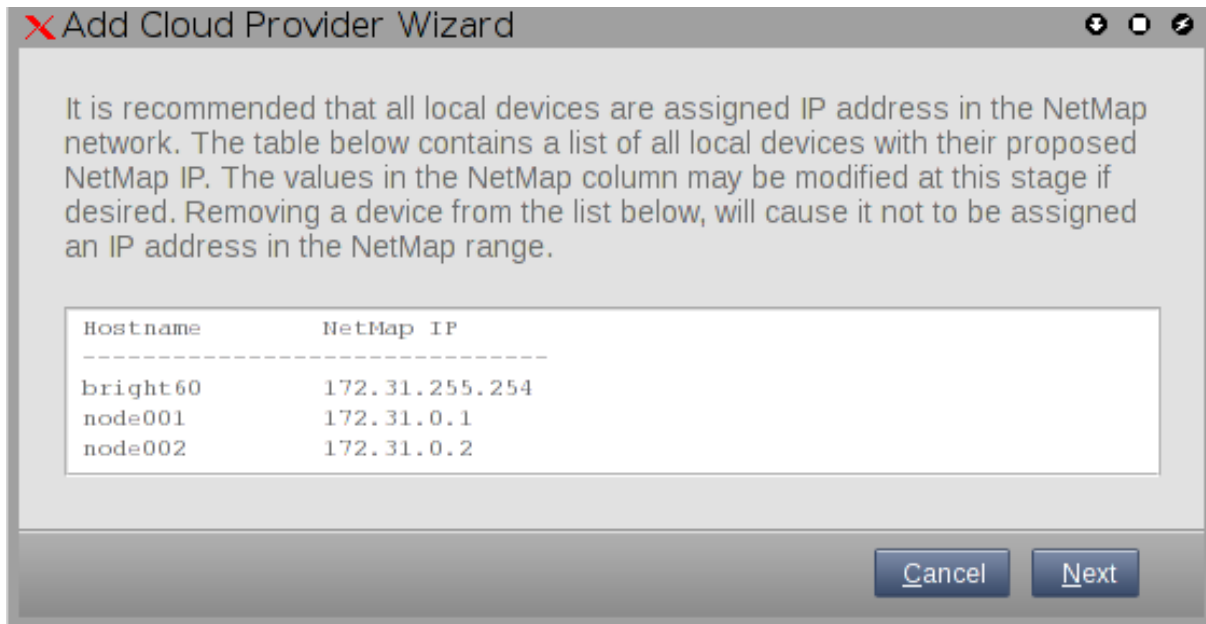


Figure 3.8: Setting The Tunnel Network Interface IP Addresses With `cmgui`

On clicking the `Next` button, the configuration is processed.

It should be noted that the default suggested NetMap, cloud network, and cloud region addresses configured by the wizard are all compliant with RFC1918 private network addressing, and are thus not public IP addresses.

If all is well, the configuration is successfully processed. A message is then displayed indicating that the cloud provider service has been added to the existing cluster and configured successfully, and that the wizard is finished with its job.

No nodes are activated yet within the cloud provider service. To start them up, the components of the cloud provider service must be started up by

- powering up the cloud directors (section 3.2)
- powering on the cloud nodes after the cloud directors are up. Often this involves creating new cloud nodes by using the “Create Cloud Nodes” wizard (section 3.3).

3.2 Cluster Extension: Cloud Director Start-up

The cloud director can take some time to start up the first time. The bottleneck is usually due to several provisioning stages, where the bandwidth between the head node and the cloud director means that the provisioning runs typically take tens of minutes to complete. The progress of the cloud director can be followed in the event viewer (section 9.6 of the *Administrator Manual*).

This bottleneck is one of the reasons why the cloud director is put in the cloud in the first place. The next time the cloud director powers up, and assuming persistent storage is used—as is the default—the cloud director runs through the provisioning stages much faster, and completes within a few minutes.

The cloud director acts as a helper instance in the cloud, providing some of the functions of the head node within the cloud in order to speed up communications and ensure greater resource efficiency. Amongst the functions it provides are:

- Cloud nodes provisioning
- Exporting a copy of the shared directory `/cm/shared` to the cloud nodes so that they can mount it

- Providing routing services using an OpenVPN server. While cloud nodes within a region communicate directly with each other, cloud nodes in one region use the OpenVPN server of their cloud director to communicate with the other cloud regions and to communicate with the head node of the cluster.

Cloud directors are not regular nodes, so they have their own category, `cloud-director`, into which they are placed by default.

The cloud-related properties of the cloud director are displayed in the “Cloud Settings” tab of the Cloud Nodes director item.

The cloud director can be started up in `cmgui` by right-clicking on the cloud director item from the Cloud Nodes resource, and selecting `Power on` from the menu. Any cloud settings options that have been set are frozen as the instance starts up, until the instance terminates.

3.2.1 Setting The Cloud Director Disk Storage Device Type

Amazon provides two kinds of storage types as part of EC2:

1. **Instance storage, using ephemeral devices:** Instance storage is not provided for the following instance types:

- `t1.micro`
- `m3.xlarge`
- `m3.2xlarge`
- `cr1.8xlarge`

However, Amazon by default currently provides 150GB or more of instance storage for all other instance types.

Details on instance storage can be found at <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/InstanceStorage.html#StorageOnInstanceTypes>. Ephemeral means that the device is temporary, which means that whatever is placed on it is lost on reboot.

2. **Elastic Block Storage (EBS) volumes:** Normally, EBS is suggested for cloud director and cloud node use. The reasons for this include:

- it can be provided to all nodes in the same availability zone
- unlike instance storage, EBS remains available for use when an instance using it reboots
- instance storage is not available for some instances types such as `t1.micro`.

Using the ephemeral device as the drive for the cloud director:

Since the cloud provider instance type is essential, and contains so much data, it is rarely wise to use ephemeral devices as the drive for the cloud provider.

However, if for some reason the administrator would like to avoid using EBS, and use the instance storage, then this can be done by removing the default EBS volume suggestion for the cloud director provided by Bright Cluster Manager. When doing this, the ephemeral device that is used as the replacement must be renamed. It must take over the name that the EBS volume device had before it was removed.

- In `cmgui`, this can be done in the “Cloud Settings” tab of the Cloud Nodes director item.
- In `cmsh`, this can be done in device mode, by going into the `cloudsettings` submode for the cloud director, and then going a level deeper into the `storage` submode. Within the `storage` submode, the `list` command shows the values of the storage devices associated with the cloud director. The values can be modified as required with the usual object commands. The `set` command can be used to modify the values.

Example

```
[bright71]% device use us-east-1-director
[bright71->device[us-east-1-director]]% cloudsettings
[bright71->device[us-east-1-director]->cloudsettings]% storage
[bright71->...->cloudsettings->storage]% list
Type          Name (key)    Drive    Size    Volume ID
-----
ebs           ebs           sdb       42GB
ephemeral     ephemeral0    sdc       0B      ephemeral0
[bright71->...->cloudsettings->storage]% remove ebs
[bright71->...->cloudsettings*->storage*]% set ephemeral0 drive sdb
[bright71->...->cloudsettings*->storage*]% list
Type          Name (key)    Drive    Size    Volume ID
-----
ephemeral     ephemeral0    sdb       0B      ephemeral0
[bright71->...->cloudsettings*->storage*]% commit
```

3.2.2 Setting The Cloud Director Disk Size

The disk size for the cloud director can be set with `cmgui` in the `Cloud Settings` tab.

By default, an EBS volume size of 42GB is suggested. This is as for a standard node layout (section D.3 of the *Administrator Manual*), and no use is then made of the ephemeral device.

42GB on its own is unlikely to be enough for most purposes other than running basic `hello world` tests. In actual use, the most important considerations are likely to be that the cloud director should have enough space for:

- the user home directories (under `/home/`)
- the cluster manager shared directory contents, (under `/cm/shared/`)
- the software image directories (under `/cm/images/`)

The cluster administrator should therefore properly consider the allocation of space, and decide if the disk layout should be modified. An example of how to access the disk setup XML file to modify the disk layout is given in section 3.9.3 of the *Administrator Manual*.

For the cloud director, an additional sensible option may be to place `/tmp` and the swap space on an ephemeral device, by appropriately modifying the XML layout for the cloud director.

3.2.3 Tracking Cloud Director Start-up

Tracking cloud director start-up from the EC2 management console:

the boot progress of the cloud director can be followed by watching the status of the instance in the Amazon EC2 management console, as illustrated in figure 2.8. The `Instance ID` that is used to identify the instance can be found

- with `cmgui`, within the `Cloud Settings` tab for the cloud director node
- with `cmsh`, by running something like:

Example

```
[bright71]% device use us-east-1-director
[bright71->device[us-east-1-director]]% get clouddid
i-f98e7441
[bright71->device[us-east-1-director]]% cloudsettings
[bright71->device[us-east-1-director]-cloudsettings]% get instanceid
i-f98e7441
```

Tracking cloud director start-up from cmgui:

the boot progress of the cloud director can also be followed by

- watching the icon changes (as in section 5.5.1 of the *Administrator Manual*)
- watching the State in the Overview tabbed window
- watching the Console log from the Tasks tabbed window

Tracking cloud director start-up from the bash shell of the head node:

there are some further possibilities to view the progress of the cloud director after it has reached at least the initrd stage. These possibilities include:

- an SSH connection to the cloud director can be made during the pre-init, initrd stage, after the cloud director system has been set up via an rsync. This allows a login to the node-installer shell.
- an SSH connection to the cloud director can be also be made after the initrd stage has ended, after the init process runs making an SSH daemon available again. This allows a login on the cloud director when it is fully up.

During the initrd stage, the cloud director is provisioned first. The cloud node image(s) and shared directory are then provisioned on the cloud director, still within the initrd stage. To see what rsync is supplying to the cloud director, the command “ps uww -C rsync” can be run on the head node. Its output can then be parsed to make obvious the source and target directories currently being transferred:

Example

```
[root@bright71 ~]# ps uww -C rsync | cut -f11- -d" " #11th part onwards
/cm/shared/ syncer@172.22.255.251::target//cm/shared/
```

Tracking cloud director start-up from cmsh:

the provisioningstatus command in cmsh can be used to view the provisioning status (some output elided):

Example

```
[root@bright71 ~]# cmsh -c "softwareimage provisioningstatus"
...
+ us-east-1-director
...
Up to date images:      none
Out of date images:    default-image
```

In the preceding output, the absence of an entry for “Up to date images” shows that the cloud director does not yet have an image that it can provision to the cloud nodes. After some time, the last few lines of output should change to something like:

Example

```
+ us-east-1-director
...
Up to date images:      default-image
```

This indicates the image for the cloud nodes is now ready.

With the -a option, the provisioningstatus -a command gives details that may be helpful. For example, while the cloud director is having the default software image placed on it for provisioning purposes, the source and destination paths are /cm/images/default-image:

Example

```
[root@bright71 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s):      4
Source node:        bright71
Source path:         /cm/images/default-image
Destination node:    us-east-1-director
Destination path:    /cm/images/default-image
...
```

After some time, when the shared filesystem is being provisioned, the source and destination paths should change to the `/cm/shared` directory:

```
[root@bright71 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s):      5
Source node:        bright71
Source path:         /cm/shared
Destination node:    us-east-1-director
Destination path:    /cm/shared
...
```

After the shared directory and the cloud node software images are provisioned, the cloud director is fully up. Cloud node instances can then be powered up and provisioned from the cloud director.

3.3 Cluster Extension: Cloud Node Start-up

The “Create Cloud Nodes” wizard button in `cmgui` conveniently creates cloud node objects. The wizard is accessed from within the “Cloud Nodes” resource, by selecting the provider item, and then choosing the Overview tab. Cloud node objects can also be created in `cmsh` as described in section 4.3.

A working cloud director is not needed to configure the regular cloud nodes. However the cloud director must be up, and the associated networks to the regular cloud nodes and to the head node must be configured correctly, in order for the regular cloud nodes to boot up properly. If needed, additional cloud provisioning nodes (section 5.2 of the *Administrator Manual*) can be configured by assigning the provisioning role to cloud nodes, along with appropriate nodegroups (page 153 of the *Administrator Manual*) values, in order to create a provisioning hierarchy.

By default, the first screen of the wizard (figure 3.9) allows the administrator to do the following:

- The first regular cloud node and last regular cloud node can be set. By default, 16 regular cloud nodes are suggested. The names of the nodes have a prefix of `cnode` by default, and end in three digit numbers, for example `cnode001`, `cnode002` and so on.
- The category can be set for these nodes. By default it is set to the `default` category
- The region for the regular cloud nodes can be set. By default it matches the cloud director region.
- The regular cloud node instance type can be set. By default, `t1.micro` is chosen.
- A spot price (section 5.3.1) can be set in this screen to take advantage of cheaper pricing to launch regular cloud nodes. By default, no spot price is set.
- The storage type and size used can be set. By default, it is EBS, and 42GB. If the `t1.micro` instance type has been chosen, then there is no ephemeral device storage available, in accordance with Amazon policies.

The next screen of the wizard (figure 3.10) applies to the region chosen in the previous screen (in figure 3.9 the region is `us-east-1`). Within the region, IP offsets (footnote on page 30 of the *Installation Manual*) can be set:

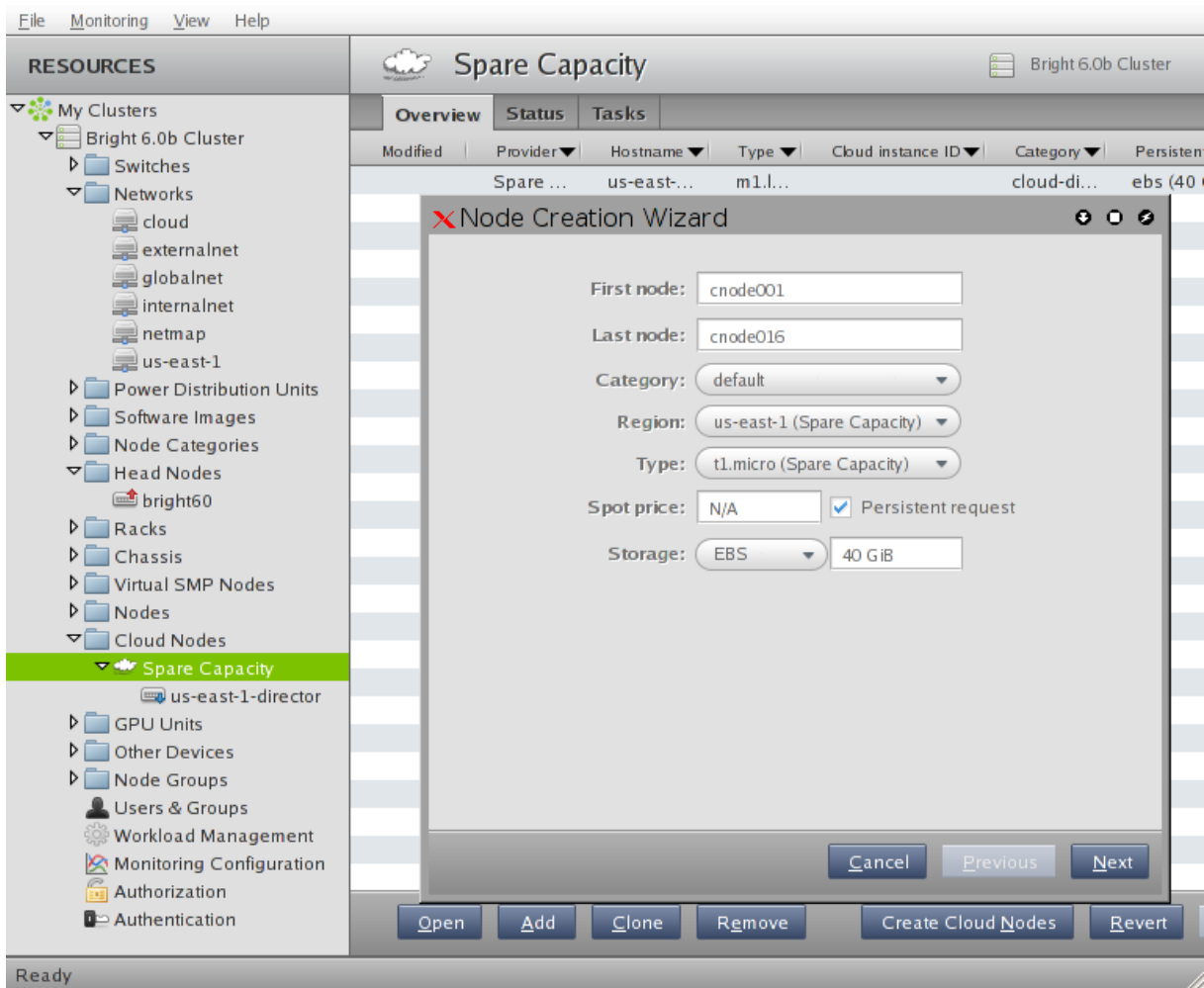


Figure 3.9: Main Cloud Node Creation Wizard Configuration Screen

- for nodes in the associated cloud network
- for nodes in the associated tunnel network

By default, both these IP offsets are 0 . 0 . 0 . 0.

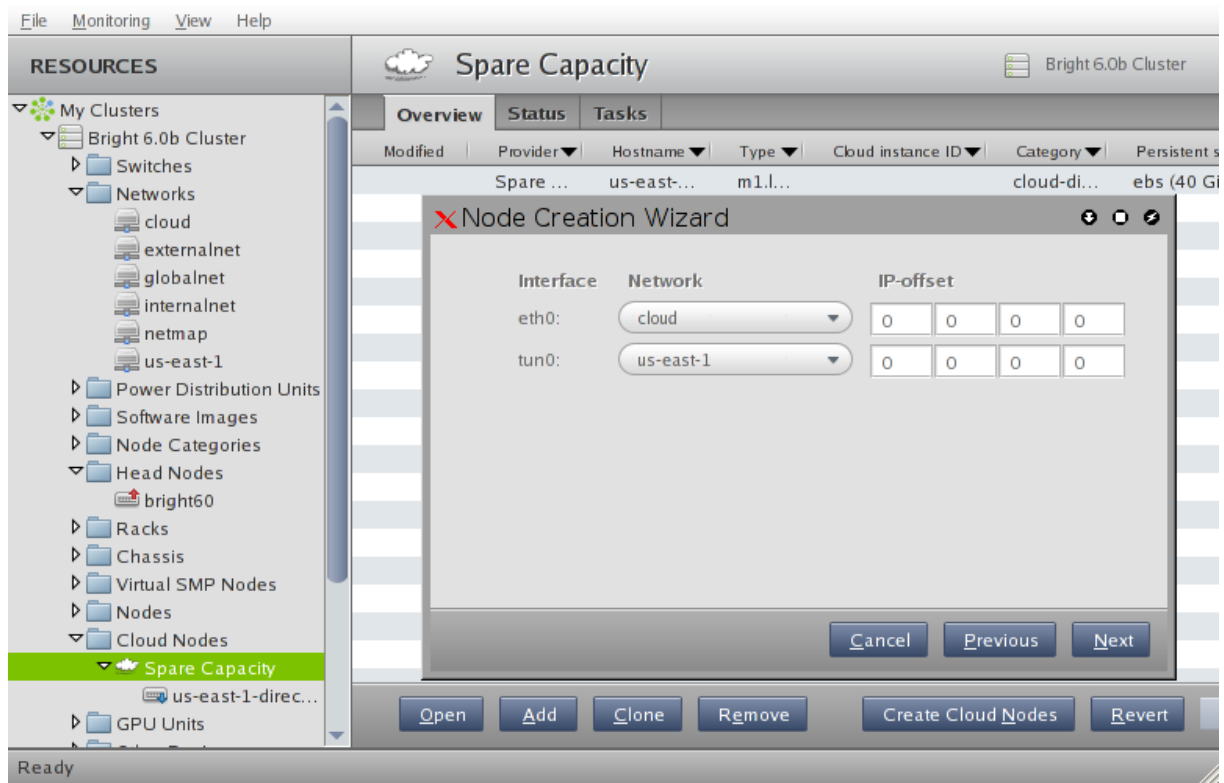


Figure 3.10: Cloud Node Wizard Network And IP Offset Configuration Screen

The last screen of the wizard (figure 3.11) shows a summary screen of the proposed IP address allocations. If the cloud IP addresses are to be assigned using DHCP, then their values are 0.0.0.0.

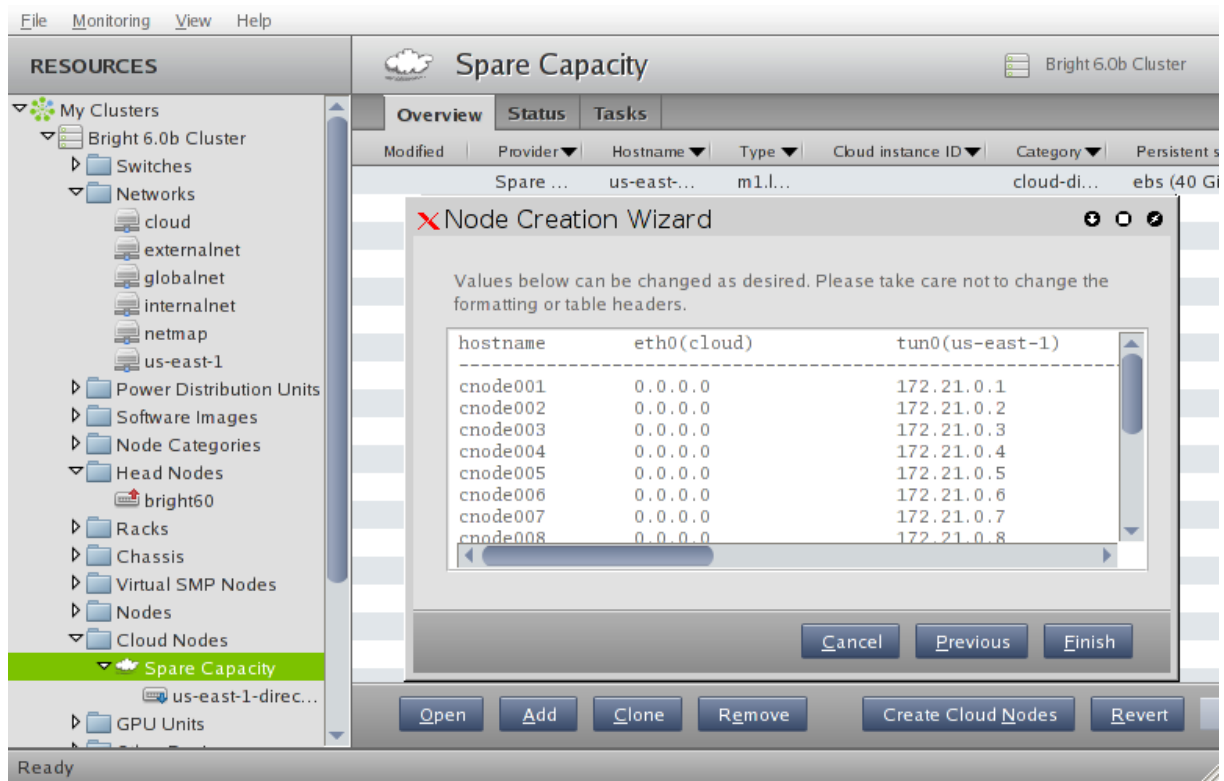


Figure 3.11: Cloud Node Wizard Network And IP Layout Screen

When the wizard is finished, the regular cloud nodes must be saved. This adds them to the default category by default.

If the cloud director is up, then the cloud nodes can be booted up by powering them up (section 4.2 of the *Administrator Manual*) by category, or individually.

4

Cloudbursting Using The Command Line And `cmsh`

The command line and `cmsh` can be used to set up Cluster-On-Demand and Cluster Extension clusters.

For Cluster-On-Demand setups, a GUI web browser is needed initially to launch the head node AMI from Amazon. However, once an `ssh` connection is made by the administrator to the head node, cloudbursting can be continued from command line. Thus, the `bright-setup` script is run from the command line as in section 2.2, and the cloud nodes can be powered up from the command line as in section 2.4.

For Cluster Extension setups, cloudbursting can be carried out entirely from the command line. The `cm-cloud-setup` script (section 4.1) sets up the cloud provider login and cloud director configuration GUI steps of section 3.1 in a guided manner on a command line dialog, after which `cmsh` power commands can launch the required cloud nodes (sections 4.2 and 4.3).

4.1 The `cm-cloud-setup` Script

The `cm-cloud-setup` script is run on the head node, and allows the administrator to specify settings to launch a cloud using the command line. The help text for this utility shows:

```
USAGE: /cm/local/apps/cluster-tools/bin/cm-cloud-setup <OPTIONS>
```

```
OPTIONS:
```

```
-----
```

<code>-p --provider <name></code>	Provider name (default: amazon)
<code>-n --name <name></code>	Account name (default: Amazon EC2)
<code>-u --username <username></code>	Username used in Amazon AWS console
<code>-w --password <password></code>	Password used in Amazon AWS console (if omitted you will be prompted, unless account keys are provided)
<code>-a --accountId</code>	Amazon account ID
<code>-k --awskey <key></code>	AWS access key ID
<code>-s --secretkey <key></code>	AWS secret access ID
<code>-d --delete</code>	Delete Amazon account if it exists
<code>-y --yes</code>	Use all
<code>-h --help</code>	Print this help

```
NOTES:
```

```
-----
```

```
--password option does not work yet
```

It can be used as follows from the prompt:

Example

```
[root@bright71 ~]# cm-cloud-setup -u rotwang@example.com -a 123923792991 \
-k OIQQOWU9LJJEI1232PJP -s ra9xaG7oUiyluqu0ahW4aixuThee5ahmUGoh9cha
```

The administrator is then guided through the steps needed to launch the cloud. The session output may show up as something like (some text elided):

Example

```
Connecting to cluster
Waiting for data from cluster
Adding cloud provider Amazon EC2 ... ok
Waiting for cloud provider data ...
Got 7 regions, 29 images, 12 types
Default region (default: eu-west-1), options:
    ap-northeast-1,
    ...
    us-west-2
> eu-west-1
Default AMI (default: latest), options
    ...
    brightinstaller-074,
    brightinstaller-075
>
Default type (default: t1.micro), options
    c1.xlarge,
    ...
    t1.micro
>
Default cloud director type (default: m1.large), options
    c1.xlarge,
    ...
    t1.micro
>
Update cloud provider Amazon EC2... ok
Got 6 networks
Found tunnel network for eu-west-1: 172.16.0.0/16
Using NetMap network: 172.30.0.0/16
Using cloud network: 10.0.0.0/8
Use regions: (default eu-west-1, space separated / all), options:
    ap-northeast-1,
    ...
    us-west-2
>
Updating head node bright71 ... ok
Updating tunnel network eu-west-1 ... ok
Cloud director ip on eu-west-1 (default 172.16.255.251)
>
Adding cloud director eu-west-1-director ... ok
Provisioning update started
[root@bright71 ~]#
```

After `cm-cloud-setup` has run, the cloud nodes (the cloud director and regular cloud nodes) can be launched.

4.2 Launching The Cloud Director

Launching the cloud requires that the cloud director and cloud nodes be powered up. This can be done using `cmgui` as described in sections 3.2 and 3.3. It can also be carried out in `cmsh`, for example, the cloud director `eu-west-1-director` can be powered up from device mode with:

Example

```
cmsh -c "device power on -n eu-west-1-director"
```

If the administrator is unsure of the exact cloud director name, one way it can easily be found is via tab-completion within the device mode of `cmsh`.

As explained in section 3.2, the cloud director takes some time to power up. Its status can be followed in the notice messages sent to the `cmsh` session, or in the `cmgui` event viewer. The status can also be queried via the `status` command in device node. For example, a `watch` instruction such as:

```
[root@bright71 ~]# watch 'cmsh -c "device status -n eu-west-1-director"'
```

will show a series of outputs similar to:

```
eu-west-1-director ..... [ PENDING ] (Waiting for instance to start)
eu-west-1-director ..... [ PENDING ] (Waiting for instance to start)
eu-west-1-director ..... [ PENDING ] (IP assigned: 54.220.240.166)
eu-west-1-director ..... [ PENDING ] (setting up tunnel)
eu-west-1-director ..... [ INSTALLER_REBOOTING ]
eu-west-1-director ..... [ INSTALLING ] (recreating partitions)
eu-west-1-director ..... [ INSTALLING ] (FULL provisioning to "/")
eu-west-1-director ..... [ INSTALLING ] (provisioning started)
...
```

4.3 Launching The Cloud Nodes

Once the cloud director is up, the cloud nodes can be powered up. This first requires that the cloud node objects exist and each have an IP address assigned to them that is consistent with that of the cloud director that manages them. With `cmgui`, this can be done with the help of a wizard to assign the IP addresses (section 3.3). With `cmsh`, assignment can be done for an individual cloud node, or for many cloud nodes, as follows:

4.3.1 Creating And Powering Up An Individual Node

In the example that follows, a single cloud node is assigned a management network, a tunnel IP address, and a tunnel network so that it can communicate with the cloud director.

Example

```
[root@bright71 ~]# cmsh
[bright71]% device
[bright71->device]% add cloudnode cnode001
Warning: tunnel ip of cnode001 not set. This CloudNode will not start!
[bright71->device*[cnode001*]]% set managementnetwork eu-west-1
[bright71->device*[cnode001*]]% show
Parameter          Value
-----
...
Management network eu-west-1
Network            eu-west-1
...
[bright71->device*[cnode001*]]% interfaces
```

```
[bright71->device*[cnode001*]->interfaces]% list
Type      Network device name  IP      Network
-----
physical  eth0 [prov,dhcp]      0.0.0.0  cloud-ec2classic
tunnel    tun0                0.0.0.0
[bright71->device*[cnode001*]->interfaces]% set tun0 ip 172.16.0.1
[bright71->device*[cnode001*]->interfaces*]% set tun0 network eu-west-1
[bright71->device*[cnode001*]->interfaces*]% list
Type      Network device name  IP      Network
-----
physical  eth0 [prov,dhcp]      0.0.0.0  cloud-ec2classic
tunnel    tun0                172.16.0.1 eu-west-1
[bright71->device*[cnode001*]->interfaces*]% commit
```

The preceding session completes the cloud node object configuration. The cloud node itself can now be launched with an explicit power command such as:

```
[bright71->device[cnode001]->interfaces]% device power on -n cnode001
```

4.3.2 Creating And Powering Up Many Nodes

For a large number of cloud nodes, the creation and assignment of IP addresses can be done with the clone option of the `foreach` command, (section 2.5.5 of the *Administrator Manual*), together with a node range specification. This is the same syntax as used to create non-cloud regular nodes with `cmsh`. Continuing on with the preceding session, where a node `cnode001` was configured:

```
[bright71->device]% foreach --clone cnode001 -n cnode002..cnode010 ()
The IP of network interface: eth0 was not updated
Warning: The Ethernet switch settings were not cloned, and have to be set manually
...
[bright71->device*]% commit
Mon Apr 23 04:19:41 2012 [alert] cnode002: Check 'DeviceIsUp' is in state FAIL on cnode002
[bright71->device]%
Mon Apr 23 04:19:41 2012 [alert] cnode003: Check 'DeviceIsUp' is in state FAIL on cnode003
...
Successfully committed 9 Devices
[bright71->device]%
```

The IP addresses are assigned via heuristics based on the value of `cnode001` and its cloud director.

As before, an alert warns each cloud node is down. The list of cloud nodes can be powered up using `cmsh` with the node range option:

Example

```
[bright71->device]% power on -n cnode002..cnode010
```

4.4 Submitting Jobs With `cmsub` And Cloud Storage Nodes

The `cmsub` command is a user command wrapper that submit job scripts to a workload manager in a Cluster Extension cluster, so that jobs are considered for running in the cloud. Its usage for an end user is covered in section 4.7 of the *User Manual*.

The `cmsub` command is available from the Bright Cluster Manager repository as part of the `cmdaemon-cmsub` package. The `cmsub` command needs the `cmsub` environment module (section 2.2 of the *Administrator Manual*) to be loaded by the user before use.

If the `cmsub` command is run by the user to submit a job, then the job is submitted to the workload manager, and the *data-aware scheduling* mechanism is initiated.

A cluster with data-aware scheduling is a cluster that ensures that it has the data needed for the cloud computing job already accessible on *cloud storage nodes*.

Cloud storage nodes are nodes that are set up by the cluster manager, before the job is executed in the cloud. Because data stored can be written and read from many cloud storage nodes for each job that is placed in the cloud, the data throughput in the cloud becomes more efficient than if only one storage space were used.

4.4.1 Installation And Configuration of `cmsub` For Data-aware Scheduling To The Cloud

The configuration of data-aware scheduling means configuring the cluster so that the tools that allow data-aware scheduling to work correctly are configured. The configuration that is carried out depends on the workload manager that is to be used.

If `cmsub` has not yet been set up, or if it needs reconfiguration, then the following steps should be carried out:

1. The `cmdaemon-cmsub` package is installed. It must be installed on the head node and in the software image that is to be used for compute cloud nodes and storage cloud nodes.

Example

```
[root@bright71 ~]# yum install cmdaemon-cmsub
[...]
```

```
[root@bright71 ~]# yum --installroot /cm/images/default-image install cmdaemon-cmsub
[...]
```

2. The `cmsub-cloud-storage-setup` utility is run. Example runs are provided later, starting on page 42, but an explanatory background is given here first.

The utility is part of the `cluster-tools` package, which is installed by default. The utility

- configures `cmsub` properties (page 42)
- creates (page 42)
 - *templates for cloud storage nodes*
 - *storage policies for `cmsub`*

Templates For Cloud Storage Nodes And Storage Policy

Templates for cloud storage nodes: are a cloud node definition associated with a cloud provider. Templates for cloud storage nodes, more conveniently called template nodes, provide a template that is used by the cloud storage nodes. Template nodes, being templates, are never powered on, and are therefore always in a Down state in `cmsh` and `cmgui`. Actual cloud storage nodes, on the other hand, can be powered on by the cluster manager, so that they can be used to store cloud job data.

In addition, any network interfaces associated with a template node can generally be regarded as non-functioning as far as the administrator is concerned. One feature of template nodes however is that the tunnel IP address set in the template is an offset to the network address that will be used to assign IP addresses to actual storage nodes.

A storage policy: defines other parameters for how storage for cloud jobs is handled. Its parameters include:

- `Name`: the name set for the policy
- `Bucket Name`: the S3 bucket used for cloud jobs to transfer input and output job data
- `Default job output size`: specifies the default free storage space that will be provisioned for the result that a job produces

- Storage node name prefix: specifies a prefix for how storage nodes are to be named. The prefix is `cstorage` by default. The number suffix scheme is as for regular nodes. Thus, by default, the storage nodes are `cstorage001`, `cstorage002` and so on.
- Template for cloud nodes: the template to use as the prototype for storage nodes

Example

Configuration Of `cmsub` Properties

A session with `cm-cloud-storage-setup` that configures `cmsub` properties on a cloud deployment is:

Example

```
[root@bright71 ~]# cm-cloud-storage-setup configure
Specify workload manager (default: slurm; options: slurm, pbspro, torque, lsf, openlava,\
 sge):
> slurm
Specify software image used for cloud nodes (default: default-image; options: default-im\
 age):
>
Do you want to create job queues for cloud nodes (default: y; options: y, n):
>
Specify a comma-separated list of job queue names:
> cloudq,extracloudq
Create symlink: /cm/images/default-image/cm/local/apps/slurm/var/prologs/10-prolog-cmsub\
 to /cm/local/apps/cmd/scripts/cloudjob/cmsub-prolog
Create symlink: /cm/images/default-image/cm/local/apps/slurm/var/epilogs/10-epilog-cmsub\
 to /cm/local/apps/cmd/scripts/cloudjob/cmsub-epilog

-----
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.
-----
```

Creation Of Templates For Storage Nodes And Creation Of Storage Policy For `cmsub`

A session with `cm-cloud-storage-setup` that creates storage node templates, and that creates storage node policies, is:

Example

```
[root@bright71 ~]# cm-cloud-storage-setup create
Specify a name for the storage node template you want to create / use:
> atemplate
Is this a new template (default: yes; options: yes, no) ?
>
Specify a name for the storage node policy you want to create / use:
> apolicy
Is this a new policy (default: yes; options: yes, no) ?
>
Specify category for storage nodes (default: default; options: default, cloud-director,\
 us-east-1):
>
Tunnel interface was found on director node us-east-1-director. So storage nodes will a\
 lso have a tunnel interface. Is this correct ? (default: yes; options: yes, no)
>
```


Define a starting point for the IPs assigned to storage nodes on the tunnel network. This IP value must contain zeros as the network part. If there is no tunnel network, specify value 0.0.0.0 (default 0.0.100.0)

>

Specify the time a storage node can be idle before it gets automatically powered off (default 15m). Input format is "<value> [s|S|m|M|h|H|d|D]"

>

Specify the name of the S3 bucket to use for transferring input data, and results of jobs.

> abucket

Adding cloud storage node template

The storage node policy settings can be modified via CMDaemon using cmsh:

```
[root@bright71 ~]# cmsh
[bright71]]% cloud
[bright71->cloud]% use amzazonec2
[bright71->cloud[Amazon EC2]]% storagenodepolicies
[bright71->cloud[Amazon EC2]->storagenodepolicy% list
Name (key)      Template for cloud nodes
-----
apolicy         atemplate
bpolicy         atemplate
[bright71->cloud[Amazon EC2]->storagenodepolicy% use apolicy
[bright71->cloud[Amazon EC2]->storagenodepolicy[apolicy]]% show
Parameter      Value
-----
Bucket Name    abucket
Default job output size  1GB
Disable cmsub   no
Maximum number of storage nodes  5
Minumum EBS volume size  1GB
Revision
Storage node name prefix  cstorage
Template for cloud nodes  atemplate
Tunnel IP start address   0.0.100.0
cloudOperationTimeout     0
exportedDirectories       home
maxDownloadTime            7200
maxUploadTime              7200
name                       apolicy
storageNodeIdleTimeLimit   900
```

Only one policy can be active at a time for a cloud object. The cm-cloud-storage-setup create session will prompt the administrator to set the policy to active during its session. A policy can also be set to active within cloud mode of cmsh, within the object, by setting the value of activestoragenodepolicy to an existing policy:

Example

```
[bright71->cloud[Amazon EC2]]% get activestoragenodepolicy
apolicy
[bright71->cloud[Amazon EC2]]% set activestoragenodepolicy bpolicy
[bright71->cloud*[Amazon EC2*]]% commit; get activestoragenodepolicy
bpolicy
```

4.5 Miscellaneous Cloud Commands

4.5.1 The `cm-cloud-copy` Tool

The `cm-cloud-copy` tool is automatically installed with the `cmdaemon-cmsub` package (section 4.4.1). Its purpose is to transfer data to and from AWS storage.

It is used automatically as a backend to `cmsub` to create and remove AWS storage containers in AWS S3, and to upload and download files and directories to those containers.

The `cm-cloud-copy` tool can also be used as a standalone tool by the cluster administrator directly. However because its behavior may change due to development, it should only be used if the administrator has explicitly been instructed to do so by Bright Computing engineers. At the time of writing, October 2015, its use requires that the `cm-cloud-copy` module is loaded. A short help can then be seen on running `cm-cloud-copy` without options, while more information and examples can be found in the `cm-cloud-copy(1)` man page.

4.5.2 The `cm-cloud-check` Utility

The `cm-cloud-check` utility checks the current cloud-bursting configuration for possible problems and misconfigurations. It reports any potential issues. The tool also tests communications with Amazon using some simple Amazon API calls.

Only a handful of tests are performed at present. More tests will be added over time.

4.5.3 The `cm-scale-cluster` Utility

The `cm-scale-cluster` utility is a Bright Cluster Manager utility that allows workload managers to scale a cluster up or down in size, depending on job requirements and administrator preferences. This can improve cluster efficiency by cutting down on needless energy consumption.

The development of the utility was originally aimed at cloud use, but it is now a general cluster management utility. Its use is covered in section 7.9.2 of the *Administrator Manual*.

4.5.4 The `cm-cloud-remove-all` Utility

This utility simply removes all clouds and associated objects:

Example

```
[root@bright71 ~]# cm-cloud-remove-all
Connecting to cluster
Removing all normal cloud nodes ...
Removing all cloud director nodes ...
  removed eu-west-1-director
Removing all netmap and tunnel interfaces ...
  remove interface tun0 of bright71
  remove interface map0 of bright71
  remove interface map0:0 of bright71
updated bright71
  remove interface map0 of node001
updated node001
  remove interface map0 of node002
updated node002
Removing all tunnel networks ...
  removed eu-west-1
Removing all cloud categories ...
  removed cloud-director
Removing all cloud networks ...
  removed cloud-ec2classic
Removing all netmap networks ...
  removed netmap
```

```
Removing all cloud providers ...  
  removed Amazon EC2  
Done.  
[root@bright71 ~]#
```

If the `-d|--dryrun` option is used, then it shows what the utility intends to remove during a run, but without actually removing it.

5

Cloud Considerations And Issues With Bright Cluster Manager

5.1 Differences Between Cluster-On-Demand And Cluster Extension

Some explicit differences between Cluster-On-Demand and Cluster Extension clusters are:

Cluster-On-Demand	Cluster Extension
cloud nodes only in 1 region	cloud nodes can use many regions
no cloud director	uses one or more cloud directors per region
no failover head node	failover head node possible
no VPN or NetMap	VPN and NetMap
no externalnet interface on head	can have an external interface
cluster has publicly accessible IP address	cloud directors have publicly accessible IP addresses

A note about the last entry: The access to the cloud director addresses can be restricted to an administrator-defined set of IP addresses, using the “Externally visible IP” entry in figure 3.1 of the *Administrator Manual*.

5.2 Hardware And Software Availability

Bright Computing head node AMIs are available for the following distributions: RHEL5/RHEL6, SL5/SL6, CentOS5/CentOS6, and SLES 11 SP1/SP2.

AMIs with GPU computing instances are available with Amazon cloud computing services only in the US East (Virginia) region the last time this was checked (April 2012). These can be used with Bright Computing AMIs with `hvm` in the name (not `xen` in the name).

To power the system off, a `shutdown -h now` can be used, or the power commands for `cmgui` or `cmsh` can be executed. These commands stop the instance, without terminating it. Any associated extra drives that were created need to be removed manually, via the `Volumes` screen in the `Elastic Block Store` resource item in the navigation menu of the AWS Management Console.

5.3 Reducing Running Costs

5.3.1 Spot Pricing

The spot price field is a mechanism to take advantage of cheaper pricing made available at irregular¹ times. The mechanism allows the user to decide a threshold spot price (a price quote) in US dollars per hour for instances. Instances that run while under the threshold are called *spot instances*. Spot instances are described further at <http://aws.amazon.com/ec2/spot-instances/>.

With the pricing threshold set:

- If the set spot price threshold is above the instantaneous spot price, then the spot instances run.
- If the set spot price threshold is below the instantaneous spot price, then the spot instances are killed.
- If the set spot price threshold is N/A, then no conditions apply, and the instances will run on demand regardless of the instantaneous spot price.

An *on demand instance* is one that runs regardless of the price, according to the pricing at <http://aws.amazon.com/ec2/pricing/>.

A *persistent request* is one that will retry running a spot instance if the conditions allow it.

5.3.2 Storage Space Reduction

Reducing the amount of EBS disk storage used per cloud node or per cloud director is often feasible. 15 GB is usually enough for a cloud director, and 5 GB is usually enough for a cloud node with common requirements. In `cmsh` these values can be set with:

Example

```
[bright71]% device cloudsettings eu-west-1-director
[bright71->device[eu-west-1-director]->cloudsettings]% storage
[bright71->...->cloudsettings->storage]% set ebs size 15GB; commit
[bright71->...->cloudsettings->storage]% device cloudsettings cnode001
[bright71->device[cnode001]->cloudsettings]% storage
[bright71->...->cloudsettings->storage]% set ebs size 5GB; commit
```

The value for the cloud node EBS storage can also be set in the cloud node wizard (fig. 3.9) for a Cluster Extension configuration.

5.4 Address Resolution In Cluster Extension Networks

5.4.1 Resolution And `globalnet`

The `globalnet` network is introduced in section 3.2.3 of the *Administrator Manual*. It allows an extra level of redirection during node resolution. The reason for the redirection is that it allows the resolution of node names across the entire cluster in a hybrid cluster, regardless of whether the node is a cloud node (cloud director node or regular cloud node) or a non-cloud node (head node, regular node or networked device). A special way of resolving nodes is needed because the Amazon IP addresses are in the 10.0.0.0/8 network space, which conflicts with some of the address spaces used by Bright Cluster Manager.

There are no IP addresses defined by `globalnet` itself. Instead, a node, with its domain defined by the `globalnet` network parameters, has its name resolved by another network to an IP address. The resolution is done by the nameserver on the head node for all nodes.

¹irregular turns out to be random within a tight range, bound to a reserve price. Or rather, that was the case during the period 20th January–13th July, 2010 that was analyzed by Ben-Yehuda et al, <http://www.cs.technion.ac.il/users/wwwb/cgi-bin/tr-info.cgi/2011/CS/CS-2011-09>

5.4.2 Resolution In And Out Of The Cloud

The networks, their addresses, their types, and their domains can be listed from the `network` mode in `cmsh`:

```
[bright71->network]% list
```

Name (key)	Type	Netmask bits	Base address	Domain name
bmcnet	Internal	16	10.148.0.0	bmc.cluster
cloud	Cloud	8	10.0.0.0	cloud.cluster
externalnet	External	16	10.2.0.0	brightcomputing.com
globalnet	Global	0	0.0.0.0	cm.cluster
ibnet	Internal	16	10.149.0.0	ib.cluster
internalnet	Internal	16	10.141.0.0	eth.cluster
netmap	NetMap	16	172.30.0.0	
us-east-1	Tunnel	16	172.21.0.0	

In a Type 1 network (section 3.3.6 of the *Installation Manual*), the head node is connected to `internalnet`. When a cloud service is configured, the head node is also “connected” to the CMDaemon-managed NetMap “network”. It is useful to think of NetMap as a special network, although it is actually a network mapping from the cloud to `internalnet`. That is, it connects (maps) from the nodes in one or more cloud networks such as the `us-east-1` network provided by Amazon, to IP addresses provided by `netmap`. The mapping is set up when a cloud extension is set up. With this mapping, packets using NetMap go from the cloud, via an OpenVPN connection to the NetMap IP address. Once the packets reach the OpenVPN interface for that address, which is actually on the head node, they are forwarded via Shorewall’s IPtables rules to their destination nodes on `internalnet`.

With default settings, nodes on the network `internalnet` and nodes in a cloud network such as `us-east-1` are both resolved with the help of the `cm.cluster` domain defined in `globalnet`. For a cluster with default settings and using the cloud network `us-east-1`, the resolution of the IP address of 1. a regular node and 2. a regular cloud node, takes place as follows:

1. `node001`, a regular node in the `internalnet` network, is resolved for `node001.cm.cluster` to
 - (a) `10.141.0.1`, when at the head node. The cluster manager assigns this address, which is on `internalnet`. It could also be an `ibnet` address instead, such as `10.149.0.1`, if InfiniBand has been configured for the nodes instead of Ethernet.
 - (b) `172.30.0.1` when at the cloud director or regular cloud node. The cluster manager assigns this address, which is a NetMap address. It helps route from the cloud to a regular node. It is not actually an IP address on the interface of the regular node, but it is convenient to think of it as being the IP address of the regular node.
2. `cnode001`, a regular cloud node in the `us-east-1` network, is resolved for `cnode001.cm.cluster` to:
 - (a) `172.21.0.1` when at the head node. The cluster manager assigns this address, which is an OpenVPN tunnel address on `us-east-1`.
 - (b) an IP address within `10.0.0.0/8` (`10.0.0.1–10.255.255.254`) when at a regular cloud node or at a cloud director. The Amazon cloud network service assigns the addresses in this network to the cloud director and regular cloud nodes.

An explanation of the networks mentioned in the preceding list follows:

- The nodes within all available cloud networks (all networks such as for example, `us-east-1`, `us-west-1`, and so on) are given CMDaemon-assigned addresses in the cloud node space range `172.16.0.0–172.29.255.255`. In CIDR notation that is: `172.16.0.0/12` (`172.16.0.0–172.31.255.255`), except for `172.31.0.0/15` (`172.30.0.0–172.31.255.255`).

- The network address space 172.30.0.0/16 (172.30.0.0–172.30.255.255) is taken by the CMDaemon-assigned NetMap network, explained shortly. The addressing scheme for each cloud network is assigned as suggested in figure 3.5.
- Each node in a cloud network is also assigned an address in the network addressing space provided by Amazon. The assignment of IP addresses to nodes within the 10.0.0.0/8 range is decided by Amazon via DHCP.
- The netmap “network” (figure 5.1) is a helper mapping reserved for use in routing from the cloud (that is, from a cloud director or a cloud node) to a regular node. The mapping uses the 172.30.0.0/16 addressing scheme. Its routing is asymmetrical, that is, a NetMap mapping from a regular node to the cloud does not exist. Packets from a regular node to the cloud do however resolve to the cloud network as indicated by 2(a) in the preceding.

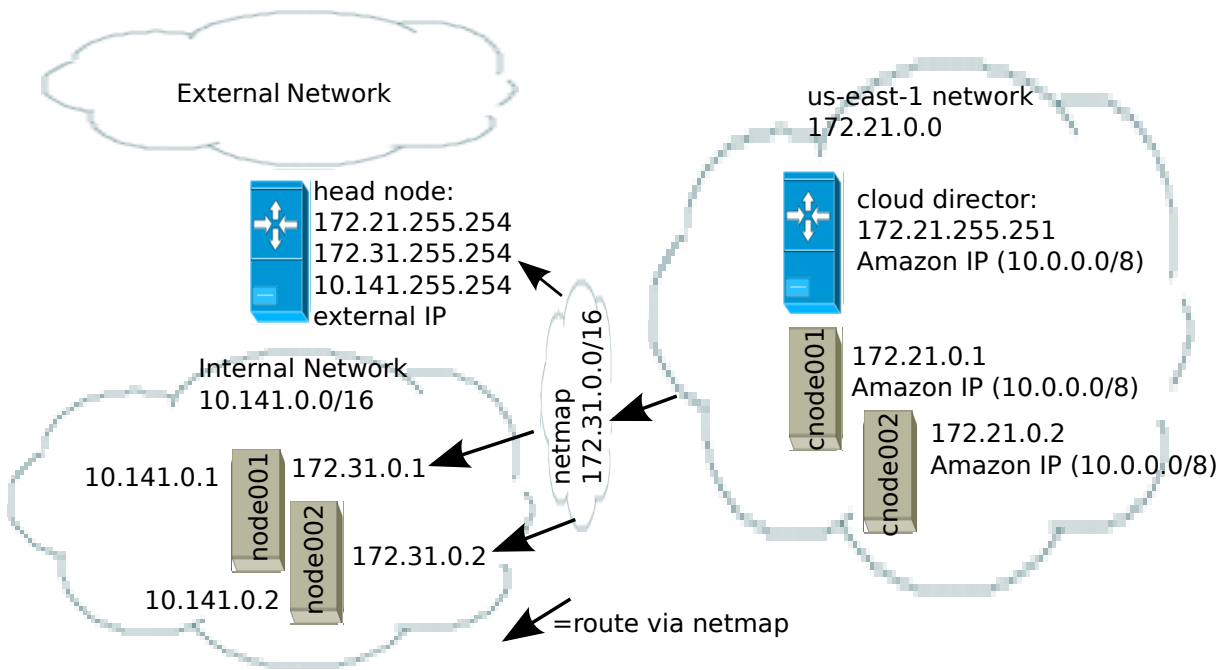


Figure 5.1: NetMap In Relation To The General Network Scheme

As pointed out in the introduction to this section (5.4), the main reason for the IP addressing network scheme used is to avoid IP address conflicts between nodes within the cloud and nodes outside the cloud.

The *difference* in resolution of the IP address for the nodes as listed in points 1 and 2 in the preceding text is primarily to get the lowest overhead route between the source and destination of the packet being routed. Thus, for example, a packet gets from the regular cloud node to the cloud director with less overhead if using the Amazon cloud IP addressing scheme (10.0.0.0/8) than if using the Bright OpenVPN addressing scheme (172.21.0.0/16). A secondary reason is convenience and reduction of networking complexity. For example, a node in the cloud may shut down and start up, and get an arbitrary Amazon IP address, but using an OpenVPN network such as `us-east-1` allows it to retain its OpenVPN address and thus stay identified instead of having the properties that have been assigned to it under Bright Cluster Manager become useless.

6

Virtual Private Clouds

A *virtual private cloud* is an implementation of a cluster on a virtual network in a cloud service provider. The Amazon Virtual Private Cloud (Amazon VPC) is an implementation of such a virtual private cloud. The Amazon VPC is documented more fully at <http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-vpc.html>.

Managing VPCs would normally require significant networking expertise. Bright Cluster Manager makes it easier to do this, so that the administrator can focus on using them productively, instead of on working out VPC configurations.

The following VPC-related terms are explained and compared in this chapter:

- *EC2-Classic* (page 51)
- *EC2-VPC* (page 51)
- *classic cloud* (page 52)
- *defaultVPC* (page 52)
- *private cloud* (page 52)
- *custom VPC* (page 52)
- *elastic IP addresses* (page 56)

6.1 EC2-Classic And EC2-VPC

6.1.1 EC2-Classic Vs EC2-VPC Overview

So far, this manual has discussed configuring clusters within Amazon EC2. The EC2 designation actually covers two kinds of platforms:

- **EC2-Classic:** This platform provides an environment that corresponds to a physical network. Instances in the same region exist on the same physical network and rely on explicitly configured security groups to restrict unauthorized access from other instances on the same network. A cloud instance that is created in such a network can be called a classic cloud cluster, or simply a cloud cluster.

Amazon is gradually phasing out the EC2-Classic platform.

- **EC2-VPC:** This platform is replacing EC2-Classic. It provides an environment corresponding to an isolated virtual network. A cloud cluster instance implemented on this virtual network is thus a virtual private cloud, or VPC, as described at the start of this section (section 6).

The EC2-VPC platform offers some extra features that are not available, or not as easy to configure, on the EC2-Classic platform:

- Multiple VPCs can be configured per region
- The inherent isolation of Amazon VPCs makes them more secure by default
- their network properties can be customized

The isolated network design of a VPC means that instances started within a VPC cannot by default communicate with instances outside. *Elastic IP* addresses (page 56) are used to explicitly allow communication with the outside.

6.1.2 EC2-Classic Vs EC2-VPC And AWS Account Creation Date

The type of platform that can be accessed by an AWS account varies as indicated by the following table:

Account Creation Date	Typical Platform Offered
Before start of 2013	EC2-Classic only
In first half of 2013	EC2-Classic or EC2-VPC*
After first half of 2013	EC2-VPC only, in most or all regions

*Typically depends on the region accessed.

Most new AWS accounts do not provide an EC2-Classic platform. However, to maintain backward compatibility for users who are migrating to EC2-VPC, and who have applications that run on the EC2-Classic platform, Amazon provides the defaultVPC instance on the EC2-VPC platform.

6.1.3 The Classic Cloud And The DefaultVPC Instances

The *classic cloud* is a cloud instance that EC2-Classic supports.

The defaultVPC instance is a special VPC instance that emulates EC2-Classic behavior on the EC2-VPC platform. This allows legacy applications that do not support EC2-VPC to run on it. A legacy application that runs in a defaultVPC instance may be thought of as having its EC2-Classic API calls translated into EC2-VPC API calls. The defaultVPC instance is available in all regions that do not offer the EC2-Classic platform.

There is one major difference between the network environments of EC2-Classic and the defaultVPC instance: For EC2-Classic instances, the base address of network inside Amazon is 10.0.0.0/8. In contrast, for defaultVPC instances the base address is 172.30.0.0/16.

When creating a new cloud provider account, Bright Cluster Manager automatically detects which regions offer the EC2-Classic platform, and which do not. The suggested base address of the cloud network that is to be created is then automatically matched according to the regions. The platform supported, EC2-Classic or EC2-VPC, is also displayed in `cmgui` when the cloud director is being created.

A few Amazon AWS accounts provide the EC2-Classic platform for only a certain subset of all available regions, and provide EC2-VPC in other regions. In such a case, when a new cloud provider account is created in Bright Cluster Manager with a cloud director in both types of platforms, then two cloud networks can be created. If only a single cloud director is run, then only one network is created, and the network base address in that case depends on the platform, EC2-Classic or EC2-VPC, that it is run on. However, if two cloud directors are started up, with each cloud director on a different platform, then one cloud director runs on one platform and associated network, and the other cloud director on the other platform and associated network.

6.1.4 The Private Cloud And Custom VPC Instances

A *private cloud* (without the “virtual” in front) is the term used in the Bright Cluster Manager manuals, as well as by Amazon, and in general, for a general VPC instance.

A *custom VPC* is the term used in the manual to mean a general VPC instance, but one that is not a defaultVPC instance.

Thus, in terms of math sets:

`private clouds = custom VPCs + defaultVPCs`

In the context of Amazon VPCs, the term private cloud is often used by administrators, by convention and for convenience, to mean the more precise term of custom VPC as defined here, implicitly ignoring possible defaultVPC instances. The Bright Cluster Manager software itself also follows this convention. In this chapter of the manual (6), however, using the term “private cloud” for this is avoided, and the terms are adhered to precisely as defined, in order to avoid confusion.

Attempting to change a defaultVPC instance to a custom VPC instance by editing defaultVPC properties directly with Bright Cluster Manager is not possible, because these properties are hidden behind the EC2-Classic facade. This kind of change can be done via the Amazon Webconsole instead. If Bright Cluster Manager requires that the custom VPC functionality of a general VPC instance is needed in Amazon VPC, then a custom VPC has to be created within Bright Cluster Manager. How to do this is described in section 6.3.

6.1.5 Cloud Cluster Terminology Summary

The cluster terminology used so far can be summarized as follows:

cluster term	platform	type and connectivity
classic cloud	EC2-Classic	classic cloud cluster that has direct connectivity to the outside
defaultVPC	EC2-VPC	a VPC that looks like it has direct connectivity to the outside because it emulates a classic cloud cluster
custom VPC	EC2-VPC	isolated VPC with no connectivity to the outside by default, and NAT gateway connectivity to the outside when made to connect
private cloud	EC2-VPC	both defaultVPC and custom VPC

6.2 Comparison Of EC2-Classic And EC2-VPC Platforms

There are several differences between EC2-Classic and EC2-VPC platforms. The most important ones are:

- Cloud nodes created inside the EC2-VPC platform do not have an external (public) IP address assigned to them by default. An exception to this is the case of nodes running in a defaultVPC instance, which emulates EC2-Classic network behaviour. Having no public IP address by default allows for a greater degree of out-of-the-box security.
- Custom VPCs are self-contained and securely isolated from the instance of other users.
- Custom VPCs are partitioned into multiple network segments, called *subnets* (section 6.3.1).
- It is possible to specify a custom base network address for the custom VPC. This is in contrast to the EC2-Classic platform, where a base network address always has the value of 10.0.0.0/8. For a defaultVPC instance the base network address takes the value of 172.30.0.0/16.

6.3 Setting Up And Creating A Custom VPC

By default, when Bright Cluster Manager creates a new cloud provider account, the cloud nodes created are EC2-Classic instances or defaultVPC instances inside the EC2-VPC platform. That is, they are not nodes in a custom VPC instance. This default behavior is expect to change in a later version of Bright Cluster Manager as Amazon and Bright Cluster Manager both evolve.

Bright Cluster Manager can be set to create custom VPC instances inside the EC2-VPC platform. The EC2-VPC platform is recommended for all new cloudbursting setups.

6.3.1 Subnets In A Custom VPC

The components of a custom VPC include subnets, the nodes that run in them, and static IP addresses. The subnets are logical network segments within the network range of that custom VPC. Subnets can be thought of as interconnected with a central “magic” router, with Bright Cluster Manager managing the routing tables on that router. The routing ensures correct subnet communication. Inside Bright Cluster Manager, subnets are represented as a type of network (section 3.2 of the *Administrator Manual*), with a value for type set to `CLOUD`.

Subnets for a custom VPC must have non-overlapping ranges. If there are multiple custom VPCs being managed by Bright Cluster Manager, then a particular subnet may be assigned to one custom VPC at the most.

Two series of valid network ranges could be:

Example

1. 10.0.0.0-10.0.31.255 (10.0.0.0/19),
10.0.32.0-10.0.63.255 (10.0.32.0/19),
10.0.64.0-10.0.95.255 (10.0.64.0/19).
2. 192.168.0.0-192.168.0.255 (192.168.0.0/24),
192.168.1.0-192.168.1.255 (192.168.1.0/24).

The `sipcalc` command (page 59 of the *Administrator Manual*) is a useful tool for calculating appropriate subnet ranges. At least one subnet must be assigned to a custom VPC before an instance can be created in that cloud. Typically two or more subnets are assigned, as shown in the custom VPC creation example in the following section.

6.3.2 Creating The Custom VPC

After subnets have been configured, a custom VPC can be created by specifying:

- the name
- the default region
- base address
- number of netmask bits

The network of the custom VPC must obviously be a superset of its subnets. Any subnets of the custom VPC must also be specified. Subnets can be added to or removed from an already-created custom VPC, but only if any cloud node instances within them are terminated first.

There are several ways to set up and create the subnets and custom VPC instance in Bright Cluster Manager:

1. by using the command line `cm-cloud-setup-private-cloud` utility,
2. by using the `cmgui` private cloud creation dialog box,
3. by manually creating and configuring the `private cloud` object using `cmsh`.

These are described next:

1. Subnet Setup And Custom VPC Instance Creation Using `cloud-setup-private-cloud`

Once the cloud provider account has been configured, using the `cm-cloud-setup` utility (section 4.1), or by using the `cmgui` wizard (section 3.1), the `cm-cloud-setup-private-cloud` utility can then be run to set up a custom VPC.

The utility prompts the user to choose a cloud provider account, a region to create the VPC in, and the base address of the VPC. It goes on to create the custom VPC, and finishes by prompting whether to move any eligible cloud nodes to the custom VPC.

2. Subnet Setup And Custom VPC Creation Using `cmgui`

For the cloud provider resource item, inside the `Private Clouds` tab, clicking the `Add` button launches a dialog box to create a custom VPC.

3. Subnet Setup And Custom VPC Creation Using `cmsh`

Similarly with `cmsh`, the subnets to be used for the custom VPC are created first, before creating the private cloud, as shown in the following examples.

- **Subnet creation and cloning:** In the following example session, an arbitrary naming scheme is used for subnets, with a pattern of: `<name of custom VPC>-sn-<number>`. Here, `sn` is an arbitrary abbreviation for “subnet”:

Example

```
[bright71->network]% add vpc-0-sn-0
[bright71->network*[vpc-0-sn-0*]]% set type cloud
[bright71->network*[vpc-0-sn-0*]]% set baseaddress 10.0.0.0
[bright71->network*[vpc-0-sn-0*]]% set netmaskbits 24
[bright71->network*[vpc-0-sn-0*]]% set ec2availabilityzone eu-west-1a
[bright71->network*[vpc-0-sn-0*]]% commit
```

Setting the `ec2availabilityzone` property is optional. It causes the subnet to be created in a specific availability zone. Leaving its value empty creates the subnet inside a randomly chosen availability zone. Having all subnets of the custom VPC inside the same availability zone is advised for better network performance. The availability zone set for the network must be one of the availability zones available for the region inside which the private cloud will be created.

Once the first subnet has been created, it can be cloned:

Example

```
[bright71->network]% clone vpc-0-sn-0 vpc-0-sn-1
[bright71->network*[vpc-0-sn-1*]]% set baseaddress 10.0.1.0
[bright71->network*[vpc-0-sn-1*]]% commit
```

- **Custom VPC creation:** The following example session in the `privateclouds` submode of the `cloud` mode, creates a private cloud called `vpc-0`. The private cloud is actually a custom VPC according to the strict definition of a private cloud instance in the section on page 52. It is of type `ec2` and within a network that contains the two subnets specified earlier.

Example

```
[bright71->cloud[Amazon EC2]->privateclouds]%
[bright71->...->privateclouds]% add ec2privatecloud vpc-0
[bright71->...->privateclouds*[vpc-0*]]% set region eu-west-1
[bright71->...*[vpc-0*]]% set baseaddress 10.10.0.0
[bright71->...*[vpc-0*]]% set netmaskbits 16
[bright71->...*[vpc-0*]]% set subnets vpc-0-sn-0 vpc-0-sn-1
[bright71->...*[vpc-0*]]% commit
```

6.3.3 Elastic IP Addresses And Their Use In Configuring Static IP Addresses

Unlike defaultVPC and EC2-Classic instances, a custom VPC instance does not have an externally visible (public) IP address assigned to it by Amazon by default. Without an externally visible IP address, the custom VPC cannot communicate with the internet, and it cannot even be an endpoint to an outside connection. To solve this issue, Amazon *elastic IP addresses* (EIPs) can be used to assign a public IP address to a custom VPC cloud.

EIP addresses are the public IP addresses that Amazon provides for the AWS account. These addresses are associated with defaultVPC and EC2-Classic cloud instances by Amazon by default. These addresses can also be associated with custom VPC instances. The public addresses in the set of addresses can then be used to expose the custom VPC instance. In this manual and in Bright Cluster Manager, EIPs are referred to as “static IPs” in the cloud context. When allocating a static IP address, the exact IP address that is allocated is a random IP address from the set of all public IP addresses made available in the specified region by the configured cloud provider.

Automatic allocation of static IP addresses:

When a cloud director instance is started inside a custom VPC, CMDaemon automatically allocates and assigns a static IP address to it. By default, the static IP address is automatically released when the cloud director instance is terminated. This behavior can be changed in the CMDaemon cloud settings for the cloud director.

Manual allocation of static IP addresses:

It is also possible to manually allocate a static IP address to a cloud director using `cmgui` or `cmsh`.

Allocating a static IP address in `cmsh` is done using the `staticip allocate` command, followed by the string indicating the region in which the static IP address is to be allocated. In `cmsh`, the command is issued inside a cloud provider object. A new static IP address is then made available and can be assigned to instances running within custom VPCs.

After allocation, the static IP address can be assigned and reassigned to any instance inside any custom VPC created within the region in which the IP address was allocated.

Example

```
[bright71] cloud use amazonec2
[bright71->cloud[Amazon EC2]]% staticip allocate us-west-1
Allocating Static IP. Please wait...
Successfully allocated the following static IP: 54.215.158.42
[bright71->cloud[Amazon EC2]]% staticip list
Cloud Provider   Cloud Region   Static IP       Assigned to
-----
Amazon EC2       us-west-1      54.215.158.42   <not assigned>
[bright71->cloud[Amazon EC2]]%
```

An allocated static IP can be released with the `staticip release` command in `cmsh`:

Example

```
[bright71->cloud[Amazon EC2]]% staticip release 54.215.158.42
Releasing static IP 54.215.158.42. Please wait...
Successfully released the static ip.
[bright71->cloud[Amazon EC2]]%
```

Once the IP address has been released, it may no longer be used for instances defined in the custom VPC.

The `staticips` command lists all allocated static IPs for all configured cloud providers.

The `staticip list` command lists static IP addresses for the currently active cloud provider object.

In `cmgui` the static IPs can be managed via the “Static IPs” tab of a cloud provider object.

6.3.4 Subnets With Static IP Addresses In A Custom VPC Recommendation

Subnets can be set up in many ways inside a custom VPC. The following is recommended:

- There must be exactly one network containing all the instances which have static IP addresses. This network should contain the cloud director. The network with the cloud director is arbitrarily referred to as the “public” network.
- There must be zero or more networks containing instances with no static IP addresses assigned to them. Such networks are arbitrarily referred to as the “private” subnets.

Instances in the private subnets have no static IP addresses assigned to them, so by default they do not communicate with outside networks. To allow them to connect to the outside, the cloud director instance is automatically configured by CMDaemon as a NAT gateway for outside-bound traffic, for the instances existing inside the private subnets.

6.3.5 Assignment Of Nodes To Subnets And Cloud Platforms

A cloud node instance is connected to a network by its `eth0` interface. The network is one of those covered in following table, that is: classic physical, classic emulated, or subnet of a custom VPC.

what cloud is the eth0 interface connected to?	cloud instance type and network that the node joins
classic cloud	classic cloud cluster instance, in classic physical network (10.0.0.0/8)
defaultVPC	defaultVPC instance, in classic emulated network (172.30.0.0/16)
custom VPC	inside VPC instance, in the connected subnet (if any) of that network

Therefore, when the cloud node is being created inside EC2, the CMDaemon must tell the EC2 environment which of these networks is going to be attached to the `eth0` interface of the newly created cloud node.

This information is deduced by CMDaemon by looking at the interface configuration of the cloud node Bright Cluster Manager. More specifically, it is deduced from the value set for `network` in the cloud node’s `eth0` interface settings.

If that network is part of a custom VPC, that is, if it is a subnet, then the node starts inside the custom VPC instance. Otherwise, it starts inside the EC2-Classic or defaultVPC instance in that region.

For example, the cloud director node is started inside the `vpc-0-sn-0` network in the following session. It is considered a custom VPC node, and starts up inside the EC2-VPC platform:

Example

```
[bright71->device[us-west-1-director]->interfaces]% list
Type           Network device name  IP                Network
-----
physical       eth0 [dhcp]          0.0.0.0           vpc-0-sn-0
tunnel         tun0 [prov]          172.18.255.251    us-west-1
```

In contrast, if the cloud network assigned to the `eth0` interface is the cloud network representing the network environment of an EC2-Classic or defaultVPC cloud, then the node is considered to be an EC2-Classic node. It then starts up inside the EC2-Classic platform by default:

Example

```
[bright71->device[us-west-1-director]->interfaces]% list
Type           Network device name  IP                Network
```


physical	eth0 [dhcp]	0.0.0.0	cloud
tunnel	tun0 [prov]	172.18.255.251	us-west-1

Once a cloud node instance has been instantiated inside a specified subnet it cannot be reassigned to a different subnet, nor can it be reassigned to a different custom VPC. The cloud instance must first be terminated and reconfigured. Only then can it be powered on inside a different subnet.

6.3.6 Creating A Cloud Director In A Custom VPC

To create a cloud director in a custom VPC using `cmgui`, the cloud director must first be created inside the EC2-Classic platform region in which the custom VPC is created. This can be done via the `Add Cloud Director` button inside the `Overview` tab of a cloud provider account. After this has been done, the cloud director must be moved from the EC2-Classic platform to the custom VPC, as explained in section 6.3.8.

6.3.7 Creating Cloud Compute nodes In A Custom VPC

Creating cloud compute nodes inside a custom VPC can be done in a similar way to creating cloud compute nodes for the EC2-Classic platform. That is, by clicking the `Create Cloud Nodes` button in the overview tab of the cloud provider in `cmgui`. However, to create a cloud node inside the custom VPC, a subnet of the custom VPC must be specified when selecting the network of the `eth0` interface of the node. To avoid confusion, it is sensible to make this a different subnet from the one in which the cloud director node for that particular custom VPC is assigned.

An alternative solution to creating cloud compute nodes in a custom VPC is to instruct the cluster manager to automatically move the existing ones while also moving the cloud director to the custom VPC, as explained in the following section.

6.3.8 Moving Existing Nodes To A Custom VPC

After a custom VPC has been configured, it is possible to automatically reconfigure the existing cloud nodes to make them start inside that custom VPC. This is an alternative to creating new nodes inside the custom VPC from scratch. An existing cloud director can be moved to a custom VPC cloud using the `Move Cloud Director` button in `cmgui`. This button can be clicked in the `Overview` tab of a cloud provider account, and it opens up a dialog box. After completion of the dialog, the cloud director is moved to a custom VPC in the same region. It can also move any other cloud compute nodes managed by the selected cloud director.

Moving a node to a custom VPC effectively terminates the current EC2 instance, and creates a new one inside the target custom VPC.