Cloudbursting Manual
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# Table of Contents

1 Introduction ................................................. 1

2 Cluster On Demand Cloudbursting ......................... 3
   2.1 Cluster On Demand: Launching The Head Node From The Cloud Provider .................. 3
      2.1.1 Getting To The “Launch Instance” Button ............................................. 3
      2.1.2 Launching The Head Node Instance ....................................................... 5
      2.1.3 Managing A Head Node Instance With The AWS EC2 Management Console ........... 9
   2.2 Cluster On Demand: Head Node Login And Cluster Configuration .......................... 13
   2.3 Cluster On Demand: Connecting To The Headnode Via cmsh Or cmgui ....................... 17
      2.3.1 Cluster On Demand: Access With A Remote, Standalone cmgui .......................... 17
      2.3.2 Cluster On Demand: Access With A Local cmsh ......................................... 18
      2.3.3 Cluster On Demand: Access With A Local cmgui ....................................... 18
   2.4 Cluster On Demand: Cloud Node Start-up ..................................................... 18
      2.4.1 IP Addresses In The Cluster On Demand Cloud ......................................... 20

3 Cluster Extension Cloudbursting .......................... 21
   3.1 Cluster Extension: Cloud Provider Login And Cloud Director Configuration ............. 22
      3.1.1 Introduction ............................................................................................... 23
      3.1.2 AWS Credentials ....................................................................................... 23
      3.1.3 Select Regions ......................................................................................... 24
      3.1.4 Summary & Deployment ............................................................................. 25
      3.1.5 Deploy ....................................................................................................... 26
   3.2 Cluster Extension: Cloud Director Startup From Scratch ...................................... 26
      3.2.1 Setting The Cloud Director Disk Storage Device Type ................................... 27
      3.2.2 Setting The Cloud Director Disk Size ....................................................... 28
      3.2.3 Tracking Cloud Director Startup .................................................................. 29
   3.3 Cluster Extension: Cloud Node Startup From Scratch ........................................... 31
   3.4 Cluster Extension: Cloud Director And Cloud Node Startup From Snapshots ............. 32
      3.4.1 Cloud Director Startup From Snapshots .................................................... 33
      3.4.2 Cloud Node Startup From Snapshots ....................................................... 34

4 Cloudbursting Using The Command Line And cmsh .... 35
   4.1 The cm-cluster-on-demand-aws Script For Cluster On Demand Cloud Clusters ............ 35
      4.1.1 cm-cluster-on-demand-aws Command Options Overview, Help Files ................ 35
      4.1.2 cm-cluster-on-demand-aws Configuration Options, YAML Configuration Files, And Environment Variables .......................................................... 37
# Table of Contents

4.1.3 cm-cluster-on-demand-aws: Launching A Cluster ........................................ 39
4.1.4 cm-cluster-on-demand-aws: Stopping And Terminating The Cluster ............ 40
4.2 The cm-cluster-extension Script For Cluster Extension Clusters ................. 41
  4.2.1 Running The cm-cluster-extension Script On The Head Node For Cluster Extension Clusters ................................................................. 41
  4.2.2 Launching The Cloud Director For Cluster Extension Clusters .................. 46
4.3 Launching The Cloud Nodes ........................................................................... 46
  4.3.1 Creating And Powering Up An Individual Node ....................................... 46
  4.3.2 Creating And Powering Up Many Nodes .................................................. 47
4.4 Submitting Jobs With cmsub And Cloud Storage Nodes, For Cluster Extension Clusters ......................................................... 48
  4.4.1 Installation And Configuration of cmsub For Data-aware Scheduling To The Cloud ................................................................. 48
4.5 Miscellaneous Cloud Commands .................................................................. 52
  4.5.1 The cm-cloud-copy Tool ...................................................................... 52
  4.5.2 The cm-scale-cluster Utility .................................................................. 53

5 Cloud Considerations And Issues With Bright Cluster Manager ...................... 55
  5.1 Differences Between Cluster On Demand And Cluster Extension ................ 55
  5.2 Hardware And Software Availability ......................................................... 55
  5.3 Reducing Running Costs ............................................................................ 55
    5.3.1 Spot Pricing ....................................................................................... 56
    5.3.2 Storage Space Reduction .................................................................. 56
  5.4 Address Resolution In Cluster Extension Networks .................................... 56
    5.4.1 Resolution And globalnet ................................................................. 56
    5.4.2 Resolution In And Out Of The Cloud ............................................... 57

6 Legacy/Current Cloud Instances, And Their Network Addressing Allocations .... 59
  6.1 EC2-Classic And EC2-VPC ....................................................................... 59
    6.1.1 EC2-Classic Vs EC2-VPC Overview ............................................... 59
    6.1.2 EC2-Classic Vs EC2-VPC And AWS Account Creation Date .................. 60
    6.1.3 The Classic Cloud And The DefaultVPC Instances ............................... 60
    6.1.4 The Private Cloud And Custom VPC Instances ................................. 60
    6.1.5 Cloud Cluster Terminology Summary .............................................. 61
  6.2 Comparison Of EC2-Classic And EC2-VPC Platforms ............................... 61
  6.3 Setting Up And Creating A Custom VPC .................................................... 61
    6.3.1 Subnets In A Custom VPC .................................................................. 61
    6.3.2 Creating The Custom VPC ................................................................. 62
    6.3.3 Elastic IP Addresses And Their Use In Configuring Static IP Addresses .... 63
    6.3.4 Subnets With Static IP Addresses In A Custom VPC Recommendation .... 64
Welcome to the Cloudbursting Manual for Bright Cluster Manager 7.3.

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 7.3 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 Big Data Deployment Manual describes how to deploy Big Data with Bright Cluster Manager.
- The UCS Deployment Manual describes how to deploy the Cisco UCS server with Bright Cluster Manager.
- The Machine Learning Manual describes how to install and configure machine learning capabilities 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 typically goes via standard e-mail. Section 11.2 of the Administrator Manual has more details on working with support.

0.4 Getting Professional Services

Bright Computing normally differentiates between professional services (customer asks Bright Computing to do something or asks Bright Computing to provide some service) and support (customer has a question or problem that requires an answer or resolution). Professional services can be provided after consulting with the reseller, or the Bright account manager.
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 behind the networking of legacy and current cloud instances supported by Bright Cluster Manager on the Amazon VPC infrastructure.
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
- 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).
By default, on login, the management console displays a list of accessible Amazon web services, including the Elastic Compute Cloud (EC2) (figure 2.2):

To set up the Cluster On Demand cluster, the EC2 service within the Compute 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).
2.1 Cluster On Demand: Launching The Head Node From The Cloud Provider

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](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).
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. From Bright Cluster Manager 7.3 onward, only AMIs that use hardware virtualization (hvm) type AMIs are supported, due to advances in hardware technology which have made paravirtualization (pvm) type AMIs less popular.

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

- **Step 2:** Choose an Instance Type: This displays a t2 micro instance by default (figure 2.5).
The t2.micro is one of the smallest and least powerful type of instances that a head node can run as, and is only useful for quite minor testing. It is likely to be overwhelmed when doing any significant work—even provisioning a regular cloud node from a t2.micro head node results in resource exhaustion. A more reasonable node type to use for testing is therefore the t2.medium type, which is an Amazon type that is part of their General purpose family.

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:** spot instances can be requested (section 5.3.1)
  
  - **Network:** A VPC-defined network owned by the user can be selected
  
  - **Subnet:** A subnet that is associated with an availability zone can be chosen, if preferred. 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**

  ```
  [bright73->cloud(Spare Capacity)]% set defaultavailabilityzone
  ```

  - **Auto-assign Public IP:** Enables or disables public IP addresses. Enabling this allows the administrator to connect to the instance via an ssh client, so it should be enabled.
Clustering On Demand Cloudbursting

- **Shutdown behavior:** This decides if the instance should be stopped (kept around in the cloud, but in a shutdown state) or terminated (removed from the cloud itself) when a shutdown command is given to the instance within the instance.

- **Step 4: Add Storage:** Among other storage options, this optional step allows the following options to be set:
  - **Size (GiB):** The size of storage to be added to the instance.
  - **Volume Type:** Whether the storage is Magnetic, Provisioned SSD, or General Purpose SSD.
  - **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:** All SSH inbound is allowed. This means that cmsh can be used to control the Cluster On Demand cluster via SSH just like a regular cluster.

It is a good idea, for security reasons, to restrict the source addresses allowed for inbound SSH. Changing it from 0.0.0.0/0, to instead be the IP address of the source for the current connection to the website should make sense for initial testing purposes. The change can be selected by choosing the My IP option from the Custom options of the Source column.

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 from anywhere via its custom protocol with the default CMDaemon back end on the head node.

The default security group setting should be restricted by the administrator 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.

If coming straight from step 2, then a warning is displayed, which says that the instance is reachable from any IP address on the internet. Typically, a restriction should be placed by the user on the source addresses that can reach the instance. The source address is typically changed by the user from the default IP address of 0.0.0.0/0, to the IP address of the user.

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

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).
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:

- a browser-based Java SSH client, MindTerm
  There is further documentation on this at:

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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.

![Connect To Your Instance](image)

**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, selecting the **Instance Settings** sub-menu, 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.

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2.2 Cluster On Demand: Head Node Login And Cluster Configuration

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 `cm-bright-setup` script be run:

**Example**

```bash
pj@office:~$ ssh -i pjkeypair.pem root@ec2-176-34-160-197.eu-west-1.com
```

```
The authenticity of host ‘ec2-176-34-160-197.eu-west-1.compute.amazonaws.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.amazonaws.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

```
cm-bright-setup
```

and follow the instructions

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

Running the `cm-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 cm-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 ~]# cm-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
```

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2.2 Cluster On Demand: Head Node Login And Cluster Configuration

<table>
<thead>
<tr>
<th>Amazon account information</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS username (I for information): <a href="mailto:exampleuser@brightcomputing.com">exampleuser@brightcomputing.com</a></td>
</tr>
<tr>
<td>AWS Account ID (I for information): 313234312222</td>
</tr>
<tr>
<td>Access Key ID (I for information): OUPOUASOUDSSAOU</td>
</tr>
<tr>
<td>Secret Access Key (I for information): Aighei8EooLi1Dae8Nio5ohl4ieXiAlaiV</td>
</tr>
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</table>

Verifying Amazon credentials

<table>
<thead>
<tr>
<th>Bright License</th>
</tr>
</thead>
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<tr>
<td>Bright Product Key (I for information): 423112-231432-134234-132423-134221</td>
</tr>
<tr>
<td>Country: US</td>
</tr>
<tr>
<td>State: CA</td>
</tr>
<tr>
<td>Locality: San Francisco</td>
</tr>
<tr>
<td>Organization name: Bright Computing</td>
</tr>
<tr>
<td>Organizational Unit: Development</td>
</tr>
<tr>
<td>Cluster Name: demo-cluster</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Head Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hostname: bright73</td>
</tr>
<tr>
<td>Administrative Password:</td>
</tr>
<tr>
<td>Verify password:</td>
</tr>
<tr>
<td>Do you want to create a second drive for more storage capacity? (I for information) [YES</td>
</tr>
<tr>
<td>Extra storage for /home (I for information)? [NO</td>
</tr>
<tr>
<td>Extra storage for monitoring data (I for information)? [NO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compute Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instance Type (I for information):</td>
</tr>
<tr>
<td>m1.small</td>
</tr>
<tr>
<td>m1.medium</td>
</tr>
<tr>
<td>c1.medium</td>
</tr>
<tr>
<td>m1.large</td>
</tr>
<tr>
<td>t1.micro</td>
</tr>
<tr>
<td>m2.xlarge</td>
</tr>
<tr>
<td>m2.2xlarge</td>
</tr>
<tr>
<td>m2.4xlarge</td>
</tr>
<tr>
<td>c1.xlarge</td>
</tr>
<tr>
<td>[t1.micro]</td>
</tr>
<tr>
<td>Node Count [2]: 2</td>
</tr>
<tr>
<td>Base name (I for information) [cnode]: cnode</td>
</tr>
<tr>
<td>Instances of type t1.micro need to use EBS storage</td>
</tr>
</tbody>
</table>
Size of EBS (GB) [40]: 15
Do you want to configure more node types? [NO|yes] no

<table>
<thead>
<tr>
<th>Workload Management system</th>
</tr>
</thead>
</table>
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: 31323431222
  Access Key ID: OUPOUASOUDSSSAOU
  Secret Access Key: Aighe18EooLil1Dae8N1o5oh14ieXiAin5eeRoaiV
  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: bright73
  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

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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 `cm-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](image)

- 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

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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 cm-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 cm-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).
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
```
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@bright73 ~]# cmsh -c "main; licenseinfo"
  License Information
  -----------------------------------------------------
  Licensee /C=US/ST=NY/L=WS/O=Bright
  Bitcoins/OU=Unit/CN=Bright 7.3 Cluster
  Serial Number 19305
  Start Time Mon Dec 20 00:00:00 2015
  End Time Wed Jun 20 00:00:00 2018
  Version 7.3
  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 simply running the `request-license` command with the product key should in most cases provide activation. Further details on activating the license are in section 4 of the *Administrator Manual*.

- Registration of the product key.
  
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 Cluster Extension Setup Wizard.

The wizard goes through the following stages:

1. Introduction (section 3.1.1)
2. AWS Credentials (section 3.1.2)
3. Select Regions (section 3.1.3)
4. Summary & Deployment (section 3.1.4)
5. Deploy (section 3.1.5)
3.1 Cluster Extension: Cloud Provider Login And Cloud Director Configuration

### 3.1.1 Introduction

The first screen displayed by the wizard is the introduction screen (figure 3.1), which reminds the administrator about the prerequisites for cloud bursting.

![Figure 3.1: Introduction Page For Cluster Extension With cmgui](image)

The Show, Save, and Load buttons allow the wizard to show, save, or load a YAML configuration text file. Saving a configuration at the start or end of a wizard run is usually convenient for an administrator.

### 3.1.2 AWS Credentials

The Next button brings up the credentials page, if the credentials for the cluster extension cloudburst are not yet known to CMDaemon (figure 3.2).

![Figure 3.2: AWS Key Configuration For Cluster Extension With cmgui](image)
This asks for:

- **Provider Name:** This is can be any user-defined value. If using Amazon, it would be sensible to just put in *amazon*.
- **AWS Access key ID:** The AWS Access key. Typically a string that is a mixture of upper case letters and numbers.
- **AWS Secret key:** The AWS secret key. Typically a longer string made up of alphanumeric characters.

In the case of Amazon, the information is obtainable after signing up for Amazon Web Services (AWS) at [https://console.aws.amazon.com/iam/home#security_credential](https://console.aws.amazon.com/iam/home#security_credential).

The “show password” checkbox toggles the visibility of the sensitive input. The Validate credentials checkbox, if ticked, validates the credentials at this point of the configuration when Next is clicked, instead of waiting until the actual deployment. Clicking the Next button submits the details of this screen, and inputs for the next screen are then retrieved from Amazon.

### 3.1.3 Select Regions

If all goes well, the next screen (figure 3.3) displays region selection options for the Amazon cloud service.

![Select Regions](image)

**Figure 3.3: Selecting Regions For The Cluster Extension Wizard With cmgui**

Regions are designated by codes, for example *us-east-1, eu-west-1*, and so on. The following are implied by the first two letters associated with the region:

- **us:** United States
- **eu:** Europe
- **ap:** Asia Pacific
- **sa:** South America
• **ca**: Canada

In addition, the special `us-gov` prefix designates a region that helps customers comply with US government regulations.

Similarly, European data regulations may, for example, mean that data should be processed only within an `eu` region.

Other than legislative considerations, choosing capacity from a region that is geographically closer is often sensible for avoiding lag with certain applications. On the other hand, using off-peak capacity from a geographically distant location may make more sense if it is cheaper.


After the administrator has selected the regions that are to be used in deployment, the Next button can be clicked, to bring up the next screen.

### 3.1.4 Summary & Deployment

The next screen is a **Summary** screen (figure 3.4).

|-----------------|--------------------|-------------------|-------------------------|-----------|

![Summary](image)

**Overview:**
- **Provider:** Amazon
- **Account ID:** 13767739600
- **Username:** bright\#av
- **Default Region:** eu-west-1
- **Default cloud director type:** m3.medium
- **Default cloud node type:** m3.medium
- **VPC regions:** eu-central-1

Automatically deploying the configuration will take several minutes, during which a log window will be shown displaying the progress of the deployment:

- Press ‘Deploy’ to start deployment.
- Press ‘Cancel’ to close the wizard (no changes will be introduced).
- Press ‘Save’ to get the Cluster Extension configuration as YAML.

**Figure 3.4: Summary Screen For The Cluster Extension Wizard With cmgui**

It summarizes the selections that have been made, and lets the administrator review them. The selections can be changed, if needed, by going back to the previous screens. Otherwise, on clicking the Deploy button, the configuration is deployed.

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3.1.5 Deploy

During configuration deployment, a progress meter indicates what is happening as the configuration is processed. At the end of processing, the display indicates that the cluster has been extended successfully (figure 3.5).

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 Startup From Scratch

The cloud director can take some time to start up the first time when it is installing from scratch. 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 10.6 of the Administrator Manual).

This bottleneck is one of the reasons why the cloud director is put in the cloud in the first place: nodes are provisioned from a cloud director in the cloud faster than from a head node outside the cloud.

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The bottle of provisioning from the head node to the cloud director is an issue only the first time around. 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 reason why powering up after the first time is faster is because the image that is to power up is already in the cloud. A similar principle—of relying on data already available with the cloud provider—can be used as a technique to make first time startup even faster. The technique is to have a pre-built image—a snapshot—of the cloud director stored already with the cloud provider. The first-time startup of a cloud director based on a snapshot restoration is discussed in section 3.4.

The remainder of this section is about starting up a cloud director from scratch—that is, a first time start, and without a pre-built image.

To recap: by default, a cloud director object is created during a run of the Cluster Extension Setup Wizard (section 3.1).

Further cloud director objects can be created by accessing the Cloud Nodes resource, then selecting the Overview subtab, and then clicking on the Add Cloud Director button, which carries out a run that is a subset of the Cluster Extension Setup Wizard.

Once a cloud director object has been made in CMDaemon, then the cloud director is ready to be started up. 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.

As indicated in the preceding discussion, the cloud director acts as a helper instance in the cloud. It provides 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 the cloud director 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.

### 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 so-called ephemeral devices. Ephemeral means that the device is temporary, and means that whatever is placed on it is lost if the instance is stopped, terminated, or if the underlying disk drive fails.

   Some instances have ephemeral storage associated with the instance type. For example, at the time of writing (July 2016), the m3.medium type of instance has 4GB of SSD storage associated with it. Details on instance storage can be found at [http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/InstanceStorage.html#instance-store-volumes](http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/InstanceStorage.html#instance-store-volumes).

2. **Elastic Block Storage (EBS) volumes**: EBS is a persistent, reliable, and highly available storage. 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 is stopped or terminated.
• instance storage is not available for many instance types such as t2.micro, t2.small, c4.large.

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 rare 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

[bright73]% device use us-east-1-director
[bright73->device[us-east-1-director]]% cloudsettings
[bright73->device[us-east-1-director]->cloudsettings]% storage
[bright73->...->cloudsettings->storage]% list
<table>
<thead>
<tr>
<th>Type</th>
<th>Name (key)</th>
<th>Drive</th>
<th>Size</th>
<th>Volume ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>ebs</td>
<td>ebs</td>
<td>sdb</td>
<td>42GB</td>
<td></td>
</tr>
<tr>
<td>ephemeral</td>
<td>ephemeral0</td>
<td>sdc</td>
<td>0B</td>
<td>ephemeral0</td>
</tr>
</tbody>
</table>
[bright73->...->cloudsettings->storage]% remove ebs
[bright73->...->cloudsettings->storage]% set ephemeral0 drive sdb
[bright73->...->cloudsettings->storage]% list
<table>
<thead>
<tr>
<th>Type</th>
<th>Name (key)</th>
<th>Drive</th>
<th>Size</th>
<th>Volume ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>ephemeral</td>
<td>ephemeral0</td>
<td>sdb</td>
<td>0B</td>
<td>ephemeral0</td>
</tr>
</tbody>
</table>
[bright73->...->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 Startup

**Tracking Cloud Director Startup 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**

  ```
  [bright73]% device use us-east-1-director
  [bright73->device[us-east-1-director]]% get cloudid
  i-f98e7441
  [bright73->device[us-east-1-director]]% cloudsettings
  [bright73->device[us-east-1-director]-cloudsettings]% get instanceid
  i-f98e7441
  ```

**Tracking Cloud Director Startup 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 Startup 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@bright73 ~]# ps uww -C rsync | cut -f11 -d" " 11th part onwards
/cm/shared/ syncer@172.21.255.251::target//cm/shared/
```
Tracking Cloud Director Startup From cmsh:

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

**Example**

```
[root@bright73 ~]# 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@bright73 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s): 4
Source node: bright73
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@bright73 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s): 5
Source node: bright73
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 Startup From Scratch

This section discusses the configuration of regular cloud node startup from scratch. Configuration of cloud node startup from snapshot is discussed in section 3.4.

To configure the regular cloud nodes does not require a working cloud director. However to boot up the regular cloud nodes does require that the cloud director be up, and that the associated networks to the regular cloud nodes and to the head node be configured correctly.

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 155 of the Administrator Manual) values, in order to create a provisioning hierarchy.

Creation and configuration of regular cloud node objects is conveniently carried out with the “Create Cloud Nodes” wizard button in cmgui. 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.

By default, the first screen of the wizard (figure 3.6)

allows configuration of these cloud node properties:

- **Region**: The region where the clusters are launched
- **Type**: The cloud node instance type. By default m3.medium
- **Category**: A category of cloud-node is available as the default cloud node category.
- **First node**: The name of the first additional cloud node to be created in the node sequence. The nodes follow a default naming convention of `<region-code>-cnode<3-digit-number>`. For example: `eu-central-1-cnode020`.
- **Last node**: The name of the last additional cloud node to be created in the node sequence.
- **Storage**: The storage type (EBS or Ephemeral), and instance family type.

The next screen (figure 3.7) sets the network interfaces for a cloud node.
The internal network for the regular cloud nodes is by default set to the VPC private network, and is somewhat similar to the internal network for regular nodes. The VPC private network can be contrasted with the VPC public network for cloud directors, which is a network that is by default assigned to cloud directors, and which floating IP addresses can connect to. Both the VPC private and VPC public networks are subnets of a cloud network. If the administrator would like to do so, the regular cloud nodes can be placed in the VPC public network and become directly accessible to the public.

The next screen displays a summary of the cloud nodes wizard configuration (figure 3.8)

Clicking on `OK` carries out the configuration of the cloud node objects, and the wizard dialog vanishes. In the `Overview` screen, the configuration change can then be saved by clicking on the `Save` button.

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.

### 3.4 Cluster Extension: Cloud Director And Cloud Node Startup From Snapshots

A technique that speeds up cluster deployment in the cloud is to use snapshots to start up the nodes in the cloud. Snapshots are snapshots of a shutdown state, and are stored by the cloud provider. In Amazon, they can be stored in EBS. It is cheaper to keep a machine in a stored state, rather than have it up but idling. Restoring from a snapshot is also significantly faster than starting up from scratch, due to optimizations by the cloud provider. An administrator should therefore get around to looking at using snapshots once cloudbursting is set up and the usage pattern has become clearer.

As a part of regular maintenance, snapshot configuration can be repeated whenever cloud director
and cloud node files change significantly, in order to keep usage efficiency up.

3.4 Cluster Extension: Cloud Director And Cloud Node Startup From Snapshots

3.4.1 Cloud Director Startup From Snapshots

Cloud Director Snapshot Preparation

A cloud director, for example *us-east-1-director*, can have a snapshot of its state prepared as follows by the administrator:

- The cloud director is started up from scratch (section 3.2)
- After it comes up for the first time, the administrator shuts it down cleanly. For example, with a command similar to `cmsh -c "device use us-east-1-director; shutdown"`
- After the cloud-director shutdown is complete, the administrator creates a snapshot of a cloud director using the EC2 Management Console. This can be done by selecting Elastic Block Store in the navigator column, then selecting the Volumes item within that menu. The volume associated with the cloud director can be identified by matching the Attachment Information column value with the name *us-east-1-director* for this node, and the device to be snapshotted. In a default configuration, the device is `/dev/sdb` at the time of writing, but that may change. The Actions button in the main pane then provides a Create Snapshot item (figure 3.9).

![Figure 3.9: Creating A Snapshot From A Selected Volume](image)

Using it creates a snapshot of a selected volume instance via a dialog. The snapshot ID is displayed at the end of the snapshot creation dialog, and should be noted for CMDaemon use later on, where it is saved as the value of `snapshotid`.

Created snapshots can be viewed within the Snapshots item of the Elastic Block Store menu.

Cloud Director Launch From Prepared Snapshot

To allow CMDaemon to launch the cloud director from the snapshot, the following procedure can be followed:

- The instance must be terminated so that the snapshot can actually be used by the instance on starting it again:

  **Example**
The snapshot ID that was noted earlier during snapshot preparation is set in the EBS storage setting configuration of the CMDaemon database, using a session similar to:

Example

```
[root@bright73 ~]# cmsh
[bright73]% device
[bright73->device]% use us-east-1-director
[bright73->device[us-east-1-director]]% cloudsettings
[bright73->...-director]->cloudsettings]% storage
[bright73->...-director]->cloudsettings->storage]% use ebs
[bright73->...-director]->cloudsettings->storage[storage[storage]]% set snapshotid snap-2a96d0c6
```

The cloud director can now be powered on:

Example

```
[bright73->device[us-east-1-director]]% power on
```

The cloud director now starts up much faster than when starting up from scratch.

### 3.4.2 Cloud Node Startup From Snapshots

When a regular cloud node is launched from scratch (section 3.3), it uses the cloud director for provisioning, rather than a node outside the cloud, because this is faster. However, having the cloud director create an EBS volume from its storage in the cloud, and then providing the image to the cloud compute nodes still involves a lot of data I/O. On the other hand, a cloud provider such as Amazon can optimize many of these steps when creating an EBS volume from a snapshot, for example, by using copy-on-write. This means that snapshot-based provisioning is even speedier than the non-snapshot, “from scratch” method.

If the administrator wants to make a snapshot that can be used as the base for speedily launching regular cloud nodes, then the same snapshot method that is used for cloud directors (section 3.4.1) should be followed to make a snapshot for a regular cloud node.

A summary of the steps that can be followed is:

- a regular cloud node is started up from scratch (section 3.3), after the cloud director is up
- after the regular cloud node has come up, it is shut down cleanly
- a snapshot is created of the cloud node using the EC2 Management Console
- the cloud node is terminated
- the snapshot ID is set:

Example

```
[bright73->device[cnode001]->cloudsettings->storage[storage]]% set snapshotid snap-5c9s3991
```

Powering on the node now launches the regular cloud node much faster than the non-snapshot method.

CMDaemon ensures that a snapshot for one cloud node can be used by other cloud nodes too, if the disk partitioning is the same. This is useful when launching cloud nodes that do not differ much from the snapshot.

It also means that even the cloud director image can be used as a snapshot to launch a regular cloud node, if the disk partitioning and other settings allow it. However, using a regular node snapshot for launch is usually much wiser, due to the extra filesystems that a cloud director has.
Cloudbursting Using The Command Line And \texttt{cmsh}

The command line and \texttt{cmsh} can be used to set up Cluster On Demand and Cluster Extension clusters.

\section*{4.1 The \texttt{cm-cluster-on-demand-aws} Script For Cluster On Demand Cloud Clusters}

For Cluster On Demand setups, the use of a GUI web browser is described in Chapter 2, where it is used to launch the cloud head node AMI from Amazon. Once an \texttt{ssh} connection is made by the administrator to the cloud head node, cloudbursting can be continued from command line. Thus, the \texttt{cm-bright-setup} script is run from the command line on the cloud head node, as in section 2.2, and the regular cloud nodes can then be powered up from the command line as in section 2.4.

For Amazon Web Services, the \texttt{cm-cluster-on-demand-aws} script automates the entire process from a machine the Bright Cluster Manager cloud head node, so that a GUI web browser procedure is no longer needed, and the \texttt{cm-bright-setup} no longer needs to be run separately within the cloud head node. The \texttt{cm-cluster-on-demand-aws} is part of Bright Cluster Manager’s \texttt{cluster-tools} package.

\subsection*{4.1.1 \texttt{cm-cluster-on-demand-aws} Command Options Overview, Help Files}

The main help text for the \texttt{cm-cluster-on-demand-aws} utility is:

```
[root@bright73 ~]# cm-cluster-on-demand-aws -h
usage: cm-cluster-on-demand-aws [-h] [-c C [C ...]] [-v] [-vv] [-vvv] ...
```

Cluster on demand by Bright Computing

\begin{description}
\item[optional arguments:] 
- \texttt{-h, --help} show this help message and exit
- \texttt{-c C [C ...]} Config file path. You can specify multiple files to overlay them on each other.
- \texttt{-v, --verbose} Generate verbose output
- \texttt{-vv} Generate very verbose log output
- \texttt{-vvv} Generate extremely verbose log output
\end{description}

\begin{description}
\item[Top-level commands:] 
- \texttt{cluster} Manage clusters
- \texttt{image} Manage Images
- \texttt{config} Manage runtime configuration of the tool
\end{description}

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Further help for the commands is displayed using the \texttt{-h|--help} option for each command. The commands can carry out the following tasks:

- **The `cluster` command:** The following subcommands under this command are used to manage clusters:
  - `create`: creates a new cluster (in default region)
  - `delete`: deletes all resources in a cluster
  - `list`: list clusters (in default region)
  - `start`: start head node instances for clusters
  - `stop`: stop all instances for clusters

- **The `image` command:** The following subcommand under this command is used to manage an image:
  - `list`: List available Bright head node images (in default region)

- **The `config` command:** The following subcommands under this command are used to manage a configuration:
  - `dump`: output an example configuration
  - `dump --run-time`: display configuration that will be used after loading environment, configuration files, arguments, and overlaying, as a format compatible with a configuration file
  - `show`: display configuration that will be used after loading environment, configuration files, arguments, and overlaying, as a plain list of key-value pairs.

Yet further help is available for each subcommand with the \texttt{-h|--help} option, which shows the usage along with a large list of possible options. The help output is truncated in the text that follows.

**Example**

```
[root@bright73~]# cm-cluster-on-demand-aws cluster create -h
usage: cm-cluster-on-demand-aws cluster create
    [-h]
```

© Bright Computing, Inc.
Create a new cluster in amazon VPC

positional arguments:
  name  Name of the cluster (VPC) to create

optional arguments:
  -h, --help  show this help message and exit
  --aws-username AWS_USERNAME
    AWS Username [AWS_USERNAME]
  --aws-account-id AWS_ACCOUNT_ID
    AWS Account ID. This value should be enclosed in 'quotes' [AWS_ACCOUNT_ID]
  --aws-access-key-id AWS_ACCESS_KEY_ID

In the optional arguments in the preceding help text, the parameters indicated in the form of

```
$parameter
```

such as $AWS_USERNAME and $AWS_USERNAME, are environment variables that can be set for a session

with, for example

```bash
export AWS_USERNAME=me@example.com
```

### 4.1.2 cm-cluster-on-demand-aws Configuration Options, YAML Configuration Files, And Environment Variables

To avoid having to specify a large number of options, a YAML configuration file can be used to provide

the settings. The cm-cluster-on-demand-aws config dump command displays a configuration file template.

The top of the dumped display suggests how an administrator can set a configuration file under the

`/etc` directory. It also suggests how a user can, in the home directory of the user, create a configuration

file `cm-cluster-on-demand.conf`, or can create several overlayable files under a directory

`cm-cluster-on-demand.d`, or can set up and use arbitrarily-named configuration files. Environment

variables and command line flags can also be used to load configurations. A truncated example of the

dump looks like:

**Example**

```bash
# To load it:
# use `--c <path>` to load it, or
# put it in `~/cm-cluster-on-demand.conf` (it will be loaded automatically), or
# put it in `~/cm-cluster-on-demand.d` (it will loaded automatically and overlaid)
#
# Tip: You can have a basic config file, and then overlay other config file on top of it
```

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e.g. have ~/cm-cluster-on-demand.conf with your base settings, and then use
'–c' to load cluster specific settings.

Tip: If you use multiple config files, run the tool with ‘–v’ to see
from which file exactly your runtime values come from

Tip: You can combine config files for different cloud providers (OpenStack and AWS)
in a single file

Config files load order:
- /etc/cm-cluster-on-demand.conf
- /etc/cm-cluster-on-demand.d/*
- ~/cm-cluster-on-demand.conf
- ~/cm-cluster-on-demand.d/*
- Environment Variables
- config files provided with ‘–c <path> [<path2>, ...]’
- command line flags

aws:
  # Licence unit
  # default: not specified
  #license_unit: not specified

  # Licence locality
  # default: not specified
  #license_locality: not specified

  # Two characters
  # default: US
  #license_country: US

...
The configuration administrator may, for example, set a configuration under `/etc/`, which the user may override with their configuration in their home directory.

The command `cm-cluster-on-demand-aws config dump --with-runtime` displays

- explicitly set values
- overriding values from elsewhere in the loading hierarchy
- default values that are still at their defaults from the dumped template. The template being the one that can be obtained by executing `cm-cluster-on-demand-aws config dump`.

In other words, the `--with-runtime` option displays, unsurprisingly, what one can call the actual runtime values. This can be useful to make it clear what configuration is active. The `-v|--verbose` option can incidentally provide further insight into what is happening with configuration lookups, when launching a cluster (section 4.1.3).

### 4.1.3 cm-cluster-on-demand-aws: Launching A Cluster

The `cm-cluster-on-demand-aws` utility can launch one, or several clusters in parallel, as follows:

**Example**

```bash
cm-cluster-on-demand-aws cluster create acluster, anothercluster
```

If the preceding command fails due to missing values in the configuration file, or missing command line configuration parameters, then cluster creation does not take place, and a message similar to the following is shown:

**Example**

```bash
The following config values are not set: license_product_key, cluster_password, aws_username, aws_account_id, aws_access_key_id, aws_secret_key, ssh_key_pair, ssh_private_key_path.
You should generate and fill out the config file with
/cm/local/apps/cluster-tools/bin/cm-cluster-on-demand-aws config dump > ~/cm-cluster-on-demand.conf
```

If the `cm-cluster-on-demand-aws` utility is run successfully with the `create` command as in the preceding example, then the `cm-bright-setup` script is run automatically by default, as defined by default in the `--run-cm-bright-setup` option. The default number of regular cloud nodes that are configured by the script is set to 5. The regular cloud nodes can be started up with a `power on` command run from the head cloud node in the cloud. More cloud nodes can be cloned and started up as required, just like in regular non-cloud clusters.

The output from a creation run looks something like this (some output elided or truncated):

**Example**

```bash
[root@bright73 ~]# cm-cluster-on-demand-aws cluster create acluster -c anotherconf
16:23:03: INFO: ---------------------------------------------------------------------
16:23:03: INFO: Image name: ami-095a387a
16:23:03: INFO: Head nodes: 1 (m3.medium)
16:23:03: INFO: Nodes: 5 (m3.medium)
16:23:03: INFO: ---------------------------------------------------------------------
16:23:04: INFO: Setting up VPC
16:23:04: INFO: Creating VPC for acluster in eu-west-1...
16:23:04: INFO: Adding internet connectivity...
16:23:04: INFO: Creating public subnet...
16:23:05: INFO: Creating head node (m3.medium)... 
16:23:06: INFO: Done setting up VPC for acluster.
```

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INFO: Starting head nodes...
INFO: Wait for head nodes running...
INFO: Starting bright setup...
INFO: Waiting for ssh connection availability... ssh root@52.208.149.137...
INFO: SSH connection timeout...
INFO: Retrying SSH connection attempt in 15 seconds...
INFO: Connection succeeded!
INFO: Wait for cloud-init to finish...
INFO: Cloud-init completed!
INFO: Starting cm-bright-setup...
INFO: stdout Please wait...
INFO: stdout Executing 23 stages
INFO: stdout ####### Starting execution for 'Bright...
INFO: stdout ## Progress: 82
INFO: stdout #### stage: brightsetup: Start CMDaemon
INFO: stderr Created symlink from /etc/systemd/system/multi-user.target....
INFO: stdout ## Progress: 86
INFO: stdout #### stage: brightsetup: Restore MOTD
INFO: stdout ## Progress: 91
INFO: stdout #### stage: brightsetup: Restore Bash RC
INFO: stdout ## Progress: 95
INFO: stdout #### stage: brightsetup: Setup Periodic File...
INFO: stdout #### stage: brightsetup: Setup Periodic File...
INFO: stdout tune2fs 1.42.9 (28-Dec-2013)
INFO: stdout Setting interval between checks to 15552000 seconds
INFO: stdout Setting time filesystem last checked to Thu Aug 4 16:28:52...
INFO: stdout Took: 03:41 min.
INFO: stdout Progress: 100/100
INFO: stdout Finished execution for 'Bright ...
INFO: stdout Bright Setup finished!
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: stdout
INFO: Time it took: 06:07
INFO: SSH string: ssh root@52.208.149.137 -i /root/eukeypair.pem

4.1.4 cm-cluster-on-demand-aws: Stopping And Terminating The Cluster

When using cm-cluster-on-demand-aws, stopping the cluster with the stop command means that the cluster is stopped, and that its objects remain in existence. Deleting the cluster with the delete command with a specific configuration means that the specified clusters are terminated, and the associated objects removed:

Example

[root@bright73 ~]# cm-cluster-on-demand-aws cluster delete acluster -c anotherconf
This will destroy VPCs for acluster, continue?
Proceed? [yes/no] yes
4.2 The `cm-cluster-extension` Script For Cluster Extension Clusters

4.2.1 Running The `cm-cluster-extension` Script On The Head Node For Cluster Extension Clusters

The `cm-cluster-extension` script is run from the head node. It is a part of the Bright Cluster Manager `cluster-tools` package. It allows cloud bursting to be carried out entirely from the command line for Cluster Extension setups. It is a command line way of carrying out the the configuration carried out by the GUI steps of section 3.1 for cloud provider login and cloud director configuration. After the script has completed its setup, then `cmsh` power commands can launch the required cloud nodes (sections 4.2.2 and 4.3).

The `cm-cluster-extension` script can be run in plain dialog mode (page 41), or as an `Ncurses` dialog (page 43).

Running The `cm-cluster-extension` Command Line Options

The administrator can specify command line options to `cm-cluster-extension`, as shown in its help text. The help text is displayed with the `-h|--help` option:

```
[root@bright73 ~]# cm-cluster-extension -h
Please wait...
Found an optional config file, '/root/cm-setup.conf'. Will attempt to load it.
usage: cm-cluster-extension
       [-v] [-h] [-c <config_file>]
       [--skip-modules <mod1,mod2,...>
       [--only-these-modules <mod1,mod2,...>]
       [--dev] [--tests]
       [--undo-on-error]
       [--output-remote-execution-runner]
       [--json-output <path_to_file>]
       [--remove [--yes-i-know-this-is-dangerous-for-this-cluster <headnode_hostname>]]
       [--test-networking]
       [--test-environment]
       [--test-configuration]
       [--test-everything]
```

class common:
Common arguments

- `-v` Verbose output
- `-h, --help` Print this screen
- `-c <config_file>` Load runtime configuration for modules from a YAML config file

advanced:
Various *advanced* configuration options flags.

--skip-modules <mod1,mod2,...>
Load and use all the default modules (cloudstorage, clusterextension), except for these. Comma-separated list.

--only-these-modules <mod1,mod2,...>
Out of all default modules, load and use only these. Comma-separated list.

--dev
Enables additional command line arguments

--tests
Test integrity of the utility by running Unit Tests

--undo-on-error
Upon encountering a critical error, instead of asking the user for a choice, setup will undo (revert) the deployment stages.

--output-remote-execution-runner
Format output for CMDaemon

--json-output <path_to_file>
Generate a file containing json-formatted summary of the deployment

Removing cluster extension:
Flags which can be used for removing AWS integration

--remove
Remove definitions of all objects required for cluster extension, e.g. cloud nodes, directors, cloud networks and cloud interfaces

--yes-i-know-this-is-dangerous-for-this-cluster <headnode_hostname>
Additional confirmation

Testing cluster extension:
Flags which can be used for troubleshooting

--test-networking
Perform networking checks (e.g. check if API endpoints are reachable)

--test-environment
Run environment checks (e.g. if proper RPMs are installed)

--test-configuration
Run configuration checks, which check if cluster extension is properly configured (e.g. if cloud director has correct interfaces, if cloud credentials are valid, if CMDaemon can create/delete objects in the cloud)

--test-everything
Run all of the abovementioned checks.

Examples:

```
cm-cluster-extension (start interactive menu, wizard)
cm-cluster-extension -c <config> (configure bursting to AWS)
cm-cluster-extension --remove (remove bursting)
cm-cluster-extension --remove --force --yes-i-know-this-is-dangerous-for-this-cluster <hostname>
(removes bursting, no confirmation)

*WARNING* This will remove the cloud extension configuration. Any data located on your cloud nodes will be lost, unless you back up beforehand.
cm-cluster-extension --test-everything
```

This tool looks for, and uses if found, the following environment variables:
AWS_USERNAME, AWS_ACCOUNT_ID, AWS_ACCESS_KEY, AWS_SECRET_KEY

It can be run with the options directly (some output skipped):

**Example**

```
[root@bright73 ~]# cm-cluster-extension --test-networking
Please wait...
```

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Found an optional config file, ‘/root/cm-setup.conf’. Will attempt to load it.

Executing 26 stages

****************** Starting execution for ‘Running networking checks’

Connecting to CMDaemon
   - cloudstorage
   - clusterextension

#### stage: clusterextension: Testing tcp connection to ec2.us-east-1.amazonaws.com:443
#### stage: clusterextension: Testing tcp connection to ec2.us-west-1.amazonaws.com:443
...  
#### stage: clusterextension: Testing udp OpenVPN connectivity

Took:   00:09 min.

****************** Finished execution for ‘Running networking checks’, status: completed

Running networking checks finished!

**Running The cm-cluster-extension Ncurses Dialog**
The more user-friendly way to run cm-cluster-extension is to run it without options. This brings up the main screen for its Ncurses dialog (figure 4.1).

![Figure 4.1: Configuration Processing With cm-cluster-extension: Main Screen](image)

The option to add a new cloud provider can be selected from the main screen, and brings up a screen asking for the credentials of the cloud provider, Amazon, in figure 4.2.
After checking the credentials, the available regions are displayed (figure 4.3).

After selecting one or more regions, a choice is made to use a new or existing VPC for the region or regions (figure 4.4).
4.2 The `cm-cluster-extension` Script For Cluster Extension Clusters

Figure 4.4: Configuration Processing With `cm-cluster-extension`: VPC selection

A new VPC should normally be chosen for each region.
After having carried out VPC selection, the final screen is displayed (figure 4.5)

Figure 4.5: Configuration Processing With `cm-cluster-extension`: Final Screen

The final screen allows some further advanced configuration settings to be modified. Normally, an administrator would ignore the advanced settings, and should just save the configuration file, `<configuration file>`, and exit the Ncurses dialog. By default, the value of `<configuration file>` is set to `cm-cluster-extension.conf` in the home directory of the user.

To carry out the setup, the administrator should then run:

```
cm-cluster-extension -c <configuration file>
```

After `cm-cluster-extension` has run successfully, the cloud nodes (the cloud director and regular cloud nodes) can be launched.
4.2.2 Launching The Cloud Director For Cluster Extension Clusters

Launching the cluster in the cloud requires that the cloud director (section 3.2) 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. Alternatively, the cloud directors can be listed with:

Example

cmsh -c "device; list -c cloud-director"

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@bright73 ~]# 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. That is, that CMDaemon must have a representation of the cloud nodes, even if they do not yet exist on the cloud provider. The objects must each have an IP address assigned to them that is consistent with that of the cloud director that manages them. That is, the network address of the cloud nodes must be what the cloud director expects. 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. The management network chosen here is the region chosen from which the service is to be provided. Typically, the administrator chooses a network that is geographically near, or turns out to be cheap. A list of regions can be viewed with cmsh -c "cloud regions". The IP address chosen for the cloud director is a private network IP address which the cloud node can use to communicate with the cloud director.

Example
[root@bright73 ~]# cmsh
[bright73]$ device
[bright73]->device% add cloudnode cnode001
Warning: tunnel ip of cnode001 not set. This CloudNode will not start!
[bright73]->device*[cnode001*]% set managementnetwork eu-central-1
[bright73]->device*[cnode001*]% show
Parameter Value
---------------------- --------------------------

... Management network eu-central-1
Network eu-central-1 ...

[bright73]->device*[cnode001*]% interfaces
[bright73]->device*[cnode001*]->interfaces% list
Type Network device name IP Network
--------- --------------------- ----------- ------------------------
physical eth0 [dhcp] 0.0.0.0 vpc-eu-central-1-private
tunnel tun0 [prov] 0.0.0.0 eu-central-1
[bright73]->device*[cnode001*]->interfaces% set tun0 ip 172.16.0.1
[bright73]->device*[cnode001*]->interfaces% set tun0 network eu-central-1
[bright73]->device*[cnode001*]->interfaces% list
Type Network device name IP Network
--------- --------------------- ----------- ------------------------
physical eth0 [dhcp] 0.0.0.0 vpc-eu-central-1-private
tunnel tun0 [prov] 172.16.0.1 eu-central-1
[bright73]->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:

[bright73]->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:

[bright73]->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 ...
[bright73]->device% commit
Mon Apr 23 04:19:41 2012 [alert] cnode002: Check 'DeviceIsUp' is in state FAIL on cnode002
[bright73]->device%
Mon Apr 23 04:19:41 2012 [alert] cnode003: Check 'DeviceIsUp' is in state FAIL on cnode003 ...
Successfully committed 9 Devices
[bright73]->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**

[bright73]->device% power on -n cnode002..cnode010

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4.4 Submitting Jobs With \texttt{cmsub} And Cloud Storage Nodes, For Cluster Extension Clusters

The \texttt{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 \textit{User Manual}.

The \texttt{cmsub} command is available from the Bright Cluster Manager repository as part of the \texttt{cmdaemon-cmsub} package. The \texttt{cmsub} command needs the \texttt{cmsub} environment module (section 2.2 of the \textit{Administrator Manual}) to be loaded by the user before use. In addition, an administrator must assign the \texttt{cloudjob} profile (section 6.4 of the \textit{Administrator Manual}) to \texttt{cmsub} users.

Example

\begin{verbatim}
[root@bright73 ~]# cmsh
[bright73]% user use henry
[bright73->user[henry]]% set profile cloudjob; commit
\end{verbatim}

If the \texttt{cmsub} command is run by the user to submit a job, then the job is submitted to the workload manager, and the \textit{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 \textit{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 \texttt{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 \texttt{cmsub} has not yet been set up, or if it needs reconfiguration, then the following steps should be carried out:

1. The \texttt{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

   \begin{verbatim}
   [root@bright73 ~]# yum install cmdaemon-cmsub
   [...]
   [root@bright73 ~]# yum --installroot /cm/images/default-image install cmdaemon-cmsub
   [...]
   \end{verbatim}

2. The \texttt{cm-cloud-storage-setup} utility is run. Example runs are provided later, starting on page 49, but an explanatory background is given here first.

   The utility is part of the \texttt{cluster-tools} package, which is installed by default. The utility
   \begin{itemize}
   \item configures \texttt{cmsub} properties
   \item creates
   \begin{itemize}
   \item \texttt{templates} for \textit{cloud storage nodes}
   \item \texttt{storage policies} for \texttt{cmsub}
   \end{itemize}
   \end{itemize}
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 are 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 With cm-cloud-storage**

The cm-cloud-storage-setup is an Ncurses utility that configures cmsub properties for a cloud deployment. When run with the -h|--help option its usage is displayed:

```
[root@bright73 ~]# cm-cloud-storage-setup -h
Please wait...
Found an optional config file, '/root/cm-setup.conf'. Will attempt to load it.
usage: Cloud storage setup cm-cloud-storage-setup [-v] [-h] [-c <config_file>]
[---dev] [---tests]
[---undo-on-error]
[---output-remote-execution-runner]
[---json-output <path_to_file>]
[---remove]
```

**common:**

Common arguments

- `-v` Verbose output
- `-h, --help` Print this screen
- `-c <config_file>` Load runtime configuration for modules from a YAML config file

**advanced:**

Various *advanced* configuration options flags.

- `-dev` Enables additional command line arguments
- `-tests` Test integrity of the utility by running Unit Tests
- `-undo-on-error` Upon encountering a critical error, instead of asking the user for a
choice, setup will undo (revert) the deployment stages.
--output-remote-execution-runner
Format output for CMDaemon
--json-output <path_to_file>
Generate a file containing json-formatted summary of the deployment

Remove storage:
--remove Cleanup storage setup

The administrator is usually expected to run `cm-cloud-storage-setup` without arguments. This brings up the Ncurses-based dialog, which starts with an introductory page (figure 4.6):

![Figure 4.6: Cloud Storage Configuration Processing With cm-cloud-storage: Main Screen](image)

Continuing on brings up the network selection screen, which sets the network in which the cloud storage is to be placed (figure 4.7):

![Figure 4.7: Cloud Storage Configuration Processing With cm-cloud-storage: Network Selection](image)

After having selected the network, a category for the storage nodes is set (figure 4.8):

![Figure 4.8: Cloud Storage Configuration Processing With cm-cloud-storage: Category Selection](image)

It is recommended that a new category be created (figure 4.9):
4.4 Submitting Jobs With \texttt{cmsub} And Cloud Storage Nodes, For Cluster Extension Clusters

A bucket name can be set (figure 4.10):

It is recommended that a new queue be created for jobs that use the storage (figure 4.12):

The queues can be assigned to the cloud category (figure 4.13):
The summary screen allows the configuration to be saved and to be deployed (figure 4.14):

![Summary Screen](image)

If the configuration is to be saved, then the file path should be specified (figure 4.15):

![Save & Deploy Screen](image)

On exit, the saved configuration can be run with:

**Example**

```
[root@bright73 ~]# cm-cloud-storage-setup -c cm-cloud-storage-setup.conf
```

### 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, on loading the *cm-cloud-copy* module. 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, July 2016, 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-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*.
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:

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

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

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5.3.1 Spot Pricing
The spot price field is a mechanism to take advantage of cheaper pricing made available at irregular 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

[bright73]% device cloudsettings eu-west-1-director
[bright73->device[eu-west-1-director]->cloudsettings]% storage
[bright73->...->cloudsettings->storage]% set ebs size 15GB; commit
[bright73->...->cloudsettings->storage]% device cloudsettings cnode001
[bright73->device[cnode001]->cloudsettings]% storage
[bright73->...->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. 3.6) 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` node in cmsh:

```
[bright73->network]% list -f name:26,type:12,netmaskbits:8,baseaddress:13,domainname:24
```

<table>
<thead>
<tr>
<th>name (key)</th>
<th>type</th>
<th>netmaskbits</th>
<th>baseaddress</th>
<th>domainname</th>
</tr>
</thead>
<tbody>
<tr>
<td>us-east-1</td>
<td>Tunnel</td>
<td>16</td>
<td>172.21.0.0</td>
<td></td>
</tr>
<tr>
<td>externalnet</td>
<td>External</td>
<td>24</td>
<td>192.168.100.0</td>
<td>brightcomputing.com</td>
</tr>
<tr>
<td>globalnet</td>
<td>Global</td>
<td>0</td>
<td>0.0.0.0</td>
<td>cm.cluster</td>
</tr>
<tr>
<td>internenet</td>
<td>Internal</td>
<td>16</td>
<td>10.141.0.0</td>
<td>eth.cluster</td>
</tr>
<tr>
<td>netmap</td>
<td>NetMap</td>
<td>16</td>
<td>172.30.0.0</td>
<td></td>
</tr>
<tr>
<td>vpc-eu-central-1-private</td>
<td>Cloud (VPC)</td>
<td>17</td>
<td>10.42.128.0</td>
<td>vpc-eu-central-1.cluster</td>
</tr>
<tr>
<td>vpc-eu-central-1-public</td>
<td>Cloud (VPC)</td>
<td>24</td>
<td>10.42.0.0</td>
<td>vpc-eu-central-1.cluster</td>
</tr>
</tbody>
</table>

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 Infini-Band 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.

• Each node in a cloud network is also assigned an address in the network addressing space provided by Amazon VPC networking. The assignment of IP addresses to nodes within the 10.0.0.0/8 range is decided by Amazon via DHCP.

The VPC networks for regular cloud nodes and cloud director nodes are subnets in this range.

• 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.

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.
Legacy/Current Cloud Instances, And Their Network Addressing Allocations

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 at http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-vpc.html.

Bright Cluster Manager manages VPCs so that the administrator can focus on using them productively, instead of on working out VPC configurations. However, some background on how the integration is done may be useful for administrators that have special requirements, or who are migrating from a legacy Amazon cloud.

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

- EC2-Classic (page 59)
- EC2-VPC (page 60)
- classic cloud (page 60)
- default VPC (page 60)
- private cloud (page 60)
- custom VPC (page 60)
- elastic IP addresses (page 63)

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 is no longer supported by Bright Cluster Manager from version 7.3 onwards. It 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 classic cloud.
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 63) 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:

<table>
<thead>
<tr>
<th>Account Creation Date</th>
<th>Typical Platform Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before start of 2013</td>
<td>EC2-Classic only</td>
</tr>
<tr>
<td>In first half of 2013</td>
<td>EC2-Classic or EC2-VPC*</td>
</tr>
<tr>
<td>After first half of 2013</td>
<td>EC2-VPC only, in most or all regions</td>
</tr>
</tbody>
</table>

*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. This is not supported by Bright Cluster Manager from version 7.3 onwards.

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, but it is not supported by Bright Cluster Manager.

### 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:

\[ \text{private clouds} = \text{custom VPCs} + \text{defaultVPCs} \]

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, which is almost invariably true for Amazon VPCs nowadays, and an absolute truth as far as Bright Cluster Manager from version 7.3 onwards is concerned. So, as far as Bright Cluster Manager 7.3 onwards is concerned:

\[ \text{private clouds} = \text{custom VPCs} \]
6.1.5 Cloud Cluster Terminology Summary

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

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

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

From Bright Cluster Manager version 7.3 onwards, the EC2-classic platform is no longer available, and all nodes within the cloud provider always run within an EC2-VPC platform.

Custom VPC for Bright Cluster Manager 7.3 subnet allocation, and allocation of EIPs (External IPs) is described in sections 6.3.1–6.3.4.

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),

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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),

The `sipcalc` command (page 60 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-cluster-extension` utility (section 4.2),
2. by using the `cmgui` private cloud creation dialog box (section 3.1),
3. by manually creating and configuring the private cloud object using `cmsh`.

To create and configure option 3, a private cloud 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**

  ```
  [bright73->network]$ add vpc=0-sn-0
  [bright73->network*[vpc=0-sn-0*]]$ set type cloud
  [bright73->network*[vpc=0-sn-0*]]$ set baseaddress 10.0.0.0
  [bright73->network*[vpc=0-sn-0*]]$ set netmaskbits 24
  [bright73->network*[vpc=0-sn-0*]]$ set ec2availabilityzone eu-west-1a
  [bright73->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:
6.3 Setting Up And Creating A Custom VPC

Example

[bright73->network]% clone vpc-0-sn-0 vpc-0-sn-1
[bright73->network[vpc-0-sn-1%]]% set baseaddress 10.0.1.0
[bright73->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 60. It is of type ec2 and within a network that contains the two subnets specified earlier.

Example

[bright73->cloud[Amazon EC2]->privateclouds%]
[bright73->...->privateclouds%] add ec2privatecloud vpc-0
[bright73->...->privateclouds[vpc-0%]]% set region eu-west-1
[bright73->...[vpc-0%]]% set baseaddress 10.10.0.0
[bright73->...[vpc-0%]]% set netmaskbits 16
[bright73->...[vpc-0%]]% set subnets vpc-0-sn-0 vpc-0-sn-1
[bright73->...[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 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 60. It is of type ec2 and within a network that contains the two subnets specified earlier.

Elastic IP 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 pool 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 when the administrator decides to set it.

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

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Legacy/Current Cloud Instances, And Their Network Addressing Allocations

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

Example

```bash
[bright73->cloud[Amazon EC2]]% staticip release 54.215.158.42
Releasing static IP 54.215.158.42. Please wait...
Successfully released the static ip.
```

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, although the “public” network without an EIP allocation is just as private. Normally the “private” network is intended to be used for regular cloud nodes. It is also possible to move the regular cloud nodes to the “public” network, which is convenient if, for example, packets to the EIP is to be routed to the regular cloud nodes via NAT.

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.

For example, the cloud director node and regular cloud nodes can be configured inside the `us-west-1` network as follows:

Example

```bash
[bright73->device[us-west-1-director]->interfaces]% list
Type Network device name IP Network
------------ ------------------ -------- ------------
physical eth0 [dhcp] 0.0.0.0 vpc-us-west-1-public
tunnel tun0 [prov] 172.18.255.251 us-west-1
```
### 6.3 Setting Up And Creating A Custom VPC

```
[bright73]->device[us-west-1-cnode001]->interfaces]# list
Type      Network device name  IP         Network
---------- ---------------------- -----------------------
physical  eth0 [dhcp]          0.0.0.0     vpc-us-west-1-private
_tunnel_  tun0 [prov]          172.18.0.1  us-west-1
```