Bright Cluster Manager 7.3

# **Cloudbursting Manual**

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# Preface

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.

# 1

# Introduction

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

Bright Cluster Manager implements cloudbursting for two scenarios:

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

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

Chapter 4 looks at cloudbursting configuration using command line tools.

Chapter 5 discusses some miscellaneous aspects of cloudbursting.

Chapter 6 describes the concepts behind the networking of legacy and current cloud instances supported by Bright Cluster Manager on the Amazon VPC infrastructure.

2

# Cluster On Demand Cloudbursting

#### Requirements

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

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

#### Steps

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

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

These steps are now covered in more detail.

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

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

## 2.1.1 Getting To The "Launch Instance" Button

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



Figure 2.1: Logging Into The Amazon Management Console

By default, on login, the management console displays a list of accessible Amazon web services, including the *Elastic Compute Cloud* (EC2) (figure 2.2):



Figure 2.2: Amazon Management Console: Accessible Services

To set up the Cluster On Demand cluster, the EC2 service within the Compute 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).

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Services V Edit	「 <sup>1</sup> 7	Martijn de Vries 🕶	N. Virginia 🕶 Help 🕶						
EC2 Dashboard	Create Instance	Feedback							
■ INSTANCES Instances Spot Requests	To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.	Report an Issue							
Reserved Instances	Note: Your instances will launch in the US East (N. Virginia) region								
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Done			<b>B</b>						



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

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

## 2.1.2 Launching The Head Node Instance

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

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

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🎁 Services 🗸 Edit 🗸	Martijn de Vriet	s ▼ Ireland ▼ Help ▼
1. Choose AMI 2. Choose Instance Type 3	Configure Instance 4. Add Storage 5. Tag Instance 6. Configure Security Group	7. Review
Step 1: Choose an Amazon	Machine Image (AMI)	Cancel and Exit
An AMI is a template that contains the software can select an AMI provided by AWS, our user o	configuration (operating system, application server, and applications) required to lau ommunity, or the AWS Marketplace; or you can select one of your own AMIs.	unch your instance. You 🔺
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© 2008 - 2013, Amazon Web Services, Inc. or its affiliate	s. All rights reserved. Privacy Policy Terms of Use	Feedback

Figure 2.4: EC2: Choosing An AMI, Step 1

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

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Amazon EC: combination more about Filter by: Currently	Amaon EC2 provides a wide selection of instance types optimized to fit different use cases. Instances are virtual servers that can run applications. They have varying combinations of CPU, memory, storage, and networking capacity, and give you the flexibility to choose the appropriate mix of resources for your applications. Learn more about instance types and how they can meet your computing needs.  Filter by: All instance types  Current generation  Show/Hide Columns												
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🗨 Feed	back 🔇 English		© 2	:008 · 2016, Amazon	Web Services, Inc. or its affili	ates. All rights reserved.	rivacy Policy Terms of Use						

Figure 2.5: EC2: Choosing An AMI, Step 2

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.

- 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, 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).

Juice	an existing key pair or create a new key p	air >
A key pa they allov to obtain securely	r consists of a <b>public key</b> that AWS stores, and a <b>private key file</b> to you to connect to your instance securely. For Windows AMIs, the p the password used to log into your instance. For Linux AMIs, the prives SSH into your instance.	that you store. Together, rivate key file is required vate key file allows you to
Crea	ite a new key pair	▼
Key akey	p <b>air name</b> pair	
		Download Key Pair
	You have to download the <b>private key file</b> (*.pem file) before you Store it in a secure and accessible location. You will not be a	u can continue.
	file again after it's created.	
	file again after it's created.	

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).

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Figure 2.7: The EC2 Instances List

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

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Reserved Instances	$\checkmark$	examplecluster	闄 i-907182f3	ami-0c2f8a65	ebs	t1.micro	running	1/2	none	basic	quicklaur
		piotr-cluster-on-	竇 i-a4d5b5d4	ami-0c2f8a65	ebs	m1.smal	🥚 stopped		none	basic	quicklaur
IMAGES		us-east-1-direct	竇 i-e17b6b91	ami-543baa3c	ebs	m1.large	🥚 stopped		none	basic	brightclot
AMIs		us-east-1-direct	)≣i-1e5fc46d	ami-e04cde8§	ebs	t1.micro	🥚 stopped		none	basic	brightclou
Bundle lasks	_		-			į	-				<b>•</b>
<ul> <li>ELASTIC BLOCK STOF</li> <li>Volumes</li> <li>Snapshots</li> </ul>	1EC: ec	2 Instance selected. EC2 Instance: 2-50-16-44-106	exampleclust .compute-1.a	er (i-907182 mazonaws.co	f3) 🔴 om					8 8	
NETWORK & SECURI Security Groups	De	atus checks detect	s Checks M problems that n	nitoring Ta	igs instance from ru	inning your	applications.		Create Sta	utus Check Ala	m 🔽
Elastic IPs Placement Groups Load Balancers Key Pairs	Elastic IPs Placement Groups Load Balancers Key Bairs								ietwork configu	ration	
Key Pairs  Key Pairs  System reachability check passed. more info  More info											

Figure 2.8: Reachability Status For An EC2 Instance

#### Acting on an instance from the AWS EC2 Management Console:

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

#### Connecting to an instance from the AWS EC2 Management Console:

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

## • a standalone SSH client

There is further documentation on this at:

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

for

### • a browser-based Java SSH client, MindTerm

There is further documentation on this at:

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

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

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

l would like to connect with	$oldsymbol{\Theta}$ A standalone SSH client $oldsymbol{O}$ A Java SSH Client directly from my browser (Java required)
To access your instance:	
1. Open an SSH client. (find ou	ut how to connect using PuTTY)
<ol> <li>Locate your private key file launch the instance.</li> </ol>	(pjeukeypair.pem). The wizard automatically detects the key you used
3. Your key must not be public	ly viewable for SSH to work. Use this command if needed:
chmod 400 pjeukeypa	ir.pem
4. Connect to your instance us	ing its Public DNS:
ec2-54-220-69-16.eu	-west-1.compute.amazonaws.com
Example:	
ssh -i pjeukeypair.	pem root@ec2-54-220-69-16.eu-west-1.compute.amazonaws.co
Please note that in most you read your AMI usage AMI username.	cases the username above will be correct, however please ensure tha e instructions to ensure that the AMI owner has not changed the defau
If you need any assistance connec	ting to your instance, please see our connection documentation .

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.

	🎁 Services 🕶 Edit 🗸	¢	iartijn de Vries 🔻	N. Virgi
Ļ	Launch Instance Actions 🗸	System Log: i-60999901	C	ancel 🗙
	Viewing: All Instances	blkfront: xvde3: barriers disabled Initialising Xen virtual ethernet driver. kjournald starting. Commit interval 5 seconds EXT3-fs (xvde2): mounted filesystem with ordered data mode dracut: Remounting /dev/vvde2/vdtb.compatime podiratime ro		<b>_</b>
	🗋 Name 🏾 🖗 Instance	Kjournalmishing / Service in the second seco		
	examplecluster	dracut: Switching root udev: starting version 147 microcode: CPU0 sig=0x10685, pf=0x1, revision=0x11 platform microcode: firmware: requesting intel-ucode/06-1a-05		
	EC2 Instance: exampleclu	Nicrocode Update Oriver: v2.00 <tigran∰äivazian fsnet.co.uk="">, Peter Oruba Built 1 zonelists in Node order, möbility grouping on. Total pages: 426389 Policy zone: DNA32</tigran∰äivazian>		
	ec2-23-20-123-252.compute-1	4		•
	Description Status Checks	Close		

Figure 2.10: System Log Of The Checkboxed Instance

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

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

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

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

#### Example

```
pj@office:~$ ssh -i pjkeypair.pem root@ec2-176-34-160-197.eu-west-1.com\
pute.amazonaws.com
The authenticity of host 'ec2-176-34-160-197.eu-west-1.compute.amazonaw\
s.com (176.34.160.197)' can't be established.
RSA key fingerprint is 66:1e:f3:77:83:f8:3f:42:c1:b7:d2:d5:56:d8:c3:58.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'ec2-176-34-160-197.eu-west-1.compute.amazon\
aws.com,176.34.160.197' (RSA) to the list of known hosts.
Welcome to Bright Cluster Manager
Based on Scientific Linux 5
Cluster Manager ID: #999915
------
To set up your cluster, type
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 e	exit
this screen, type 'q'. Press any key to continue	
Do you agree with the license terms and conditions? (yes, no, show	v): yes

\_\_\_\_\_ Amazon account information \_\_\_\_\_ AWS username (I for information): exampleuser@brightcomputing.com AWS Account ID (I for information): 313234312222 Access Key ID (I for information): OUPOUASOUDSSSAOU Secret Access Key (I for information): Aighei8EooLilDae8Nio5ohl4ieXiAiaiV Verifying Amazon credentials \_\_\_\_\_ 1 Bright License \_\_\_\_\_ Bright Product Key (I for information): 423112-231432-134234-132423-134221 Country: US State: CA Locality: San Francisco Organization name: Bright Computing Organizational Unit: Development Cluster Name: demo-cluster \_\_\_\_\_ \_\_\_\_\_ Head Node \_\_\_\_\_ Hostname: bright73 Administrative Password: Verify password: Do you want to create a second drive for more storage capacity? (I for information) [YES|no] no Extra storage for /home (I for information)? [NO|yes] n Extra storage for monitoring data (I for information)? [NO|yes] n \_\_\_\_\_ Compute Nodes \_\_\_\_\_ Instance Type (I for information): m1.small m1.medium c1.medium m1.large t1.micro m2.xlarge m2.2xlarge m2.4xlarge c1.xlarge [t1.micro] > t1.micro Node Count [2]: 2 Base name (I for information) [cnode]: cnode Instances of type t1.micro need to use EBS storage

```
Size of EBS (GB) [40]: 15
Do you want to configure more node types? [NO|yes]
no
                                _____
_____
1
               Workload Management system
                                                                _____
Which workload management system do you want to use? (I for information)?
 slurm
 sge
 torque
 [slurm]
>
slurm
Number of slots per node [8]:
8
Do you want to use the head node for compute jobs? [NO|yes]
no
The following information will be used to configure this head node:
 Amazon information:
                         exampleuser@brightcomputing.com
313234312222
   AWS username:
   AWS Account ID:
                          OUPOUASOUDSSSAOU
   Access Key ID:
                      Aighei8EooLi1Dae8Nio5ohl4ieXiAin5eeRoaiV
   Secret Access Key:
  Bright Product Key:
                         423112-231432-134234-132423-134221
  License information
                         US
   Country:
                          CA
   State:
   Locality:
                          San Francisco
   Organization name: Bright Computing
Organizational Unit: Development
Cluster Name: demo-cluster
   Cluster Name:
  Hostname:
                          bright73
  Second drive size:
                        no
  Instance Type:
                         t1.micro
                          2
  Node Count:
  Base name:
                          cnode
  Storage type:
                          EBS
 Size of storage: 15 GB
  Workload management system: slurm
  Number of slots: 8
  Head node for compute jobs: no
The information to configure this head node has been collected, and shown
above. The next phase will be to process this information. A new Bright
license will be installed, the Bright Cluster Manager software will be
initialized and the workload management software will be initialized
```

Do you want to continue? [YES|no] yes

Starting to configure this head node Successfully retrieved the license Installed license Initializing Bright Cluster Manager Installing admin certificates Configuring default scheduler, slurm Set up finished

It is recommended that the system administrator log out and login again after the script has been run, in order to enable the new environment for the shell that the administrator is in. If the hostname was changed in the 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

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

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

# 2.3.2 Cluster On Demand: Access With A Local cmsh

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

# 2.3.3 Cluster On Demand: Access With A Local cmgui

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

# 2.4 Cluster On Demand: Cloud Node Start-up

Cloud nodes must be explicitly started up. This is done by powering them up, assuming the associated cloud node objects exist. The cloud node objects are typically specified in the 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).

ℵBright Cluster Manager							0	0 0
<u>File Monitoring View Bookma</u>	arks Help							
RESOURCES	(	📷 cnode	e <b>001</b>				Bright 5.2 Clus	ter
<ul> <li>✓ Switches</li> <li>✓ Networks</li> <li>globalnet</li> <li>internalnet</li> <li>✓ Power Distribution Un</li> <li>✓ Software Images</li> <li>④ default-image</li> <li>✓ Node Categories</li> <li>ⓓ efault</li> <li>✓ Head Nodes</li> <li>☑ headnode</li> <li>✓ Racks</li> <li>✓ 1</li> <li>✓ 2</li> <li>✓ Chassis</li> <li>✓ Virtual SMP Nodes</li> <li>✓ Nodes</li> <li>✓ Cloud Nodes</li> <li>✓ Amazon EC2</li> </ul>	its Power on	Overview       Tasks       Settings       Cloud Settings       System Inform         Hostname:       cnode001         State:       Down (Internal ip detected: 10.235.51.56)         Power:       • cloud         Load       0 (1 min) • (5 min) • 0 (15 min)         Uptime:       • days • hours • 0 minutes         Memory:       • OB out of • OB         Swap Memory:       • OB out of • OB         CPU Usage:       • O% u • 0% s • 0% • 0% i					Ation Services	Pr
cnode002	Power off	et				)		•
	Terminate							8
All Events           V         Time           23/Apr/2012 17:10         23/Apr/2012 17:0           23/Apr/2012 17:0         23/Apr/2012 17:0           23/Apr/2012 17:0         23/Apr/2012 17:0           23/Apr/2012 17:0         23/Apr/2012 17:0           23/Apr/2012 17:0         23/Apr/2012 17:0	Shutdown Reboot Drain Undrain Open Close Root Shell Bemote C	onsole		P C S S S S S	lessage ower on (cnode001 heck 'DeviceIsUp' is ervice slurm was re ervice munge was s ervice slurm was st ervice slurmdbd wa ervice postfix was r	) in state PASS on h started on headnoc arted on headnode s started on headr estarted on headn iestarted on headn	eadnode de le iode ode	
Ready	Hedata	unsole						.:#

Figure 2.12: Powering on a cloud node with cmgui

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

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

#### Example

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

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

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

#### 2.4.1 IP Addresses In The Cluster On Demand Cloud

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

# 3

# **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
_____
                     /C=US/ST=NY/L=WS/O=Bright
Licensee
                      Bitcoins/OU=Unit/CN=Bright 7.3 Cluster
Serial Number
                     19305
                     Mon Dec 20 00:00:00 2015
Start Time
End Time
                     Wed Jun 20 00:00:00 2018
                      7.3
Version
                     Advanced
Edition
Pre-paid Nodes
                      100
Max Pay-per-use Nodes N/A
                     80
Max Hadoop Nodes
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 must also be registered on the Bright Computing Customer Portal website at http://customer.brightcomputing.com/Customer-Login. A Customer Portal account is needed to do this.

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

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

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

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

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

#### Steps

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

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

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

#### **Cluster Extension Cloudbursting With A Hardware VPN**

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

# 3.1 Cluster Extension: Cloud Provider Login And Cloud Director Configuration

To access the Amazon cloud service from cmgui, the "Cloud Nodes" resource is selected, and the "Cloud Accounts" tabled 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  $\boxplus$  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)

# 3.1.1 Introduction

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

1. Introduction 2. AWS Credentials	Cluster Extension Setup Wizard
<ol> <li>Select Regions</li> <li>Summary &amp; Deployment</li> <li>Deploy</li> </ol>	Cluster Extension cloud bursting allows for seamless extention of the existing on-premise cluster with new resources provisioned in Amazon Web Services. Cluster Extension cloud bursting requires:
	<ul> <li>An activated cluster license If activation is indeed needed, then it is most likely a case of simply running the request-license command with the product key. Further details on activating the license are in the Administrator Manual.</li> <li>Registration of the product key The product key must also be registered on the Bright Computing Customer Portal website at https://customer.brightcomputing.com</li> <li>An Amazon Web Services account</li> <li>Outbound UDP connectivity By default an outbound UDP connection to port 1194 will be used for the OpenVPN tunnel from the head node to the cloud director's external IP. To use TCP, and/or other ports, the Bright Computing knowledge base 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.</li> </ul>
Sho <u>w</u> Save	Load Help <u>C</u> ancel <u>P</u> revious <u>N</u> ext

Figure 3.1: Introduction Page For Cluster Extension With cmgui

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).

<ol> <li>Introduction</li> <li>AWS Credentials</li> <li>Select Regions</li> <li>Summary &amp; Deployment</li> <li>Deploy</li> </ol>	AWS Credentials Provide your AWS credent verified by contacting AW Provider Name: AWS Access key ID: AWS Secret key:	tials. "Access Key ID" and "Secret Key" will be 'S in the next step. Show password Validate credentials amazon
Sho <u>w</u> <u>S</u> ave	He	lp <u>C</u> ancel <u>P</u> revious <u>N</u> ext

Figure 3.2: AWS Key Configuration For Cluster Extension With cmgui

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.

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.

<ol> <li>Introduction</li> <li>AWS Credentials</li> <li>Select Regions</li> <li>Summary &amp; Deployment</li> <li>Deploy</li> </ol>	Select Regions Please select at least one of the regions below. For each selected region, a VPC will be created in that region during the deployment process.
	<pre>us-east-1 us-west-1 us-west-2 eu-west-1 v eu-central-1 ap-northeast-1 ap-southeast-2 ap-southeast-1 ap-southeast-2 sa-east-1 us-gov-west-1</pre>
Sho <u>w</u> <u>S</u> ave	Help <u>C</u> ancel <u>P</u> revious <u>N</u> ext

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.

Further details on regions can be found at http://docs.aws.amazon.com/AWSEC2/latest/ UserGuide/using-regions-availability-zones.html.

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).

```
1. Introduction
                                  Summary
2. AWS Credentials
3. Select Regions
                            Overview:
4. Summary & Deployment
                                 • Provider:
                                   amazon

    Account ID:

                                   137677339600

    Username:

                                   brightdev
                                 • 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.

    Show
                    Save
                                                                Cancel
                                                                               Previous
                                                                                               <u>D</u>eploy
```

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.

# 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).

4. Summary & Deployment	100%	scro
5. Deploy	Oloud Extension has been deployed successfully.	
	🕝 clusterextension: Running: 'service cmd status'	
	🧭 clusterextension: Running: 'rpm -q python2-boto'	
	🥥 clusterextension: Running: 'rpm -q openvpn'	
	🥝 clusterextension: Running: 'rpm -q openvpn   grep '_cm''	
	🥝 clusterextension: Create Provider	
	🥝 clusterextension: Wait For AWSData	
	🥝 clusterextension: Update Provider	
	🥥 clusterextension: Create Netmap Network	
	Contraction: Create Tunnel Networks	
	Clusterextension: Configure Headnodes	
	Clusterextension: Enable Management On Tunnel Interface	
	Custerextension: Creating VPC subnet \${vpc}-public	
	Clusterextension: Creating VPC subnet \${vpc}-private	
	Clusterextension: Configure VFC	
	Clusterextension: Configure Director Categories	
	Clusterextension, Configure Node Categories	
	Custerextension: Configure Cloud Nodes In VPC	
	Custerextension: Configure Regular Nodes For VPC	
	Cluster has been extended successfully	
	Sector has been observed baccostally.	

Figure 3.5: Cluster Extension Configuration Processing With cmgui

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.

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.

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
        Name (key) Drive Size Volume ID
Tvpe
   _____ ____
ebs ebs sdb 42GB
ephemeral ephemeral0 sdc 0B
                                  ephemeral0
[bright73->...->cloudsettings->storage]% remove ebs
[bright73->...->cloudsettings*->storage*]% set ephemeral0 drive sdb
[bright73->...->cloudsettings*->storage*]% list
       Name (key) Drive Size Volume ID
Tvpe
 ephemeral ephemeral0 sdb 0B ephemeral0
[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)

<u>File Monitoring</u> Filter View	<u>B</u> ookmarks Help Deb	ug	
RESOURCES	👝 amazon	Ē	bright73
🕂 📄 Node Catego	Overview Status	Tasks Private Clouds Static IPs Prices	
+ Head Nodes	Hostname	V Type V Category V Persistent storage	· · .
+ Racks + Chassis	eu-central-1-cnode001 eu-central-1-cnode002	× Cluster Extension Wizard	000
+ Virtual SMP N + 1 Nodes - 1 Cloud Nodes	eu-central-1-cnode003 eu-central-1-director	1. Node Selection 2. Network Interfaces	
- 📤 amazon		4. Summary & Deployment Region: eu-central-1	
eu-cent		Type: (m3.medium 💌	
a eu-cent		Category: cloud-node	
📖 eu-cent		First node: eu-central-1-cnode004	
+ 📄 MIC Nodes			
⊕ GPU Units		Last node: eu-central-1-cnode020	
+ Other Devices		Storage: EBS V SC1 V 500	GiB
- Big Data			
Ceph			
🔬 Puppet			
🙆 Kubernetes		Sho <u>w S</u> ave <u>L</u> oad <u>C</u> ancel <u>P</u> revious <u>1</u>	Next
🖃 💶 OpenStack			
Lusers & Grou	<u>O</u> pen <u>A</u> dd	Clone Remove Create Cloud Nodes Add Cloud Director Revert	<u>S</u> ave
Ready			

Figure 3.6: Main Cloud Node Creation Wizard Configuration Screen

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.

<ol> <li>Node Selection</li> <li>Network Interfaces</li> <li>Summary &amp; Deployment</li> </ol>	Network Interfaces Interface Network eth0: vpc-eu-central-1-private
Sho <u>w</u> <u>S</u> ave	<u>L</u> oad <u>C</u> ancel <u>P</u> revious <u>N</u> ext

Figure 3.7: Setting 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)

<ol> <li>Node Selection</li> <li>Network Interfaces</li> <li>Summary &amp; Deployment</li> </ol>	Summary The following cloud nodes will Region: eu-central-1 Type: m3.medium Storage Driver: EBS	be created:	
	hostname	eth0(vpc-eu-central-1-private)	tun0(eu-cen 🖽
	eu-central-1-cnode004	DHCP	172.16.0.4
	eu-central-1-cnode005	DHCP	172.16.0.5
	eu-central-1-cnode006	DHCP	172.16.0.6
	eu-central-1-cnode007	DHCP	172.16.0.7
	1 11 1 000	DU OD	1701000
Sho <u>w</u> <u>S</u> ave	Load	<u>C</u> ancel <u>P</u> revious	<u>0</u> k

Figure 3.8: Creating Cloud Nodes Summary

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.

#### 3.4.1 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

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

```
[bright73->device[us-east-1-director]->cloudsettings]% terminate
us-east-1-director terminated
```

• 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[ebs]]% 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[ebs]]% 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.

# 4

# Cloudbursting Using The Command Line And cmsh

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

# 4.1 The 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 ssh connection is made by the administrator to the cloud head node, cloudbursting can be continued from command line. Thus, the 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 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 cm-bright-setup no longer needs to be run separately within the cloud head node. The cm-cluster-on-demand-aws is part of Bright Cluster Manager's cluster-tools package.

# 4.1.1 cm-cluster-on-demand-aws Command Options Overview, Help Files

The main help text for the cm-cluster-on-demand-aws utility is:

Top-level commands:

cluster	Manage	clusters	5			
image	Manage	Images				
config	Manage	runtime	configuration	of	the	tool

Further help for the commands is displayed using the -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 -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]
                               [--aws-username AWS_USERNAME]
                                [--aws-account-id AWS_ACCOUNT_ID]
                                [--aws-access-key-id AWS_ACCESS_KEY_ID]
                                [--aws-secret-key AWS_SECRET_KEY]
                                [--aws-region AWS_REGION]
                                [--license-unit LICENSE_UNIT]
                                [--license-locality LICENSE_LOCALITY]
                                [--license-country LICENSE_COUNTRY]
                                [--license-product-key LICENSE_PRODUCT_KEY]
                               [--license-organization LICENSE_ORGANIZATION]
                               [--license-state LICENSE_STATE]
                                [--timezone TIMEZONE]
                                [--wlm WORKLOAD_MANAGER_NAME]
                                [--cluster-password CLUSTER_PASSWORD]
                                [--store-head-node-ip PATH_TO_FILE]
                                [--ssh-key-pair SSH_KEY_PAIR]
                                [--ssh-private-key-path SSH_PRIVATE_KEY_PATH]
                                [--ingress-ports INGRESS_PORTS]
                                [--ingress-cidr-block INGRESS_CIDR_BLOCK]
                                [--head-node-image ID]
                                [--head-node-type HEAD_NODE_TYPE]
```

```
[--head-node-root-volume-size SIZE_IN_GB]
                                [--head-node-root-volume-type HEAD_NODE_ROOT_VOLUME_TYPE]
                                [--nodes NODES]
                                [--node-type TYPE]
                                [--vpc-cidr-block CIDR]
                                [--public-subnet-cidr-block CIDR]
                                [--private-subnet-cidr-block CIDR]
                                [--tags TAGS]
                                [--version VERSION]
                                [--clusters CLUSTERS]
                                [--run-cm-bright-setup True, False]
                                name [name ...]
Create a new cluster in amazon VPC
positional arguments:
                       Name of the cluster (VPC) to create
  name
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 <code>\$AWS\_USERNAME</code> and <code>\$AWS\_USERNAME</code>, are environment variables that can be set for a session with, for example

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

```
# 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
```

```
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 indentations are important in the template. Values should be set for the configuration options, or within the cm-cluster-on-demand.conf or the overlay files, for the following:

- license\_product\_key (environment variable LICENSE\_PRODUCT\_KEY)
- cluster\_password
- aws\_username (environment variable AWS\_USERNAME)
- aws\_account\_id (environment variable AWS\_ACCOUNT\_ID)
- aws\_access\_key\_id (environment variable AWS\_ACCESS\_KEY\_ID)
- aws\_secret\_key (environment variable AWS\_SECRET\_KEY)
- ssh\_key\_pair (environment variable SSH\_KEY\_PAIR)
- ssh\_private\_key\_path

Some of these values can alternatively be set as environment variables, as indicated by the text in parentheses in the preceding list.

Default values are the commented values in the configuration file. However, the defaults can be overridden by configuration settings elsewhere in the loading hierarchy shown in the top part of the file.

Configuration values can be overlaid. That means that values loaded earlier in the load order are overridden by values set later on, and if no value is set, then the default value remains. The cluster

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

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

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-dem\
and.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

```
[root@bright73 ~]# cm-cluster-on-demand-aws cluster create acluster -c anotherconf
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: Nodes: 5 (m3.medium)
16:23:04: INFO: Setting up VPC
16:23:04: INFO: Setting up VPC
16:23:04: INFO: Creating VPC for acluster in eu-west-1...
16:23:04: INFO: Addinng 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.
```

```
16:23:06:
                     INFO: Starting head nodes...

16:23:06: INFO: Wait for head nodes running...
16:23:23: INFO: Starting bright setup...
16:23:23: INFO: Waiting for ssh connection availability... ssh root@52.208.149.137...
16:23:33: INFO: SSH connection timeout

 . . .
16:24:30: INFO: Retrying SSH connection attempt in 15 seconds...
16:24:45: INFO: Connection succeeded!
16:24:45: INFO: Wait for cloud-init to finish...
16:24:48: INFO: Cloud-init completed!
16:24:48: INFO: Starting cm-bright-setup...
16:25:06:
                  INFO: stdout Please wait...
. . .
...
16:28:48: INFO: stdout ## Progress: 82
16:28:48: INFO: stdout #### stage: brightsetup: Start CMDaemon
16:28:51: INFO: stderr Created symlink from /etc/systemd/system/multi-user.target....
16:28:52: INFO: stdout ## Progress: 86
16:28:52: INFO: stdout #### stage: brightsetup: Restore MOTD
16:28:52: INFO: stdout ## Progress: 91
16:28:52: INFO: stdout #### stage: brightsetup: Restore Bash RC
16:28:52: INFO: stdout ## Progress: 95
16:28:52: INFO: stdout ## Progress: 100
16:28:52: INFO: stdout #### stage: brightsetup: Setup Periodic File...
16:28:52: INFO: stdout #### stage: brightsetup: Setup Periodic File...
16:28:52:
                  INFO: stdout tune2fs 1.42.9 (28-Dec-2013)
16:28:52:
                  INFO: stdout Setting interval between checks to 15552000 seconds
                   INFO: stdout Setting time filesystem last checked to Thu Aug 4 16:28:52...
16:28:52:
                   INFO: stdout
16:28:52:
                   INFO: stdout
16:28:52:
                   INFO: -----
16:29:11:
                                                                       _____
16:29:11:
                   INFO: Time it took: 06:07
                  INFO: SSH string: ssh root@52.208.149.137 -i /root/eukeypair.pem
 16:29:11:
 52.208.149.137 acluster
```

#### 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

17:11:45: INI	IFO: S	Stopping instances for VPCs on-demand acluster
17:11:45: INI	IFO: I	Listing instances
17:11:45: INI	IFO: ]	Issuing instances termination requests
17:11:46: INI	IFO: V	Naiting until instances terminated
17:12:31: INI	IFO: I	Destroying VPC on-demand acluster
17:12:31: INI	IFO: I	Deleting subnets
17:12:31: INI	IFO: I	Detaching and deleting gateways
17:12:32: INI	IFO: E	flushing permissions
17:12:33: INI	IFO: I	Deleting security groups
17:12:34: INI	IFO: I	Deleting VPC
17:12:34: INI	IFO: I	Done destroying VPC on-demand acluster
[root@bright73 ~]	] #	

#### 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 cloudbursting 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

Th 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]
common:
```

```
Common arguments
```

-V	Verbose output
-h,help	Print this screen
-c <config_file></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
                       Test integrity of the utility by running Unit Tests
 --tests
                      Upon encountering a critical error, instead of asking the user for a
 --undo-on-error
                       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 definitions of all objects required for cluster extension, e.g.
 --remove
                        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
                      Perform networking checks (e.g. check if API endpoints are reachable)
 --test-networking
 --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:
                                                  (start interactive menu, wizard)
 cm-cluster-extension
 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>
    (remove 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 tools 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...
```

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 Neurses dialog (figure 4.1).

Main menu	
<mark>idd new AMS provider</mark> Test networking Exit	Setup new AMS cloud provider account Run only AWS network connectivity test Return to the command line
-	
	K IK >

Figure 4.1: Configuration Processing With cm-cluster-extension: Main Screen

The option to add a new cloud provider can be selected from the from the main screen, and brings up a screen asking for the credentials of the cloud provider, Amazon, in figure 4.2.

Provide your AWS credentials
"Provider name" is a custom, human readable, string. "Access Key ID" and "Secret Key" will be verified in the next step by contacting AWS.
Provider name AWS Access Key ID AWS Secret Key <b>ra9xaG7oUiy1uquOahW4aixuThee5ahwUGoh</b>
C_DK > < Back >

Figure 4.2: Configuration Processing With cm-cluster-extension: Obtaining Credentials

After checking the credentials, the available regions are displayed (figure 4.3).

Please select at least one of the For each selected region, a VPC wi deployment process.	regions below. 11 be created in that region during the US East (Virginia) US West (N. California) US West (Oregon) EU Mest (Oregon) EU Central (Frankfurt) Asia Pacific (Tokyo) Asia Pacific (Seoul) Asia Pacific (Seoul) Asia Pacific (Singapore) Asia Pacific (Sydney) South America (Sao Paolo)
	< Back >

Figure 4.3: Configuration Processing With cm-cluster-extension: Regions Selection

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).



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
                   Value
Parameter
_____
. . .
Management network eu-central-1
Network
                  eu-central-1
. . .
[bright73->device*[cnode001*]]% interfaces
[bright73->device*[cnode001*]->interfaces]% list
       Network device name IP
Type
                                     Network
_____ ____
physical eth0 [dhcp]0.0.0.0vpc-eu-central-1-privatetunnel tun0 [prov]0.0.0.0eu-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
       Network device name IP
                                 Network
Type
physical eth0 [dhcp]0.0.0.0vpc-eu-central-1-privatetunnel tun0 [prov]172.16.0.1eu-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

# 4.4 Submitting Jobs With cmsub And Cloud Storage Nodes, For Cluster Extension Clusters

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

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

#### Example

```
[root@bright73 ~]# cmsh
[bright73]% user use henry
[bright73->user[henry]]% set profile cloudjob; commit
```

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

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

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

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

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

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

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

#### Example

```
[root@bright73 ~]# yum install cmdaemon-cmsub
[...]
[root@bright73 ~]# yum --installroot /cm/images/default-image install cmdaemon-cmsub
[...]
```

2. The 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 cluster-tools package, which is installed by default. The utility

- configures cmsub properties
- creates
  - templates for cloud storage nodes
  - storage polices for cmsub

#### Templates For Cloud Storage Nodes And Storage Policy

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

In addition, any network interfaces associated with a template node can generally be regarded 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 Neurses 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
  -77
                      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.
                      Enables additional command line arguments
  --dev
  --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 Neurses-based dialog, which starts with an introductory page (figure 4.6):

Cloud storage setup		
Cloud storage setup		]
	Exit Return to the command line	
-		

Figure 4.6: Cloud Storage Configuration Processing With cm-cloud-storage: Main Screen

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

In which network would you like storage node to be placed? You should choose the one with compute nodes with it.
<mark>pc-eu-central-1-private Recommended</mark> vpc-eu-central-1-public
K LK > < Back >

Figure 4.7: Cloud Storage Configuration Processing With cm-cloud-storage: Network Selection

Select category for the storage nodes.			qq
	<pre>Create new category&gt; default cloud-director cloud-node</pre>	Recommended	
	K LK >	< Back >	-

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

It is recommended that a new category be created (figure 4.9):



Figure 4.9: Cloud Storage Configuration Processing With cm-cloud-storage: Category Creation

A bucket name can be set (figure 4.10):

S3 bucket name	
cmsub-561d5f3d-3ac2-4433-9c89-ba4943c4	37e5
K OK >	< Back >

Figure 4.10: Cloud Storage Configuration Processing With cm-cloud-storage: S3 Bucket Entry

A workload manager is set for the cloud storage (figure 4.11):

Workload Manager			
	lsf pbspro Lurm torque uge openlava sge	Recommended	
-			
	K DK >	< Back >	

Figure 4.11: Cloud Storage Configuration Processing With cm-cloud-storage: Workload Manager Selection

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

Select work load queu	e.		
	<mark>≺Create new queue&gt;</mark> defq	Recommended	
L			
	K UK >	< Back >	

Figure 4.12: Cloud Storage Configuration Processing With cm-cloud-storage: Queue Creation

The queues can be assigned to the cloud category (figure 4.13):



Figure 4.13: Cloud Storage Configuration Processing With cm-cloud-storage: Setting The Queue Category

The summary screen allows the configuration to be saved and to be deployed (figure 4.14):

Summary After saving the config into a file, exit the utility and run cm-cloud-storage-setup -c <config> to deploy the selected configuration.</config>	
K ↓ K > K → K → K → K → K → K → K → K → K →	

Figure 4.14: Cloud Storage Configuration Processing With cm-cloud-storage: Summary Screen

Please specify the filepath.	
/root/cm-cloud-storage-setup.conf[	
<mark>&lt; OK &gt;</mark> < Back >	1

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

Figure 4.15: Cloud Storage Configuration Processing With cm-cloud-storage: Save & Deploy Screen

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*.

# 5

# Cloud Considerations And Issues With Bright Cluster Manager

# 5.1 Differences Between Cluster On Demand And Cluster Extension

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

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

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

# 5.2 Hardware And Software Availability

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

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

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

# 5.3 Reducing Running Costs

#### 5.3.1 Spot Pricing

The spot price field is a mechanism to take advantage of cheaper pricing made available at irregular<sup>1</sup> 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.

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

#### 5.4.2 Resolution In And Out Of The Cloud

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

[bright73->network]% list -f name:26,type:12,netmaskbits:8,baseaddress:13,domainname:24				
name (key)	type	netmaskb	baseaddress	domainname
us-east-1	Tunnel	16	172.21.0.0	
externalnet	External	24	192.168.100.0	brightcomputing.com
globalnet	Global	0	0.0.0.0	cm.cluster
internalnet	Internal	16	10.141.0.0	eth.cluster
netmap	NetMap	16	172.30.0.0	
vpc-eu-central-1-private	Cloud (VPC)	17	10.42.128.0	vpc-eu-central-1.cluster
vpc-eu-central-1-public	Cloud (VPC)	24	10.42.0.0	vpc-eu-central-1.cluster

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 CMDaemonassigned 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 10.0.0/8 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.



Figure 5.1: NetMap In Relation To The General Network Scheme

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

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

# 6

# 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)
- *defaultVPC* (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:

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

\*Typically depends on the region accessed.

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

#### 6.1.3 The Classic Cloud And The DefaultVPC Instances

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

private clouds = custom VPCs + defaultVPCs

In the context of Amazon VPCs, the term private cloud is often used by administrators, by convention and for convenience, to mean the more precise term of custom VPC as defined here, implicitly ignoring possible defaultVPC instances. The Bright Cluster Manager software itself also follows this convention, 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:

private clouds = custom VPCs

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#### 6.1.5 Cloud Cluster Terminology Summary

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

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

# 6.2 Comparison Of EC2-Classic And EC2-VPC Platforms

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

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

# 6.3 Setting Up And Creating A Custom VPC

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),

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).

192.168.0.0-192.168.0.255 (192.168.0.0/24),
 192.168.1.0-192.168.1.255 (192.168.1.0/24).

The sipcalc command (page 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:

#### 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->...*[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 the internet, and it cannot even be an endpoint to an outside connection. To solve this issue, Amazon *elastic IP addresses* (EIPs) can be used to assign a public IP address to a custom VPC.

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

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

#### Example

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

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

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

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

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

#### 6.3.4 Subnets With Static IP Addresses In A Custom VPC Recommendation

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

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

```
[bright73->device[us-west-1-director]->interfaces]% listTypeNetwork device nameIPNetwork----------------------------physicaleth0 [dhcp]0.0.0.0vpc-us-west-1-publictunneltun0 [prov]172.18.255.251 us-west-1
```

#### Example

[bright73->device[us-west-1-cnode001]->interfaces]% list					
Туре	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		

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