Bright Cluster Manager 9.0

Cloudbursting Manual

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Preface

Welcome to the *Cloudbursting Manual* for Bright Cluster Manager 9.0.

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 9.0 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 *Edge Manual* describes how to deploy Bright Edge 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`.

There is also a feedback form available via Bright View, via the Account icon, 👤, following the clickpath:

`Account→Help→Feedback`

0.3 Getting Administrator-Level Support

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

Otherwise the primary means of support is via the website `https://support.brightcomputing.com`. This allows the administrator to submit a support request via a web form, and opens up a trouble ticket. It is a good idea to try to use a clear subject header, since that is used as part of a reference tag as the ticket progresses. Also helpful is a good description of the issue. The followup communication for this ticket goes via standard e-mail. Section 13.2 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 mainly the GUI configuration of the Cluster On Demand and Cluster Extension scenarios.

Chapter 4 looks at mainly command line tools for configuration of the Cluster On Demand and Cluster Extension scenarios, considering mainly AWS.

Chapter 5 looks at Cluster Extension for Azure.

Chapter 7 discusses some miscellaneous aspects of cloudbursting.

2

Cluster On Demand Cloudbursting With Azure Or AWS

Cluster On Demand (COD) cloudbursting is when a separate cluster is started up in a cloud, with the cluster head node that manages the cluster also in that cloud. A COD cluster is regarded as an independent virtual cluster (sometimes described as a ’pure’ cloud cluster), and not an extension of an existing physical cluster.

2.1 Requirements For COD Cloudbursting

COD can run in Azure (COD-Azure), in AWS (COD-AWS), or in Bright OpenStack (COD-OS). This chapter discusses COD-Azure and COD-AWS. COD-OS is discussed in Chapter 6 of the *OpenStack Deployment Manual*.

The requirements for COD-Azure and COD-AWS are:

- an account on the Bright Computing Customer Portal website at `http://customer.brightcomputing.com/Customer-Login` from which to run the COD (section 2.2), or a Docker container to run an image that requests the COD (section 2.3).

- a Bright Cluster Manager product key. This key is later activated when the license is installed (Chapter 4 of the *Installation Manual*) on the head node. The head node and regular nodes in this case are in the cloud.

- Requirements For COD-Azure: To use Azure, an Azure account subscription is needed from Microsoft. COD cloudbursting requires the following associated Azure credentials to launch:

  - tenant ID
  - subscription ID
  - Client ID
  - Client Secret

  A CLI-centric way to obtain these credentials requires logging into the Azure web portal using an account that has sufficient privileges. The Azure web bash console is then opened, and the subscription ID can then be listed for the account with:

  Example

```
azure@Azure:~$ az account list -o table
Name          CloudName    SubscriptionId                        State    IsDefault
------------  -----------  ------------------------------------  -------  -----------
anne          AzureCloud   23748c3e-507b-11e9-a994-fa163e9854eb  Enabled  False
nerds         AzureCloud   b9e22a88-507a-11e9-9352-fa163e9854eb  Enabled  False
```

A service principal (sp) is now created for role-based access control `create-for-rbac` in Active Directory (ad), and the remaining 3 credentials can then be seen:

Example

```
azure@Azure:~$ az ad sp create-for-rbac --name my-temp-service-principal-for-fred
Changing "my-temp-service-principal-for-fred" to a valid URI of
"http://my-temp-service-principal-for-fred", which is the required format used for service
principal names
Retrying role assignment creation: 1/36
Retrying role assignment creation: 2/36

  "appId": "dcf8151e-507a-11e9-a104-fa163e9854eb",    ## "Client ID"
  "displayName": "my-temp-service-principal-for-fred",
  "name": "http://my-temp-service-principal-for-fred",
  "password": "bc9f571e-fe4c-43d5-909d-4bc66796eb41",   ## "Client secret"
  "tenant": "8cb88849-6e18-46d6-b0fa-551a47a31681"    ## Tenant ID
```

The newly-created service principal is added to the desired subscription as a contributor. The value of `appID` must be used as the value to the `--assignee` option. This gives the application sufficient permissions for the cluster to run:

Example

```
azure@Azure:~$ az role assignment create --assignee dcf8151e-507a-11e9-a104-fa163e9854eb --role\
 Contributor --subscription b9e22a88-507a-11e9-9352-fa163e9854eb

  "canDelegate": null,
  "id": "/subscriptions/b9e22a88-507a-11e9-9352-fa163e9854eb/providers/Microsoft.Authorization\
/roleAssignments/1094f75c-507b-11e9-ac8f-fa163e9854eb",
  "name": "1094f75c-507b-11e9-ac8f-fa163e9854eb",
  "principalId": "2f899334-507b-11e9-b312-fa163e9854eb",
  "roleDefinitionId": "/subscriptions/b9e22a88-507a-11e9-9352-fa163e9854eb/providers\
/Microsoft.Authorization/roleDefinitions/b24988ac-6180-42a0-ab88-20f7382dd24c",
  "scope": "/subscriptions/b9e22a88-507a-11e9-9352-fa163e9854eb",
  "type": "Microsoft.Authorization/roleAssignments"
```

The Microsoft documentation suggests that using the name instead of the subscription ID should also work. However in the version that was used at the time of writing (May 2019) this did not work, and an `error 400` was displayed.

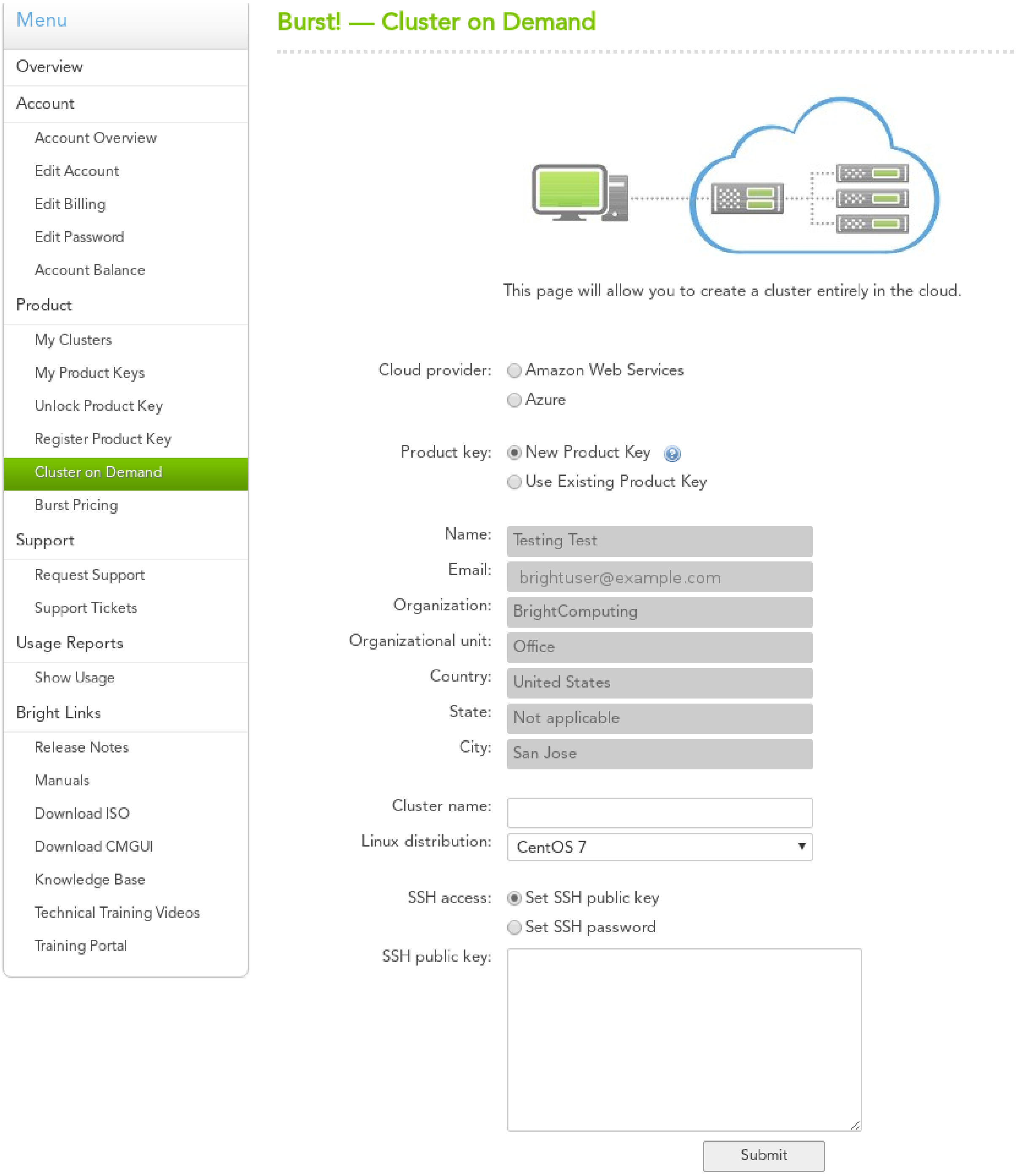
- Requirements For COD-AWS: To use AWS, an AWS subscription is needed from Amazon. COD cloudbursting requires the following associated AWS credentials for launch:
  - Secret Access Key: Available only once, when first generated, as described at `https://docs.aws.amazon.com/general/latest/gr/aws-sec-cred-types.html#access-keys-and-secret-access-keys`

- Access Key ID: as described at `https://docs.aws.amazon.com/general/latest/gr/aws-sec-cred-types.html#access-keys-and-secret-access-keys`
- AWS Account ID, as described at `https://docs.aws.amazon.com/general/latest/gr/acct-identifiers.html`
- AWS Username: This can be either the AWS account root user (the e-mail address of the root user), or it can be an IAM username with sufficient permissions to launch the cluster.

COD cloudbursting can be configured and started up via the Bright Computing customer portal (section 2.2), or via a Docker image (section 2.3).

2.2 COD Via Bright Computing Customer Portal

The customer portal (section 2.1) has a menu option `Cluster on Demand`. Selecting this displays an input form (figure 2.1).



Burst! — Cluster on Demand

This page will allow you to create a cluster entirely in the cloud.

Cloud provider: ○ Amazon Web Services ○ Azure

Product key: ● New Product Key ○ Use Existing Product Key

Name:	Testing Test
Email:	brightuser@example.com
Organization:	BrightComputing
Organizational unit:	Office
Country:	United States
State:	Not applicable
City:	San Jose
Cluster name:	
Linux distribution:	CentOS 7

SSH access: ● Set SSH public key ○ Set SSH password

SSH public key:

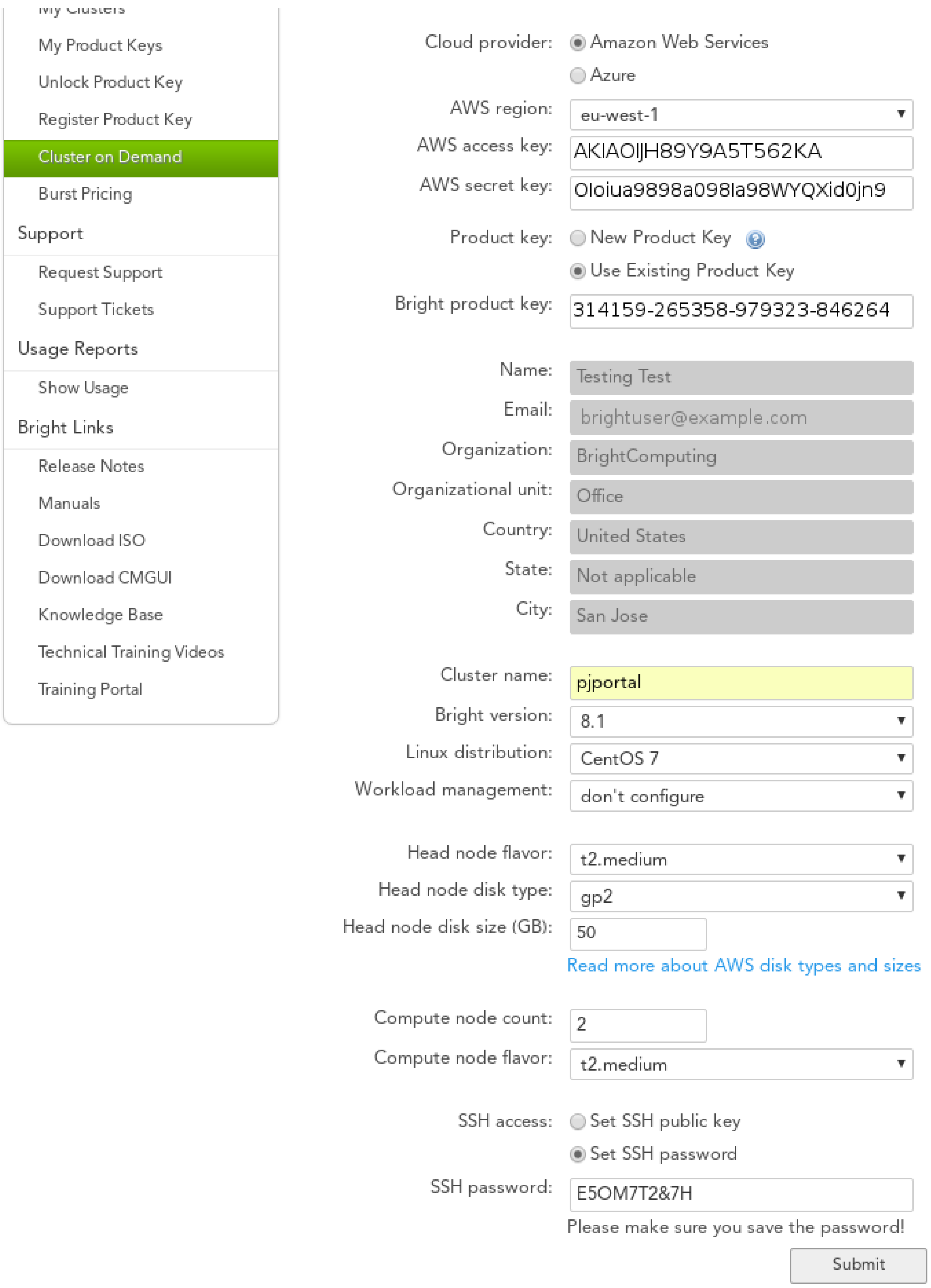
Figure 2.1: COD via customer portal: start screen

If this is filled in, then a COD can be launched in AWS or Azure.
Some of the options are:

- Cloud provider
- The product key. This can be the existing key, or a new one. Using the existing one for a cluster that is already in use is not normally possible.
- The cluster name. This can be arbitrary.

- The SSH access method.
  - SSH public key access is recommended, and should then be pasted into the text field. Using key access disables SSH password authentication.
  - Alternatively, a password can be set instead. This generates a somewhat random password for SSH password authentication that is not very strong. The password should normally be changed and saved, because brute force password attacks in the AWS and Azure IP address ranges are common.

Selecting AWS as an option presents some extra fields that are appropriate for launching an AWS COD (figure 2.2). How to obtain the values for the AWS keys is discussed in section 2.1. The default values that are in the form for the virtual machine types and sizes will work for small clusters. Other virtual machine types are documented at `https://aws.amazon.com/ec2/instance-types/`.



Cloud provider: ● Amazon Web Services ○ Azure

AWS region: eu-west-1 ▾

AWS access key: AKIAOIJH89Y9A5T562KA

AWS secret key: OIoiua9898a098la98WYQXid0jn9

Product key: ○ New Product Key ● Use Existing Product Key

Bright product key: 314159-265358-979323-846264

Name: Testing Test

Email: brightuser@example.com

Organization: BrightComputing

Organizational unit: Office

Country: United States

State: Not applicable

City: San Jose

Cluster name: pjportal

Bright version: 8.1 ▾

Linux distribution: CentOS 7 ▾

Workload management: don't configure ▾

Head node flavor: t2.medium ▾

Head node disk type: gp2 ▾

Head node disk size (GB): 50

Read more about AWS disk types and sizes

Compute node count: 2

Compute node flavor: t2.medium ▾

SSH access: ○ Set SSH public key ● Set SSH password

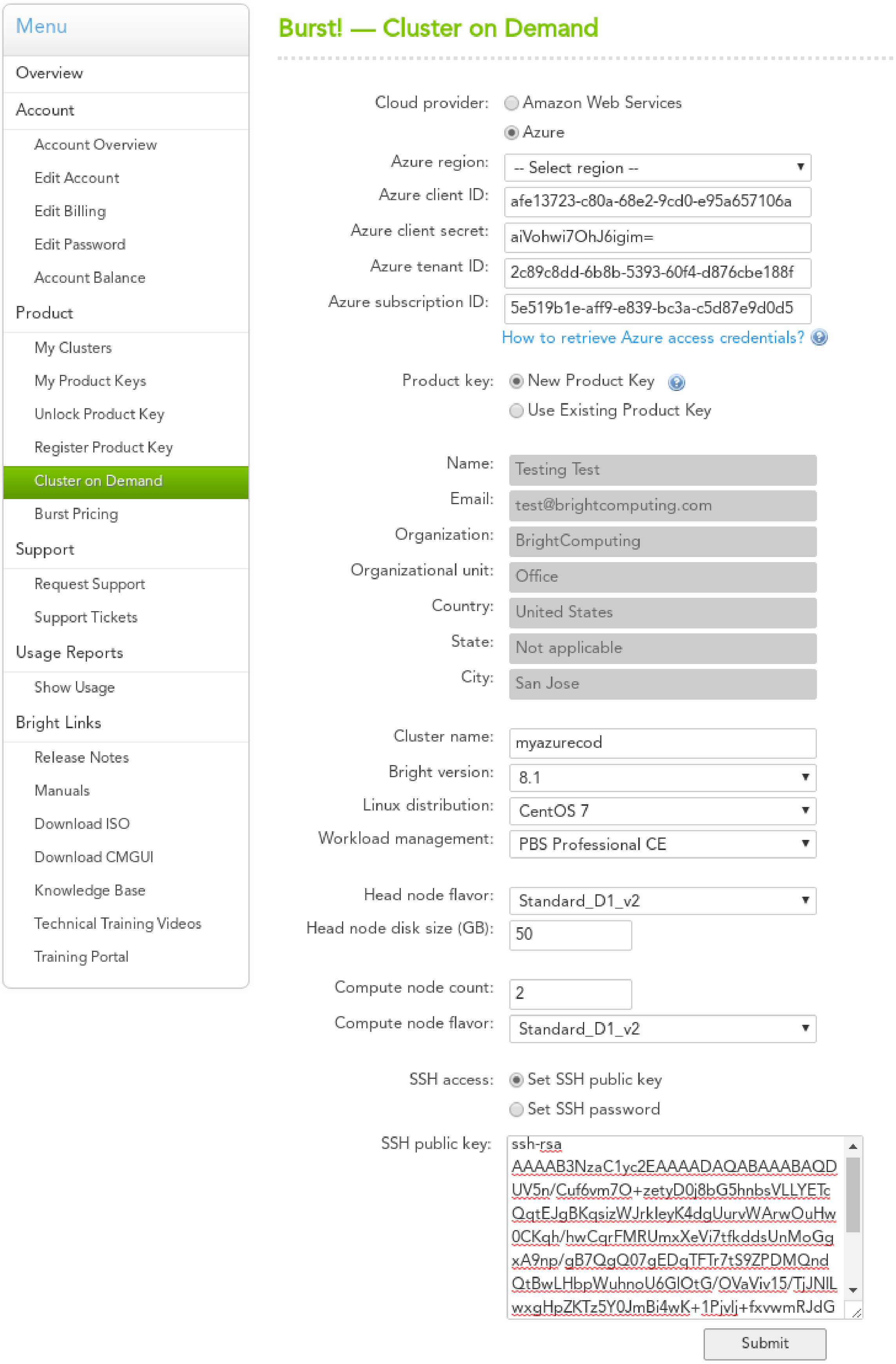
SSH password: E5OM7T2&7H

Please make sure you save the password!

Submit

Figure 2.2: COD-AWS via customer portal: example inputs

Selecting Azure as an option presents some extra fields that are appropriate for launching an Azure COD (figure 2.3). How to obtain the values for the Azure credentials is discussed in section 2.1. The default values that are in the form for the virtual machine types and sizes will work for small clusters. Other virtual machine types are documented at `https://docs.microsoft.com/en-us/azure/virtual-machines/linux/sizes`.



Burst! — Cluster on Demand

Cloud provider: ○ Amazon Web Services ● Azure

Azure region: -- Select region --

Azure client ID: afe13723-c80a-68e2-9cd0-e95a657106a

Azure client secret: aiVohwi7OhJ6igim=

Azure tenant ID: 2c89c8dd-6b8b-5393-60f4-d876cbe188f

Azure subscription ID: 5e519b1e-aff9-e839-bc3a-c5d87e9d0d5

How to retrieve Azure access credentials?

Product key: ● New Product Key ○ Use Existing Product Key

Name: Testing Test

Email: test@brightcomputing.com

Organization: BrightComputing

Organizational unit: Office

Country: United States

State: Not applicable

City: San Jose

Cluster name: myazurecod

Bright version: 8.1

Linux distribution: CentOS 7

Workload management: PBS Professional CE

Head node flavor: Standard_D1_v2

Head node disk size (GB): 50

Compute node count: 2

Compute node flavor: Standard_D1_v2

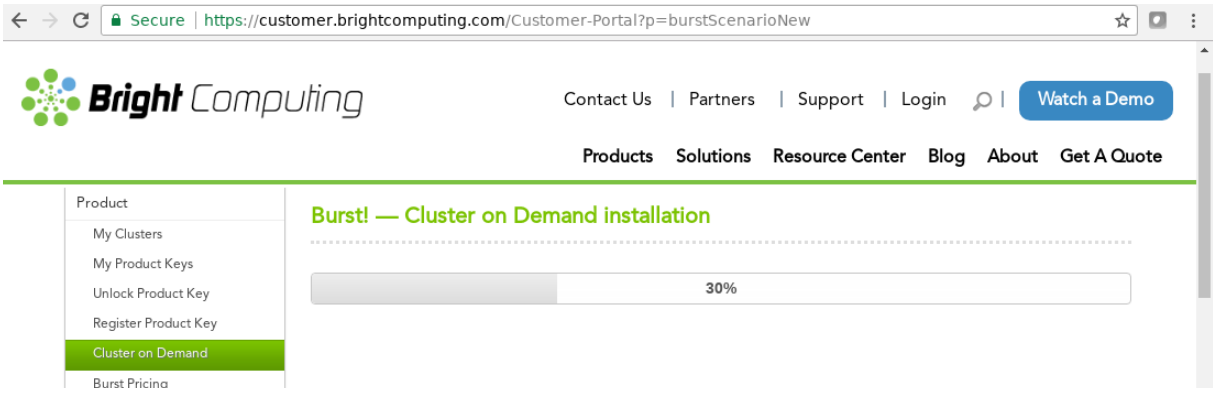
SSH access: ● Set SSH public key ○ Set SSH password

SSH public key:

```
ssh-rsa
AAAAB3NzaC1yc2EAAAADAQABAAABAQD
UV5n/Cuf6vm7O+zetyD0j8bG5hnbsVLLYETc
QqtEJgBKqsizWJrkleyK4dgUurvWArwOuHw
0CKqh/hwCqrFMRUmxXeVi7tfkddsUnMoGg
xA9np/gB7QgQ07gEDqTFTr7tS9ZPDMQnd
QtBwLHbpWuhnoU6GlOtG/OVaViv15/TjJNIL
wxgHpZKTz5Y0JmBi4wK+1Pjvlj+fxvwmRJdG
```

Figure 2.3: COD-Azure via customer portal: example inputs

Form submission begins the COD installation (figure 2.4).

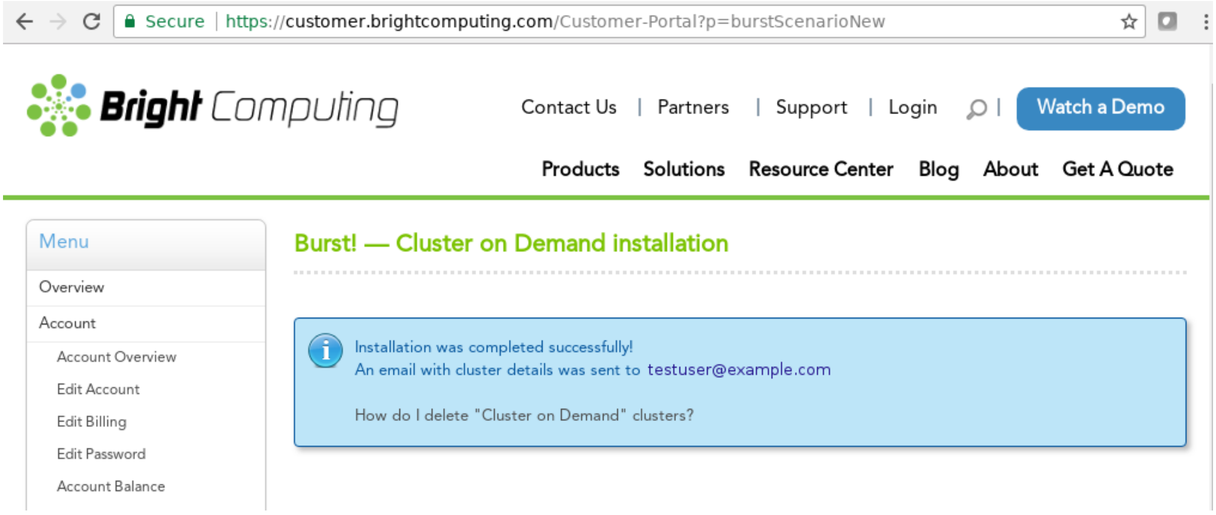

Secure | https://customer.brightcomputing.com/Customer-Portal?p=burstScenarioNew
Bright Computing
Contact Us | Partners | Support | Login
Watch a Demo
Products Solutions Resource Center Blog About Get A Quote
Product
My Clusters
My Product Keys
Unlock Product Key
Register Product Key
Cluster on Demand
Burst Pricing

Burst! — Cluster on Demand installation

30%

Figure 2.4: COD via customer portal: deployment in progress

When deployment is completed, an e-mail is sent with the details to the e-mail address that was entered in the form earlier. A final screen comes up if the installation was successful (figure 2.4).


Secure | https://customer.brightcomputing.com/Customer-Portal?p=burstScenarioNew
Bright Computing
Contact Us | Partners | Support | Login
Watch a Demo
Products Solutions Resource Center Blog About Get A Quote
Menu
Overview
Account
Account Overview
Edit Account
Edit Billing
Edit Password
Account Balance

Burst! — Cluster on Demand installation

Installation was completed successfully!
An email with cluster details was sent to testuser@example.com

How do I delete "Cluster on Demand" clusters?

Figure 2.5: COD via customer portal: finished deploying

2.3 COD Via Docker Image

The procedure described in this section runs COD using a Docker image. The Docker instance that runs from the image can be hosted on a standalone PC that is not part of a Bright cluster, or it can be hosted on a Bright node. In this section the example uses a regular node from a Bright cluster as the Docker host.

2.3.1 COD Via Docker Image–Procedure Summary

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

- A Docker host is used to pull the Bright Cluster Manager COD (Cluster On Demand) image from the Docker registry.
- The image is run in a Docker container.
- From within the instance of the image running in the container, a cloudbursting request for a COD is carried out to a cloud service provider.

- When the request completes successfully, a cluster that is running in the cloud is ready for use.

These steps are now covered in more detail.

2.3.2 COD Via Docker Image–Procedure Details

A COD can be launched from a Bright COD Docker image running inside Docker.

This is typically run from a standalone machine, such as, for example, a laptop that is not part of a Bright cluster.

However, launching a COD from a Bright cluster is also possible, and can be carried out as follows:

- Docker is installed in Bright Cluster Manager with `cm-docker-setup` (section 9.1.1 of the *Administrator Manual*), or using the Bright View Docker setup wizard.
- The node that is to run the Docker image is used to pull the image to the node

  Example

```
[root@bright90 ~]# ssh node001
[root@node001 ~]# module load docker
[root@node001 ~]# docker pull brightcomputing/cod:latest
...
cac15ba059ef: Pull complete
Digest: sha256:19b263033090e1a70043989decdf3c3870d3def8c2e69b2a85ac293fd7d149ab
Status: Downloaded newer image for brightcomputing/cod:latest
```

- The appropriate image ID can be found. For example:

  Example

```
[root@node001 ~]# docker images
REPOSITORY              TAG    IMAGE ID        CREATED        SIZE
brightcomputing/cod     latest aeddb120e78f    5 hours ago    593 MB
```

- The image can be run in a Docker container. This is done by running the image by specifying its ID from the preceding output. The container with that image (`aeddb120e78f`) can run (`run`) interactively (`-i`), over a pseudo-tty (`-t`), using the host (`host` option, which in this case is node001) network (`-network`) stack, and running, for example, a Bash shell (`/bin/bash`):

  Example

```
[root@node001 ~]# docker run --network host -it aeddb120e78f  /bin/bash
[root@node001 /]#
```

  Without `--network host` Docker allows only outgoing connections by default.

- In that container an existing SSH public key should be saved, so that it can be specified as an option to the COD cluster creation command. The associated private key should be located on any machine that is to be used to access the COD via SSH.

  Instead of using an existing SSH key pair, it may be convenient to generate a completely new key pair within the container, using `ssh-keygen`. In that case, the following may have to be borne in mind:

  - If exiting from the container, then returning to that container is possible after restarting and attaching to the container again, so that the keys to the cluster remain accessible.

- However, if the container is to be removed, then a copy of the keys, or at least the private key, should exist outside the container, so that the cluster can still be accessed. For example the keys can be displayed with the cat command and then copied and pasted (some text elided):

  Example

  ```
  [root@256ac248b583 /]# cat /root/.ssh/id_rsa
  -----BEGIN RSA PRIVATE KEY-----
  ...
  -----END RSA PRIVATE KEY-----
  [root@256ac248b583 /]# cat /root/.ssh/id_rsa.pub
  ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAABAQDOXPZUImfrolTHJQT5DepyCQ...
  ```

It is a good idea for the administrator to plan key management, in order to minimize the spread of the private key in general, and to manage keys in a way that works well with the work flow and use.

Up to this point, the preparation for running a COD from Docker has been the same for whether Azure or AWS are to be used as the cloud provider. The next stage is to launch the COD inside the cloud service.

There are two cloud services that a COD from Docker can be launched into. These are:

- AWS (Amazon Web Services), made available by Amazon. The CLI utility in the Docker instance that launches the COD is then `cm-cod-aws` (page 15).
- Azure, made available by Microsoft. The CLI utility in the Docker instance that launches the COD is then `cm-cod-azure` (page 12).

For completeness, a non-Dockerized COD can also be launched into the Bright OpenStack private cloud service. The Bright OpenStack private cloud service is a cloud service that can be provided with the Bright OpenStack edition of Bright Cluster Manager. The launch utility for this third type of COD is `cm-cod-os`, and its use is described in detail in Chapter 6 of the *OpenStack Deployment Manual*.

Procedure When Running `cm-cod-azure`

Launching a COD inside Azure is carried by running `cm-cod-azure` from within the Docker container that is outside Azure.

Running `cm-cod-azure` from within the Docker container that is outside Azure, launches a COD within Azure.

Options For `cm-cod-azure`: The `cm-cod-azure` command options include the cluster name, node types, credentials, and so on. Running `cm-cod-azure cluster create -h` displays a list of options and explanations for the options.

Some of the options are described in table 2.1:

Option	Example Value
`--azure-client-id`	`afe13723-c80a-68e2-9cd0-e95a657106a`
`--azure-client-secret`	`aiVohwi7OhJ6igim=`
`--azure-tenant-id`	`2c89c8dd-6b8b-5393-60f4-d876cbe188f`
`--azure-subscription-id`	`5e519b1e-aff9-e839-bc3a-c5d87e9d0d5`
`--azure-location`	`westeurope`
<cluster_name>	`noviceazurecluster`
`--node-type`	`Standard_D1_v2`
`--head-node-type`	`Standard_D1_v2`

...continues

...continued

Option	Example Value
`--version`	`9.0`
`--wlm`	`dont-configure`
`--head-node-root-volume-size`	`50`
`--nodes`	`3`
`--ssh-pub-key-path`	`/root/.ssh/id_rsa.pub`
`--license-organization`	`Illuminati`
`--license-unit`	`Eleusis`
`--license-locality`	`Munich`
`--license-state`	`Bavaria`
`--license-country`	`Germany`
`--license-product-key`	`12334-324234-3413413-32-324`

The example values for the credentials given here, if used literally, will not work. They are just to show the rough format of the values.

Table 2.1: `cm-cod-azure` *options*

The first four `-azure-*` options in the preceding table require the actual Azure credentials that the cluster adminstrator obtains from Microsoft.

For the distinguished name values (organization, unit, and so on), the values can be arbitrary, although the administrator may find it useful to have them match the ones set in the product key license.

The `verify-license` utility shows the distinguished name values that were set in the product key license.

For example:

```
[root@bright90 ~]# verify-license /cm/local/apps/cmd/etc/cluster.pem  \
/cm/local/apps/cmd/etc/cluster.key info
========= Certificate Information ========
settings for organization, unit, etc, are displayed
```

It is normally not possible to use the product key of the host cluster itself. So, normally a fresh product key must be used with the `cm-cod-azure` command.

Cluster creation run with `cm-cod-azure`: An example of a `cm-cod-azure` command that can be run is then:

Example

```
cm-cod-azure cluster create                                               \
    --azure-location 'westeurope'                                         \
    --azure-client-id 'afe13723-c80a-68e2-9cd0-e95a657106a'               \
    --azure-client-secret 'aiVohwi7OhJ6igim='                             \
    --azure-tenant-id '2c89c8dd-6b8b-5393-60f4-d876cbe188f'               \
    --azure-subscription-id '5e519b1e-aff9-e839-bc3a-c5d87e9d0d5'         \
    --head-node-type 'Standard_D1_v2' --head-node-root-volume-size '50'   \
    --nodes '3' --node-type 'Standard_D1_v2'                              \
    --ssh-pub-key-path '/root/.ssh/id_rsa.pub'                            \
    --license-product-key '12334-324234-3413413-32-324' 'noviceazurecluster'
```

If all is well, then something similar to the following is displayed (some output elided):

```
13:22:50:     INFO: Credentials are valid and have read/write authorizations
13:23:23:     INFO: Cluster Create
13:23:24:     INFO: ---------------------------------------------------------------------
13:23:24:     INFO:    Cluster:   noviceazurecluster
13:23:24:     INFO: ---------------------------------------------------------------------
13:23:24:     INFO:      Image:   bcm-cod-image-latest-4.vhd
13:23:24:     INFO: Image date:   2018-02-27 09:01:27+00:00
13:23:24:     INFO: Head nodes:   1 (Standard_D1_V2)
13:23:24:     INFO:      Nodes:   3 (Standard_D1_v2)
13:23:24:     INFO:     Region:   westeurope
13:23:24:     INFO:   Key path:   /root/.ssh/id_rsa.pub
13:23:24:     INFO: ---------------------------------------------------------------------
Press ENTER to continue and create the cluster.
Press ctrl+c (or type 'a') to abort. Type 'i' for more info.

13:23:56:     INFO: ## Progress: 2
13:23:56:     INFO: #### stage: Creating resource group noviceazurecluster_cod_resource_group
13:23:58:     INFO: Creating storage account noviceazureclusterstorageaccount
13:24:22:     INFO: ## Progress: 5
13:24:22:     INFO: #### stage: Building deployment template
13:24:22:     INFO: generating cloud-init script
13:24:22:     INFO: ## Progress: 7
13:24:22:     INFO: #### stage: Copying head node image
13:24:22:     INFO: Copying https://brightimages.blob.core.windows.net/images/bcm-cod-image-\
latest-4.vhd to noviceazureclusterstorageaccount/images/noviceazurecluster-head-node-os-disk.vhd
13:24:22:     INFO: ## Progress: 12.0
13:24:22:     INFO: #### stage: Server side copy
13:25:01:     INFO: ## Progress: 12.2
13:25:01:     INFO: #### stage: Server side copy
13:25:05:     INFO: ## Progress: 12.4
13:25:05:     INFO: #### stage: Server side copy
13:25:09:     INFO: ## Progress: 12.6
...
13:35:32:     INFO: #### stage: Server side copy
13:35:35:     INFO: ## Progress: 61.77
13:35:35:     INFO: #### stage: Server side copy
13:35:38:     INFO: ## Progress: 61.97
13:35:38:     INFO: #### stage: Server side copy
13:35:40:     INFO: Elapsed: 11:18 min
13:35:40:     INFO: ## Progress: 85
13:35:40:     INFO: #### stage: Creating and deploying Head node
13:39:53:     INFO: Waiting for CMDaemon to come up
...
13:41:34:     INFO: Waiting for CMDaemon to come up
13:41:34:     INFO: CMDaemon is not up yet, waiting 10 seconds...
13:41:34:     INFO: ## Progress: 100
13:41:34:     INFO: #### stage: Deployment finished successfully.
13:41:34:     INFO: ----------------------------------------------------------------
13:41:34:     INFO:      Cluster:   noviceazurecluster
13:41:34:     INFO: ----------------------------------------------------------------
13:41:34:     INFO:        Image:   bcm-cod-image-latest-4.vhd
13:41:34:     INFO:   Image date:   2018-02-27 09:01:27+00:00
13:41:34:     INFO:   Head nodes:   1 (Standard_D1_V2)
13:41:34:     INFO:        Nodes:   3 (Standard]_D1_v2)
13:41:34:     INFO:       Region:   westeurope
```

```
13:41:34:     INFO:     Key path:   /root/.ssh/id_rsa.pub
13:41:34:     INFO: Head node ID:   3e6d2b24-2c7b-40cb-a594-fb3e66f31319
13:41:34:     INFO:    Public IP:   13.93.90.5
13:41:34:     INFO: ----------------------------------------------------------------
[root@743d346dca20 /]#
```

The cluster can now be logged into by using the SSH keys generated earlier, and using the public IP address shown in the last few lines of the preceding output.

Listing with `cm-cod-azure`**:** The clusters that are running from the container can be listed with their properties, using the credentials, as follows:

Example

```
[root@743d346dca20 /]# cm-cod-azure cluster list                                \
    --azure-location 'westeurope'                                               \
    --azure-client-id 'afe13723-c80a-68e2-9cd0-e95a657106a'                     \
    --azure-client-secret 'aiVohwi7OhJ6igim='                                   \
    --azure-tenant-id '2c89c8dd-6b8b-5393-60f4-d876cbe188f'                     \
    --azure-subscription-id '5e519b1e-aff9-e839-bc3a-c5d87e9d0d5'


+--------------------+-----------------------------+------------+------------+-...
| Cluster Name       | Head node name              | Public IP  | Location   | ...
+--------------------+-----------------------------+------------+------------+-...
| noviceazurecluster | noviceazurecluster-head_node | 13.98.90.5 | westeurope | ...
+--------------------+-----------------------------+------------+------------+-...
```

Removal with `cm-cod-azure` A cluster can be removed from the container with:

```
[root@743d346dca20 /]# cm-cod-azure cluster delete                                  \
        --azure-location 'westeurope'                                               \
        --azure-client-id 'afe13723-c80a-68e2-9cd0-e95a657106a'                     \
        --azure-client-secret 'aiVohwi7OhJ6igim='                                   \
        --azure-tenant-id '2c89c8dd-6b8b-5393-60f4-d876cbe188f'                     \
        --azure-subscription-id '5e519b1e-aff9-e839-bc3a-c5d87e9d0d5'               \
        'noviceazurecluster'
```

Procedure When Running `cm-cod-aws`

Launching a COD from within AWS is carried by running `cm-cod-aws` from within the Docker container. This process is similar to that of launching within Azure (page 15).

Options For `cm-cod-aws`**:** The `cm-cod-aws` command takes options to create a cluster. Running `cm-cod-aws cluster create -h` displays a list of options and explanations for the options.

Some of the options are described in table 2.2:

Table 2.2: `cm-cod-aws` *options*

Option	Example Value

...continues

...continued

Option	Example Value
`--aws-region`	`eu-central-1`
`--aws-secret-key`	`Oocei6eiieshahG7IiJe9QuoudOoo`
`--aws-access-key-id`	`AKIAJAICHAZI7OHH1EEGO`
`--head-node-type`	`t2.medium`
`--node-type`	`t2.medium`
`--license-product-key`	`12334-324234-3413413-32-324`
`--cluster-password`	`justinbieberrocks`
`--log-cluster-password`	*does not take a value*
`--ssh-pub-key-path`	`/root/.ssh/id_rsa.pub`
`--nodes`	`3`
<*cluster_name*> `[...]`	`noobawscluster`

The example values for the credentials given here, if used literally, will not work. They are just to show the rough format of the values.

The `--aws-secret-key` and `--aws-access-key-id` options in the preceding table require the actual AWS credentials that the cluster adminstrator obtains from Amazon.

Setting a root password via the `--cluster-password` option is a possible way to configure a login to the cluster. Another possibility is to use ssh keys. The keys generated within the docker instance using `ssh-keygen` earlier on can be used for this.

The password can be seen in the logs of the command if the `--log-cluster-password` option is used.

If the root password is not set with `--cluster-password`, then a random password is set, and ssh keys can be used to login to the cluster. A root password can always be specified later using `cm-change-password`, after logging into the cluster via SSH key access or the root password. The default login to Bright View also uses the root password.

For the product key of cluster in AWS, it is normally not possible to use the product key of the host cluster itself. So, normally a fresh product key must be used with the `cm-cod-azure` command.

Cluster creation run with `cm-cod-aws`: An example of a `cm-cod-aws` command that can be run is then:

Example

```
cm-cod-aws cluster create                                             \
    --aws-region 'eu-central'                                         \
    --aws-secret-key 'Oocei6eiieshahG7IiJe9QuoudOoo'                  \
    --aws-access-key-id 'AKIAJAICHAZI7OHH1EEGO'                       \
    --nodes '3' --node-type 't2.medium'                               \
    --ssh-pub-key-path '/root/.ssh/id_rsa.pub'                        \
    --license-product-key '12334-324234-3413413-32-324' 'noobawscluster'
```

If all is well, then the output is similar to (some output elided):

```
12:06:57:    INFO: ---------------------------------------------------------------------
12:06:57:    INFO:    Cluster:   noobawscluster
12:06:57:    INFO: ---------------------------------------------------------------------
12:06:57:    INFO:      Image:   brightheadnode-latest-centos7u4-hvm-3 (ami-71691308)
12:06:57:    INFO: Image date:   2018-02-26 16:10 (27d 19h ago)
12:06:57:    INFO: Head nodes:   1 (t2.medium)
12:06:57:    INFO:      Nodes:   5 (t2.medium)
```

```
12:06:57:     INFO:     Region:   eu-west-1
12:06:57:     INFO: ssh pub key:   /root/.ssh/id_rsa.pub
12:06:57:     INFO: ---------------------------------------------------------------------
Press ENTER to continue and create the cluster.
Press ctrl+c (or type 'a') to abort. Type 'i' for more info.

12:07:01:     INFO: ## Progress: 2
12:07:01:     INFO: #### stage: Setting up VPC
12:07:01:     INFO: ## Progress: 5
12:07:01:     INFO: #### stage: Creating VPC for noobawscluster in eu-west-1...
12:07:02:     INFO: ## Progress: 10
12:07:02:     INFO: #### stage: Adding internet connectivity...
12:07:03:     INFO: ## Progress: 12
12:07:03:     INFO: #### stage: Creating public subnet...
12:07:04:     INFO: ## Progress: 16
12:07:04:     INFO: #### stage: Creating head node (t2.medium)...
12:07:04:     INFO: ## Progress: 20
12:07:04:     INFO: #### stage: Public key specified, no need to enable password authentication
12:07:04:     INFO: Scheduling cm-bright-setup.
12:07:06:     INFO: ## Progress: 22
12:07:06:     INFO: #### stage: Done setting up VPC for noobawscluster.
12:07:06:     INFO: ## Progress: 22
12:07:06:     INFO: #### stage: Starting head nodes...
12:07:06:     INFO: ## Progress: 30
12:07:06:     INFO: #### stage: Waiting for head nodes to start...
12:07:38:     INFO: ## Progress: 30
12:07:38:     INFO: #### stage: Wait for cloud-init to finish on cluster noobawscluster...
12:07:43:     INFO: ## Progress: 30
12:07:43:     INFO: #### stage: Cloud-init is not finished, waiting 10 seconds...
12:07:53:     INFO: ## Progress: 30
...
12:10:34:     INFO: #### stage: Cloud-init is not finished, waiting 10 seconds...
12:10:44:     INFO: ## Progress: 30
12:10:44:     INFO: #### stage: Wait for cloud-init to finish on cluster noobawscluster...
12:10:44:     INFO: ## Progress: 100
12:10:44:     INFO: #### stage: Deployment of cluster: noobawscluster finished successfully.
12:10:54:     INFO: Script completed.
12:10:54:     INFO: ---------------------------------------------------------------------
12:10:54:     INFO: Time it took:   03:52
12:10:54:     INFO:   SSH string:   ssh root@52.30.93.49
52.30.93.49 noobawscluster
12:10:54:     INFO: Head node ID:   i-0120058780aa736eb
[root@256ac248b583 /]# ssh root@52.30.93.49
```

At this point, the head node running on AWS is ready for use. It can be accessed via ssh, as suggested in the last line of the preceding output.

The regular nodes running on AWS are configured for use, but are not powered on. They can be powered on using the cmsh or Bright View front ends, just as in a regular cluster.

From cmsh, the first cloud node can be powered on with, for example:

```
[noobawscluster->device]% power on cnode001
```

Listing with cm-cod-aws: The clusters that are running from the container can be listed with their properties, using the credentials with the region, as follows:

Example

```
[root@743d346dca20 /]# cm-cod-aws cluster list                            \
    --aws-region 'eu-west-1'                                              \
    --aws-secret-key 'Oocei6eiieshahG7IiJe9QuoudOoo'                      \
    --aws-access-key-id 'AKIAJAICHAZI7OHH1EEGO'                           \
    --license-product-key '12334-324234-3413413-32-324'

+--------------------+------------------------------+-------------+
| Cluster Name       | Head node name               | VPC ID      |...
+--------------------+------------------------------+-------------+
| noobawscluster     | noobawscluster-head_node     | vpc-as89ada |...
+--------------------+------------------------------+-------------+
```

Removal with `cm-cod-aws` A cluster can be removed from the container with:

```
[root@743d346dca20 /]# cm-cod-aws cluster delete                       \
    --aws-region 'eu-west-1'                                           \
    --aws-secret-key 'Oocei6eiieshahG7IiJe9QuoudOoo'                   \
    --aws-access-key-id 'AKIAJAICHAZI7OHH1EEGO'                        \
    --license-product-key '12334-324234-3413413-32-324'                \
    noobawscluster
```

2.4 Using The AWS EC2 Management Console

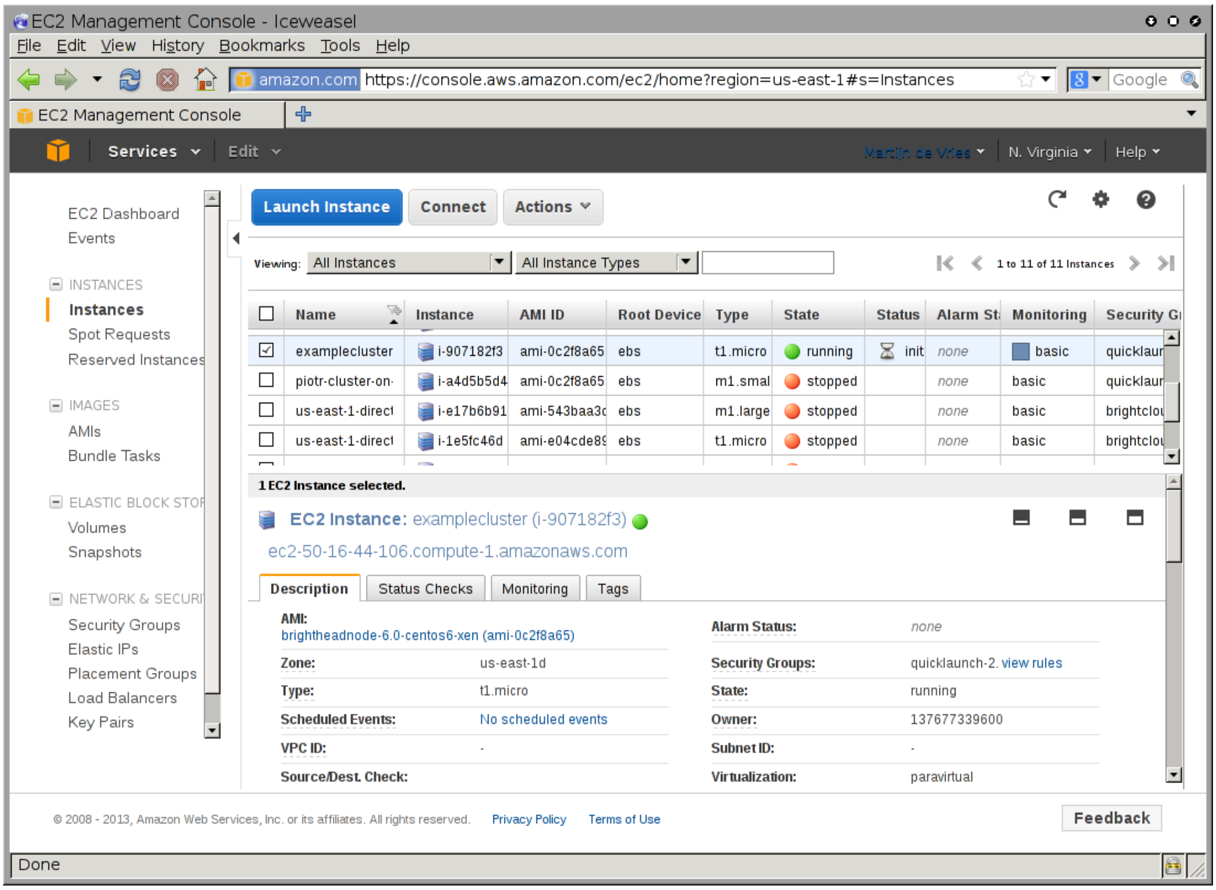
The recommended way of managing COD is using Bright View via its public IP address, or by using `cmsh` via the head node (section 2.4.5). This section (section 2.4) describes how the Amazon management console can also be used, to manage some AWS aspects of the instance.

A login is possible from `https://console.aws.amazon.com/console/` by using the e-mail address and password of the associated AWS root account, or AWS IAM user account.

The head node instance can be watched and managed without Bright Cluster Manager in the following ways.

2.4.1 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 2.6).



☐	Name	Instance	AMI ID	Root Device	Type	State	Status	Alarm St	Monitoring	Security Gr
☑	examplecluster	i-907182f3	ami-0c2f8a65	ebs	t1.micro	● running	⌛ init	none	basic	quicklaun
☐	piotr-cluster-on-	i-a4d5b5d4	ami-0c2f8a65	ebs	m1.smal	● stopped		none	basic	quicklaun
☐	us-east-1-direct	i-e17b6b91	ami-543baa3c	ebs	m1.large	● stopped		none	basic	brightclou
☐	us-east-1-direct	i-1e5fc46d	ami-e04cde89	ebs	t1.micro	● stopped		none	basic	brightclou

1 EC2 Instance selected.

EC2 Instance: examplecluster (i-907182f3) ●

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

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

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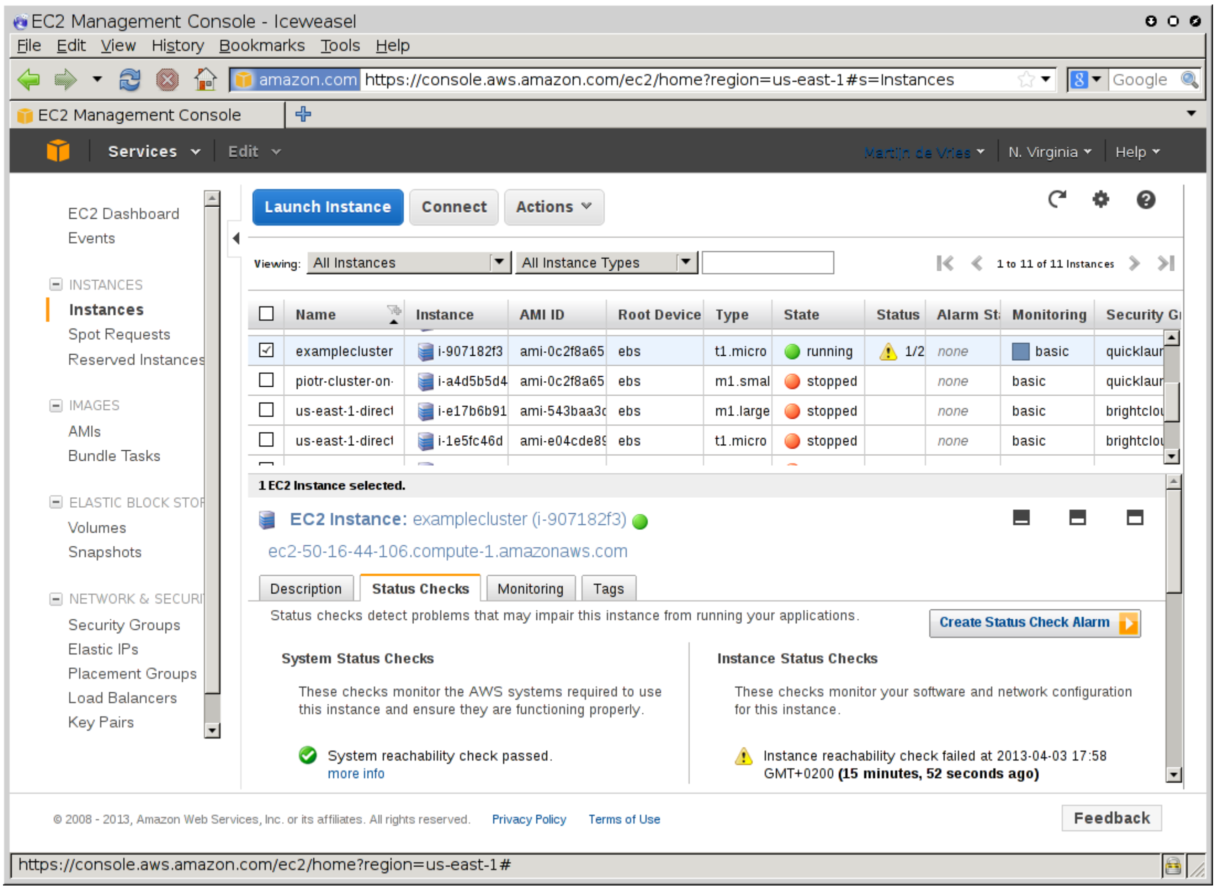
Figure 2.6: The EC2 Instances List

System (Amazon machine infrastructure) and instance (instance running under the infrastructure) reachabilities are similarly shown under the neighboring "Status Checks" tab (figure 2.7).



☐	Name	Instance	AMI ID	Root Device	Type	State	Status	Alarm St	Monitoring	Security Gi
☑	examplecluster	i-907182f3	ami-0c2f8a65	ebs	t1.micro	● running	⚠ 1/2	none	basic	quicklaur
☐	piotr-cluster-on·	i-a4d5b5d4	ami-0c2f8a65	ebs	m1.smal	● stopped		none	basic	quicklaur
☐	us-east-1-direct	i-e17b6b91	ami-543baa3c	ebs	m1.large	● stopped		none	basic	brightclou
☐	us-east-1-direct	i-1e5fc46d	ami-e04cde89	ebs	t1.micro	● stopped		none	basic	brightclou

1 EC2 Instance selected.

EC2 Instance: examplecluster (i-907182f3) ●

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

Status checks detect problems that may impair this instance from running your applications.

System Status Checks

These checks monitor the AWS systems required to use this instance and ensure they are functioning properly.

✓ System reachability check passed.
more info

Instance Status Checks

These checks monitor your software and network configuration for this instance.

⚠ Instance reachability check failed at 2013-04-03 17:58 GMT+0200 (**15 minutes, 52 seconds ago**)

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Figure 2.7: Reachability Status For An EC2 Instance

2.4.2 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.

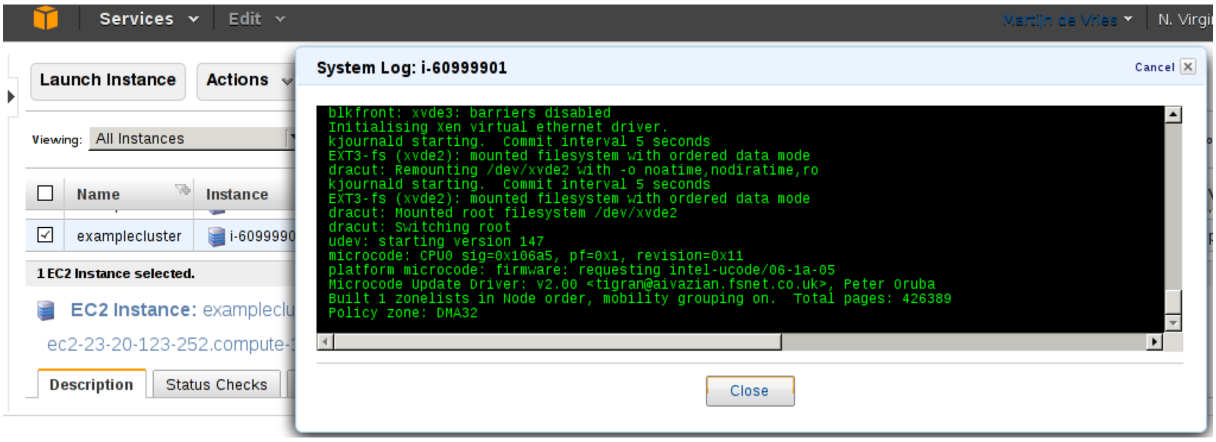
2.4.3 Connecting To An Instance From The AWS EC2 Management Console

A marked and running instance can have an SSH connection made to it.

As in the Azure case, for most users this means running ssh to the public IP address as suggested at the end of the AWS COD cluster creation run (page 16). This is assuming the private ssh key that was generated by the ssh-keygen command in the container is used for the ssh connection, which may mean that copying it out of the container is needed.

2.4.4 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 2.8). A successful start of the system generates a log with a tail similar to that of figure 2.8.



```
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/xvde2 with -o noatime,nodiratime,ro
kjournald starting.  Commit interval 5 seconds
EXT3-fs (xvde2): mounted filesystem with ordered data mode
dracut: Mounted root filesystem /dev/xvde2
dracut: Switching root
udev: starting version 147
microcode: CPU0 sig=0x106a5, pf=0x1, revision=0x11
platform microcode: firmware: requesting intel-ucode/06-1a-05
Microcode Update Driver: v2.00 <tigran@aivazian.fsnet.co.uk>, Peter Oruba
Built 1 zonelists in Node order, mobility grouping on.  Total pages: 426389
Policy zone: DMA32
```

Figure 2.8: System Log Of The Checkboxed Instance

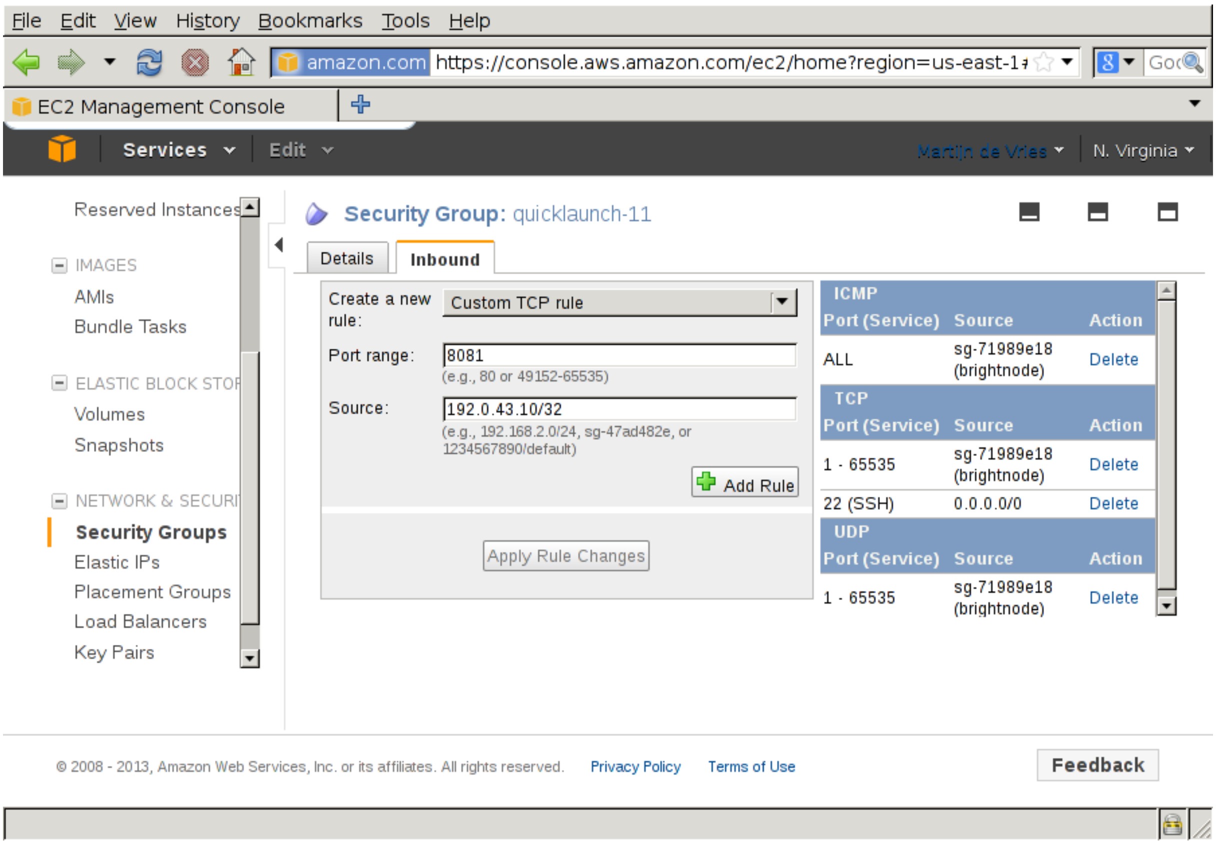
A screenshot of the instance is also possible by right-clicking on the selected instance, then following the clickpath `Instance Settings`→`Get Instance Screenshot`.

2.4.5 Security Group Configuration To Allow Access To The Head Node Via `cmsh` Or Bright View

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 2.9. Security groups can also be accessed from the navigation menu on the left side of the EC2 Management Console.

COD With AWS: Access With Bright View:

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 2.9).



Security Group: quicklaunch-11

Create a new rule: Custom TCP rule

Port range: 8081
(e.g., 80 or 49152-65535)

Source: 192.0.43.10/32
(e.g., 192.168.2.0/24, sg-47ad482e, or 1234567890/default)

Port (Service)	Source	Action
ICMP		
ALL	sg-71989e18 (brightnode)	Delete
TCP		
1 - 65535	sg-71989e18 (brightnode)	Delete
22 (SSH)	0.0.0.0/0	Delete
UDP		
1 - 65535	sg-71989e18 (brightnode)	Delete

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Figure 2.9: Security Group Network And Port Access Restriction

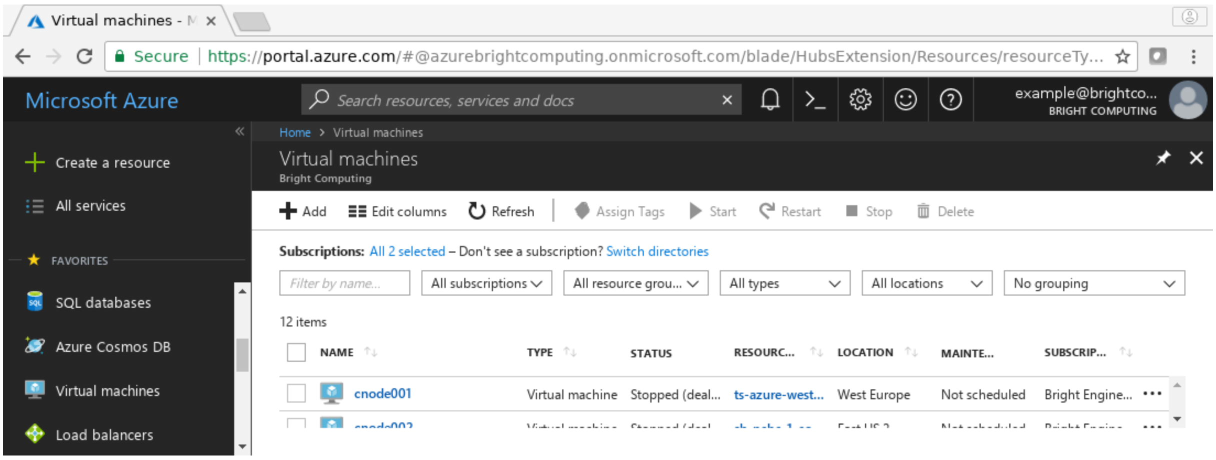
- To allow only a specific network block to access the instance, the network from which remote connections are allowed can be specified in CIDR format.
- By default, port 8081 is open on the head node to allow Bright View (section 2.4 of the *Administrator Manual*) to connect to the head node. This is because the Bright View back end, which is CMDaemon, communicates via port 8081.

COD With AWS: 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 should work without lag.

2.5 Using The Azure Dashboard

For Azure, as is the case for AWS, the cluster is normally expected to be managed via Bright View or `cmsh`. Sometimes when carrying out some special configurations, there may be a need to manage the cluster objects directly via the portal at `https://portal.azure.com`. This requires an Azure login and password, which opens up the Azure dashboard, and allows the objects to be viewed and managed.

For example, the virtual machines of the COD can be viewed and managed via the `Virtual machines` resource (figure 2.10), and the virtual networks associated with the COD nodes can similarly be viewed and managed via `Virtual networks` resource.



Subscriptions: All 2 selected – Don't see a subscription? Switch directories

Filter by name... | All subscriptions | All resource grou... | All types | All locations | No grouping

12 items

NAME	TYPE	STATUS	RESOURC...	LOCATION	MAINTE...	SUBSCRIP...
cnode001	Virtual machine	Stopped (deal...	ts-azure-west...	West Europe	Not scheduled	Bright Engine...
cnode002	Virtual machine	Stopped (deal...	[illegible]	East US 2	Not scheduled	Bright Engine...

Figure 2.10: Viewing Virtual Machines In A Cluster On Demand In Azure

Some items that may be useful when accessing the portal:

- An overview of the COD head node is possible via the clickpath:

  `Home`→`Virtual machines`→<*head node*>→`Overview`

- Boot process diagnostics can be viewed using the clickpath:

  `Home`→`Virtual machines`→<*head node*>→`Boot diagnostics`→`Serial log`

- A serial console can be accessed the clickpath:

  `Home`→`Virtual machines`→<*head node*>→`Serial console`

  The file `/etc/ssh/sshd_config` should have the parameter `ChallengeResponseAuthentication` set to `yes`, and the service restarted, for serial console login to work.

2.6 COD: 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-cod-aws` or `cm-cod-azure` script which is run in the Docker instance. In the preceding example the cloud node objects are `cnode001` and `cnode002`.

However, more cloud node objects can be created if needed after the scripts have 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 Bright View they can conveniently be cloned via the clickpath:

  `Devices`→`Cloud Nodes`→<*cloud node*>↓`Clone`→<*number*>

- In `cmsh` a large number of cloud node objects can conveniently be created with the "`foreach --clone`" command instead, as described in section 4.2.

After creation, an individual cloud node, <*cloud node*>, can be powered up from within Bright View via the clickpath:

`Devices`→`Cloud Nodes`→<*cloud node*>↓`Power`→`On`

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

Example

```
[head1->device]% power status
cloud ................. [  FAILED ] cnode001 (Cloud instance ID not set)
cloud ................. [  FAILED ] cnode002 (Cloud instance ID not set)
No power control ...... [ UNKNOWN ] head1
[head1->device]% power on -n cnode001
cloud ................. [   ON    ] cnode001
[head1->device]% power status
cloud ................. [   OFF   ] cnode001 (pending)
cloud ................. [  FAILED ] cnode002 (Cloud instance ID not set)
No power control ...... [ UNKNOWN ] head1
[head1->device]% power on -n cnode002
cloud ................. [   ON    ] cnode002
[head1->device]% power status
cloud ................. [   ON    ] cnode001 (running)
cloud ................. [   OFF   ] cnode002 (pending)
No power control ...... [ UNKNOWN ] head1
[head1->device]% !ping -c1 cnode001
ping: unknown host cnode001
[head1->device]% status
head1 .................... [   UP   ]
node001 .................. [   UP   ]
node002 .................. [  DOWN  ]
[head1->device]% !ping -c1 cnode001
PING cnode001.cm.cluster (10.234.226.155) 56(84) bytes of data.
64 bytes from cnode001.cm.cluster (10.234.226.155): icmp_seq=1 ttl=63 t\
ime=3.94 ms
```

Multiple cloud nodes can be powered up at a time in cmsh with the "power on" command using ranges and other options (section 4.2.3 of the *Administrator Manual*).

2.6.1 COD: IP Addresses In The Cloud

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

2.7 COD With AWS: Optimizing AWS For High Performance Computing (HPC)

Optimization of cloud nodes for HPC in AWS is discussed in section 3.5.

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. Thus, the head node in a Cluster Extension configuration is always outside the cloud, and there may be some non-cloud-extension regular nodes that are outside the cloud too.

Cluster Extension cloudbursting can burst into a cloud that is running within:

- AWS (CX-AWS). This is described in Chapters 3 and 4 of the *Cloudbursting Manual*.
- Azure (CX-Azure). This is described in Chapter 5 of the *Cloudbursting Manual*.
- OpenStack (CX-OS). This is described in Chapter 6.

Requirements

Cluster Extension cloudbursting requires:

- **An activated cluster license.**

  One does not simply cloudburst right away in a Cluster Extension configuration. The license must first be made active, or the attempt will fail.

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

  Example

```
[root@bright90 ~]# cmsh -c "main; licenseinfo"
License Information
----------------------------------  ----------------------------------------
Licensee                           /C=US/ST=NY/L=WS/O=Bright
                                   Mordor/OU=Mt. Doom/CN=Bright 9.0 Cluster
Serial Number                      1210883
Start Time                         Mon Oct 16 01:00:00 2017
End Time                           Fri Dec 31 23:59:00 2038
Version                            7.0 and above
Edition                            Advanced
Type                               Commercial
Pre-paid Nodes                     100
Pay-per-use Nodes                  yes
Data Science Nodes                 80
Node Count                         6
Allow edge sites                   Yes
Accelerator Node Count             0
MAC Address / Cloud ID             FA:16:3E:DE:A4:35
```

The value of `End Time`, `Pre-paid Nodes`, and `Pay-per-use Nodes` in the preceding license should be checked. Pre-paid nodes are nodes that may be started without incurring any additional charges. Pay-per-use nodes are nodes that incur additional charges when started. Both pre-paid and pay-per-use can be on-premise or off-premise. That is, both kinds can be used for cluster extension cloudbursting.

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 given in Chapter 4 of the *Installation Manual*.

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

- **An Azure account**, if the cloud provider is Microsoft Azure.

- **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, the Shorewall firewall 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.

- **A special proxy environment configuration setting**, if an HTTP proxy is used to access the AWS or Azure APIs.

  The proxy environment configuration is carried out using the `ScriptEnvironment` directive (page 717 of the *Administrator Manual*), which is a CMDaemon directive that can be set and activated (page 699 of the *Administrator Manual*).

  For example, if the proxy host is `my.proxy` and accepting connections on port `8080` with a username `my` and password `pass`, then the setting can be specified as:

```
ScriptEnvironment = { "http_proxy=http://my:pass@my.proxy:8080", \
"https_proxy=http://my:pass@my.proxy:8080", "ftp_proxy=http://my:pass@my.proxy:8080" }
```

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 Bright View, 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".

Cluster Extension Cloudbursting Logging

All AWS logging goes to the CMDaemon log in `/var/log/cmdaemon`. The `CLOUD` tag in the log is used to indicate cloud-related operations.

3.1 Cluster Extension With AWS: The Bright View Cluster Extension Wizard

Cluster Extension with the Bright View cluster extension wizard is described in sections 3.1, 3.2, and 3.3.

Cluster Extension with Azure is described in Chapter 5.

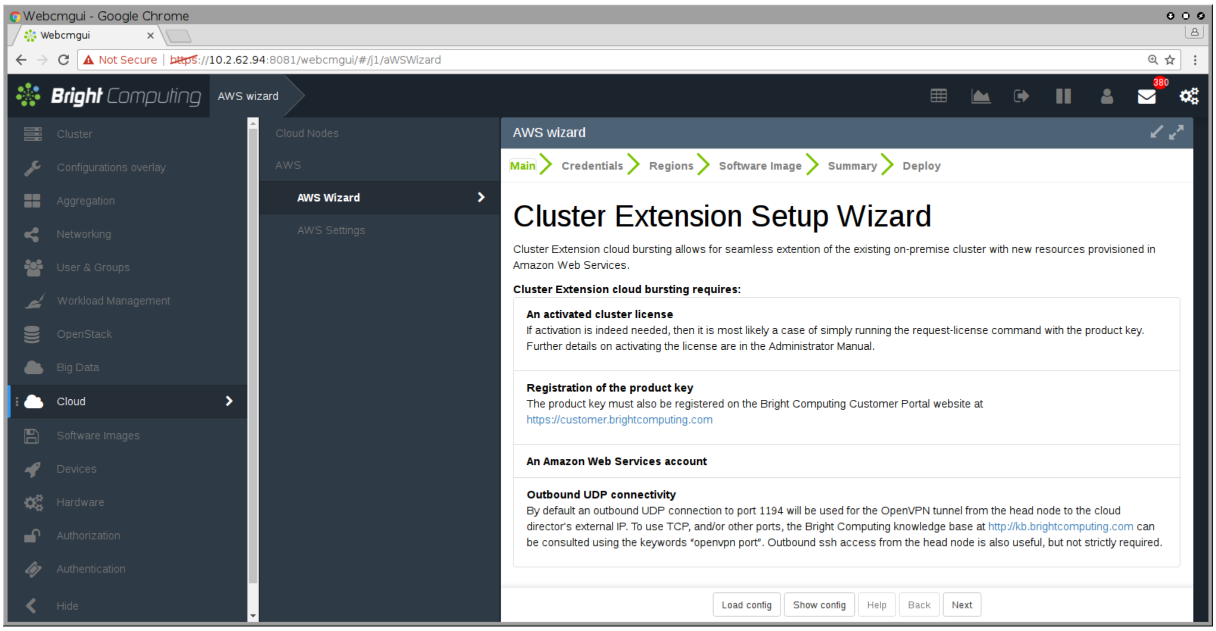
The Amazon cloud service can be configured for Cluster Extension from Bright View. This can be done via the URL `https://`<*head node address*>`:8081/bright-view/`, and then selecting the clickpath `Cloud`→`AWS`→`AWS Wizard`. A screen introducing the `AWS Wizard` is then displayed.

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 3.1.5)
5. Deploy (section 3.1.6)

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.



Cluster Extension Setup Wizard

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:

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.

Registration of the product key
The product key must also be registered on the Bright Computing Customer Portal website at https://customer.brightcomputing.com

An Amazon Web Services account

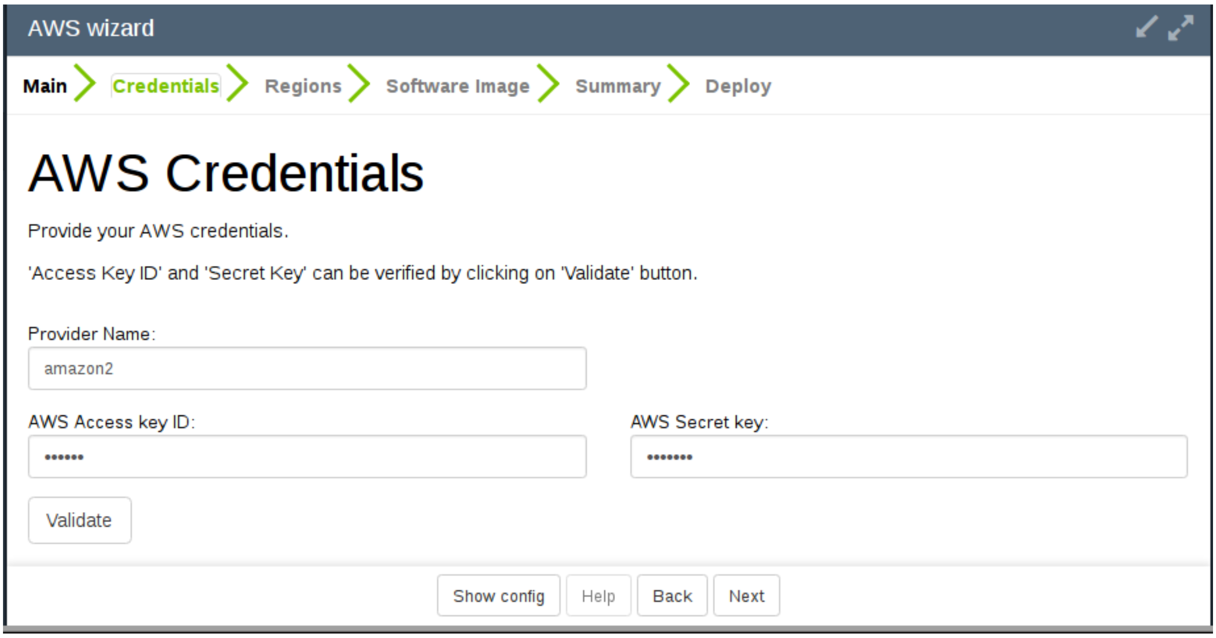
Outbound UDP connectivity
By default an outbound UDP connection to port 1194 will be used for the OpenVPN tunnel from the head node to the cloud director's external IP. To use TCP, and/or other ports, the Bright Computing knowledge base at http://kb.brightcomputing.com can be consulted using the keywords "openvpn port". Outbound ssh access from the head node is also useful, but not strictly required.

Figure 3.1: Introduction Page For Cluster Extension With Bright View

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).



AWS Credentials

Provide your AWS credentials.

'Access Key ID' and 'Secret Key' can be verified by clicking on 'Validate' button.

Provider Name: amazon2

AWS Access key ID: ••••••

AWS Secret key: •••••••

Figure 3.2: AWS Key Configuration For Cluster Extension With Bright View

This asks for:

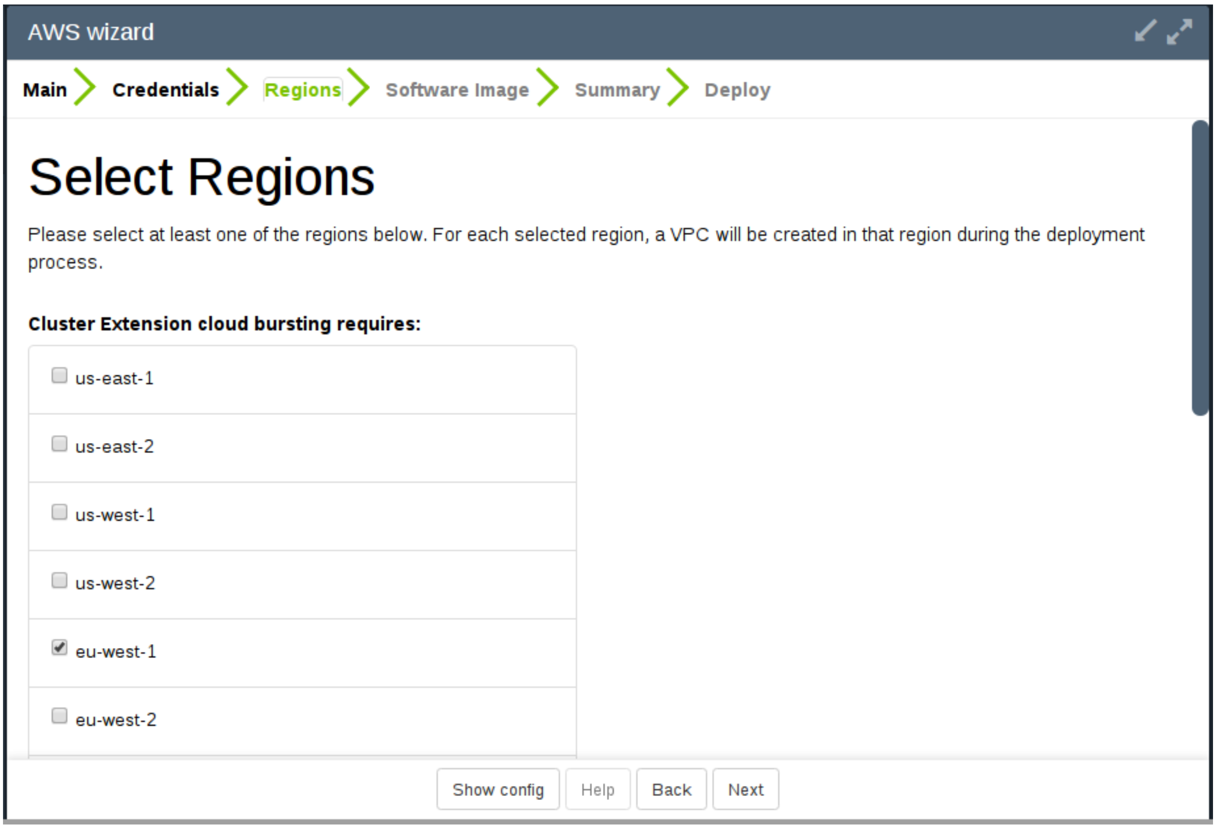
- Provider Name: This is can be any user-defined value. If using Amazon, it would be sensible to just put in amazon
- AWS Access key ID: The AWS Access key. Typically a string that is a mixture of upper case letters and numbers.
- AWS Secret key: The AWS secret key. Typically a longer string made up 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 Validate button validates the credentials at this point of the configuration when clicked, instead of waiting until the actual deployment. Clicking the Next button submits the details of this screen, and inputs for the next screen are then retrieved from Amazon.

3.1.3 Select Regions

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



Select Regions

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.

Cluster Extension cloud bursting requires:

- □ us-east-1
- □ us-east-2
- □ us-west-1
- □ us-west-2
- ☑ eu-west-1
- □ eu-west-2

Figure 3.3: Selecting Regions For The Cluster Extension Wizard With Bright View

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.

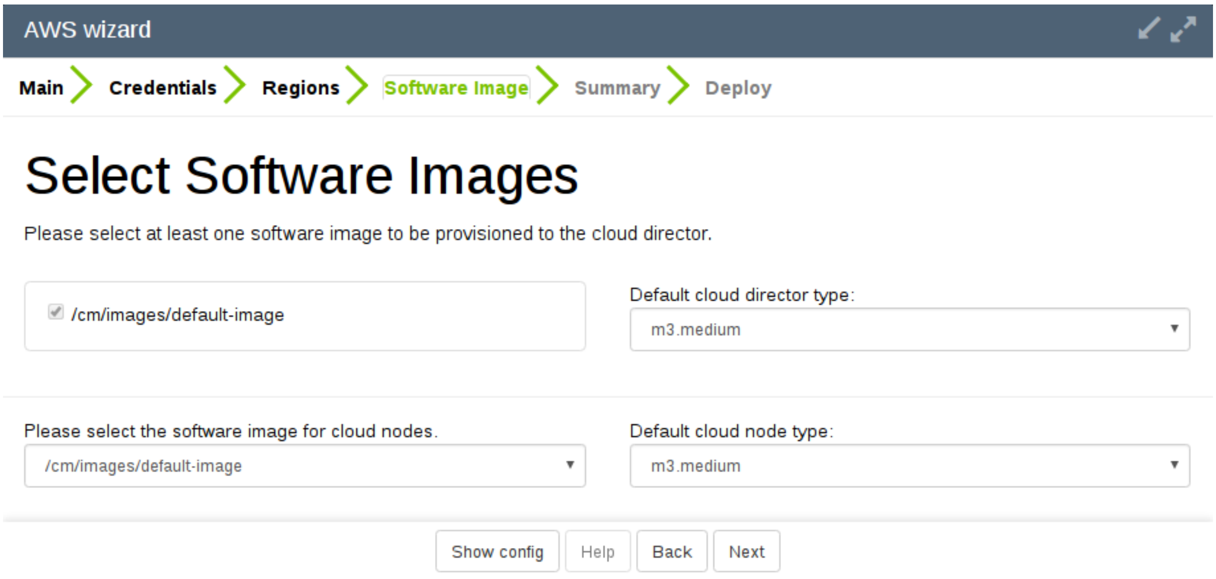
Further details on regions can be found at `http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-regions-availability-zones.html`.

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 Select Software Images

The Select Software Images screen (figure 3.4) lets the administrator select possible cloud node software images to be placed on the cloud director node. These can then be provisioned from the director to the cloud nodes. A default cloud node image is selected from one of the possible cloud node software images.

The cloud director virtual hardware type and cloud node virtual hardware type can also be selected in this screen.



Select Software Images

Please select at least one software image to be provisioned to the cloud director.

☑ /cm/images/default-image

Default cloud director type: m3.medium ▾

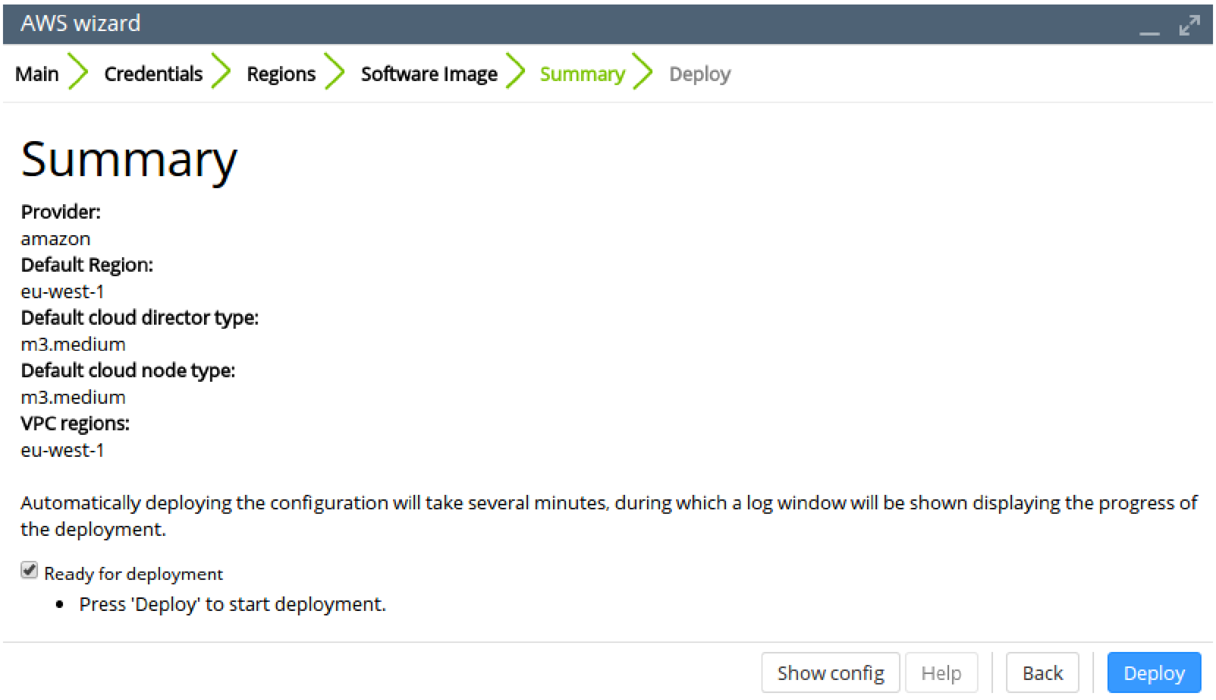
Please select the software image for cloud nodes. /cm/images/default-image ▾

Default cloud node type: m3.medium ▾

Figure 3.4: Selecting Software Images The Cluster Extension Wizard With Bright View

3.1.5 Summary & Deployment

The next screen is a Summary screen (figure 3.5).



Summary

Provider:
amazon
Default Region:
eu-west-1
Default cloud director type:
m3.medium
Default cloud node type:
m3.medium
VPC regions:
eu-west-1

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

☑ Ready for deployment

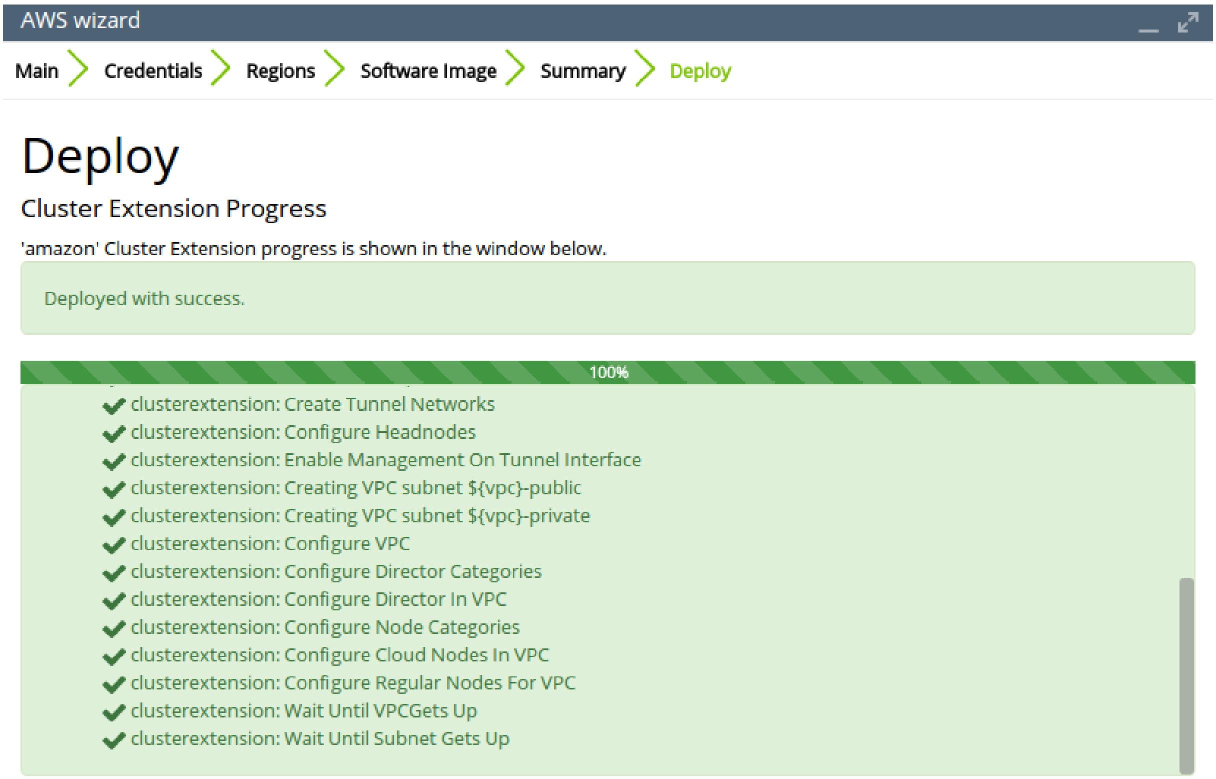
- Press 'Deploy' to start deployment.

Figure 3.5: Summary Screen For The Cluster Extension Wizard With Bright View

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, by directly clicking on the values. Otherwise, on clicking the Deploy button, the configuration is deployed.

3.1.6 Deploy

During configuration deployment, a progress meter indicates what is happening as the configuration is processed. At the end of processing, the display indicates with the `Deployed with success` message that the cluster has been extended successfully (figure 3.6).



Deploy

Cluster Extension Progress

'amazon' Cluster Extension progress is shown in the window below.

Deployed with success.

✓ clusterextension: Create Tunnel Networks
✓ clusterextension: Configure Headnodes
✓ clusterextension: Enable Management On Tunnel Interface
✓ clusterextension: Creating VPC subnet ${vpc}-public
✓ clusterextension: Creating VPC subnet ${vpc}-private
✓ clusterextension: Configure VPC
✓ clusterextension: Configure Director Categories
✓ clusterextension: Configure Director In VPC
✓ clusterextension: Configure Node Categories
✓ clusterextension: Configure Cloud Nodes In VPC
✓ clusterextension: Configure Regular Nodes For VPC
✓ clusterextension: Wait Until VPCGets Up
✓ clusterextension: Wait Until Subnet Gets Up

Figure 3.6: Cluster Extension Configuration Processing With Bright View

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 (section 3.3).

3.2 Cluster Extension With AWS: 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 Bright View event log viewer (section 12.2.11 of the *Administrator Manual*), or they can be followed in an open `cmsh` session, as the events are sent to the `cmsh` session.

The 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 bottleneck 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 wizard (section 3.1).

There can be only one cloud director per region. Because a cloud director also has properties specific to the region within which it directs nodes, it means that cloud directors can only be created from scratch, via cluster extension.

Once a cloud director object has been made in CMDaemon, then the cloud director is ready to be started up. In Bright View the cloud director can be started by powering it up from its node settings, just like a regular node. If the cloud director node is not visible, then a browser refresh should clear up the cache so that it becomes visible. For the cloud director a clickpath to power it up is:

`Devices→Cloud Nodes→Cloud director→↓Power→On`

As indicated earlier on, 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 can be viewed and edited via the clickpath:

`Devices→Cloud Nodes→Cloud director→Edit`

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 (May 2017), 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 director instance type is essential, and contains so much data, it is rare to use an ephemeral device for its storage.

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 Bright View, this can be done in the EC2 Storages window, which for a cloud director <*cloud director hostname*> can be viewed and modified via the clickpath:

  Devices→Cloud Nodes→<*cloud director hostname*>→Edit→Settings→Cloud settings→STORAGE→Storage→<*storage type*>→Edit

- 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

  ```
  [bright90]% device use us-east-1-director
  [bright90->device[us-east-1-director]]% cloudsettings
  [bright90->device[us-east-1-director]->cloudsettings]% storage
  [bright90->...->cloudsettings->storage]% list
  Type       Name (key)   Drive     Size    Volume ID
  ---------- ------------ --------- ------- ----------
  ebs        ebs          sdb       42GB
  ephemeral  ephemeral0   sdc       0B      ephemeral0
  [bright90->...->cloudsettings->storage]% remove ebs
  [bright90->...->cloudsettings*->storage*]% set ephemeral0 drive sdb
  [bright90->...->cloudsettings*->storage*]% list
  Type       Name (key)   Drive     Size    Volume ID
  ---------- ------------ --------- ------- ---------
  ephemeral  ephemeral0   sdb       0B      ephemeral0
  [bright90->...->cloudsettings*->storage*]% commit
  ```

3.2.2 Setting The Cloud Director Disk Size

The disk size for the cloud director can be set in Bright View using the EC2 Storages window (section 3.2.1).

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 <*cloud director*> can be followed by watching the status of the instance in the Amazon EC2 management console, as illustrated in figure 2.7. The Instance ID that is used to identify the instance can be found

- with Bright View, within the clickpath
  Devices→Cloud Nodes→<*cloud director*>→Edit→Settings→Cloud settings→Instance ID

- with cmsh, by running something like:

  Example

  ```
  [bright90]% device use us-east-1-director
  [bright90->device[us-east-1-director]]% get cloudid
  i-f98e7441
  [bright90->device[us-east-1-director]]% cloudsettings
  [bright90->device[us-east-1-director]-cloudsettings]% get instanceid
  i-f98e7441
  ```

Tracking Cloud Director Startup From Bright View

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

- watching the icon changes for the cloud node states in the clickpath Devices→Cloud Nodes. The icons indicating the state follow the description given in section 5.5.1 of the *Administrator Manual*

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@bright90 ~]# ps uww -C rsync | grep -o ' /cm/.*$'
 /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@bright90 ~]# 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@bright90 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s):        4
Source node:          bright90
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@bright90 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s):        5
Source node:          bright90
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 With AWS: 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. Regular cloud nodes are the cloud nodes that the cloud director starts up.

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

Creation and configuration of regular cloud node objects is conveniently carried out by cloning another regular cloud node from one of the default cloud nodes already created by the cluster extension wizard (section 3.1). A clickpath is:

`Device`→`Cloud Nodes`→<*cloud node hostname*>→↓`Clone`

Cloud node objects can also be created in `cmsh` as described in section 4.2.

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.

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 With AWS: 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.

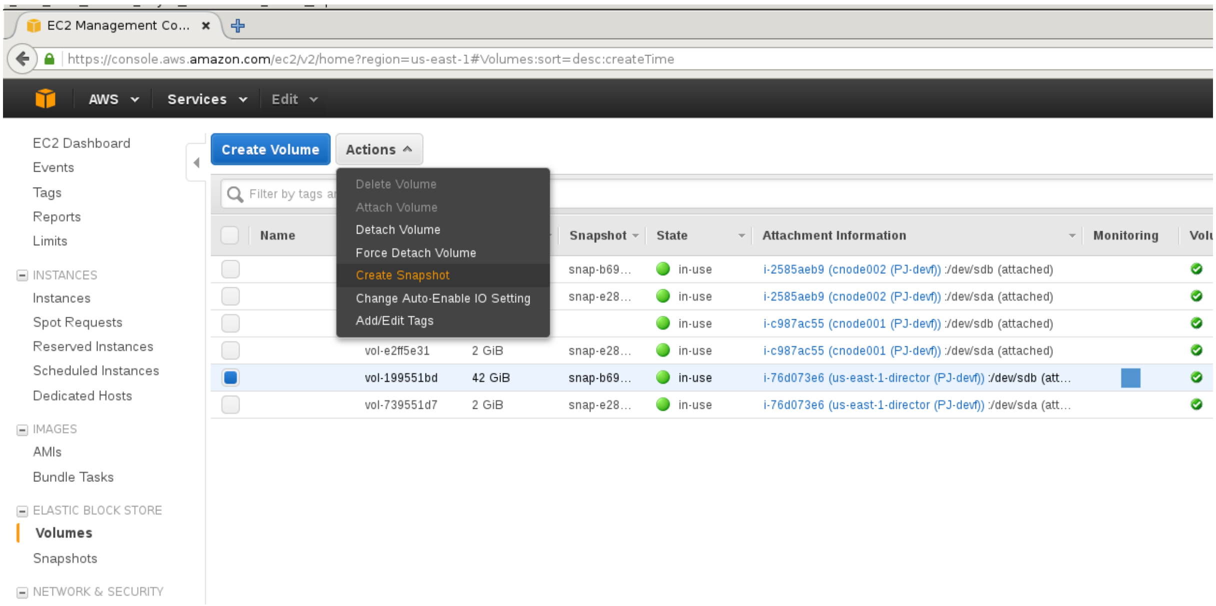
3.4.1 Cloud Director Startup From Snapshots

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 3.7).



☐	Name			Snapshot	State	Attachment Information	Monitoring	Volu
☐				snap-b69...	in-use	i-2585aeb9 (cnode002 (PJ-devf)) :/dev/sdb (attached)		✓
☐				snap-e28...	in-use	i-2585aeb9 (cnode002 (PJ-devf)) :/dev/sda (attached)		✓
☐					in-use	i-c987ac55 (cnode001 (PJ-devf)) :/dev/sdb (attached)		✓
☐		vol-e2ff5e31	2 GiB	snap-e28...	in-use	i-c987ac55 (cnode001 (PJ-devf)) :/dev/sda (attached)		✓
☑		vol-199551bd	42 GiB	snap-b69...	in-use	i-76d073e6 (us-east-1-director (PJ-devf)) :/dev/sdb (att...		✓
☐		vol-739551d7	2 GiB	snap-e28...	in-use	i-76d073e6 (us-east-1-director (PJ-devf)) :/dev/sda (att...		✓

Figure 3.7: 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

  ```
  [bright90->device[us-east-1-director]]% 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@bright90 ~]# cmsh
  [bright90]% device
  [bright90->device]% use us-east-1-director
  [bright90->device[us-east-1-director]]% cloudsettings
  [bright90->...-director]->cloudsettings]% storage
  [bright90->...-director]->cloudsettings->storage]% use ebs
  [bright90->...-director]->cloudsettings->storage[ebs]]% set snapshotid snap-2a96d0c6
  ```

The cloud director can now be powered on:

Example

```
[bright90->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

  ```
  [bright90->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.

3.5 Cluster Extension With AWS: Optimizing AWS For High Performance Computing (HPC)

For HPC, performance is a central concern. Optimization for the jobs that are run can be carried out by the administrator considering what are the most cost-effective aspects of the system that can be improved. The considerations in this section for AWS, apply to COD instances as well as to Cluster Extension instances.

3.5.1 Optimizing HPC Performance: EBS Volume Type

The volume type used for EBS storage can be considered. AWS provides the gp2, io1, sc1, st1, and standard storage volume types. These volume types, and their associated IOPS performances, are described at https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EBSVolumeTypes.html.

- In cmsh these can be set in the storage mode:

  Example

  ```
  [bright90->device[cnode001]->cloudsettings->storage[ebs]]% set volumetype io1
  ```

- In Bright View, the equivalent clickpath is:

  Devices→Cloud Nodes→<*cloud node hostname*>→Edit→Settings→Cloud settings→STORAGE→Storage→ebs→CREATION TIME→Volume type

3.5.2 Optimizing HPC Performance: Placement Groups

The locality of the cloud nodes with respect to each other and with respect to the cluster that they extend from can be considered.

For cloud nodes in the same placement group, lag times are minimized between the nodes. For cloud nodes that are geographically near cluster that they extend from, the lag times are reduced between the cloud nodes and the cluster they extend from.

Localizing HPC cloud nodes within the same placement group is usually desirable. This can be achieved using the AWS web console to access the cluster extension AWS account. A placement group can be created for a region via the AWS web console for the instance.

The clickpath to carry this out is Services→EC2→Services→Placement Groups→Create Placement Group. A name should be set. The value of Strategy should be set to Cluster, to localize the nodes.

The same placement group name can then be set via cmsh for the not-yet-instantiated cloud nodes. Setting this means that those nodes are now started in that placement group.

Example

```
[bright90->device[cnode001]->cloudsettings]% set placementgroup indahood
```

3.5.3 Optimizing HPC Performance: Disabling Hyper-Threading

Hyper-Threading (HT) in many cases hinders HPC performance. When running cluster extension cloud nodes, HT can be left enabled on some instancesm and disabled on others, depending on the need.

To disable HT, the following can be inserted into the /etc/rc.local file for the cloud node image, and made executable with a chmod +x:

```
for cpunum in $(cat /sys/devices/system/cpu/cpu*/topology/thread_siblings_list | \
 cut -s -d\- -f2- | tr ',' '\n' | sort -un)
do echo 0 > /sys/devices/system/cpu/cpu$cpunum/online; done;
```

The delimiter used in the cut command is "-" instead of a ",".

If HT is disabled on the cloud node, then it can be confirmed by checking the output of the lscpu -extended command (output truncated):

Example

```
[root@cnode001 ~]# lscpu --extended
CPU NODE SOCKET CORE L1d:L1i:L2:L3 ONLINE
0   0    0      0    0:0:0:0       yes
1   -    -      -    :::           no
...
```

In the line just before the "...", the "no" indicates that that logical CPU (CPU1 in this case) has been disabled.

3.5.4 Optimizing HPC Performance: Using Elastic Network Adapter Instances

Enhanced networking that is needed for some instance types is possible if the AMI used has the Elastic Network Adapter (ENA) support attribute set. By default, all AMIs provided by Bright Cluster Manager since release 8.1-9 have ENA, as provided by the ena kernel module. If this kernel module is absent, the administrator should update the AMI.

3.5.5 Optimizing HPC Performance: Using A Different Clock Source

Xen is the default clocksource on AWS. Occasionally, some applications can benefit from using the TSC clocksource. Because of this, the clock source is generally changed as a best practice. The clock source can be changed with the following command:

Example

```
[root@cnode001 ~]# echo "tsc" > /sys/devices/system/cl*/cl*/current_clocksource
```

3.5.6 Optimizing HPC Performance: Setting The Socket Buffer Sizes And TCP/IP Parameters In The Sofware Image

The socket and TCP/IP window values can be modified by inserting the following values into the sysctl.conf file in the image:

Example

```
[root@bright90 ~]# cat >> /cm/images/default-image/etc/sysctl.conf << EOF
net.core.netdev_max_backlog   = 1000000

net.core.rmem_default = 124928
net.core.rmem_max     = 67108864
net.core.wmem_default = 124928
net.core.wmem_max     = 67108864

net.ipv4.tcp_keepalive_time   = 1800
net.ipv4.tcp_mem      = 12184608        16246144        24369216
net.ipv4.tcp_rmem     = 4194304 8388608 67108864
net.ipv4.tcp_syn_retries      = 5
net.ipv4.tcp_wmem     = 4194304 8388608 67108864
EOF
```

4

Cluster Extension Cloudbursting With AWS Using The Command Line And cmsh

The command line and cmsh can be used to set up Cluster On Demand clusters for AWS and Azure, as discussed in Chapter 2. The command line and cmsh can also be used to set up Cluster Extension clusters, as are discussed in this chapter for AWS, and in Chapter 5 for Azure.

4.1 The cm-cluster-extension Script For Cluster Extension Clusters

4.1.1 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 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 4.1.2 and 4.2).

The cm-cluster-extension script can be run in plain dialog mode (page 43) , or as an Ncurses dialog (page 45).

Running The cm-cluster-extension Command Line Options As A Shell Dialog

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

```
[root@bright90 ~]# cm-cluster-extension -h
Please wait...
usage: cm-cluster-extension
         [-v] [-h] [-c <config_file>]
         [--skip-modules <mod1,mod2,...>]
         [--only-these-modules <mod1,mod2,...>]
         [--dev]
         [--on-error-action {debug,remotedebug,undo,abort}]
         [--output-remote-execution-runner]
         [--json] [--no-distro-checks]
         [--min-reboot-timeout <reboot_timeout_seconds>]
         [--remove]
         [--terminate-instances]
         [--remove-fsx-instances]
         [--force]
         [--yes-i-know-this-is-dangerous-for-this-cluster <headnode_hostname>]
         [--test-networking]
         [--test-environment]
         [--test-configuration]
         [--test-everything]
         [--enable-external-network-connectivity]

common:
  Common arguments

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

advanced:
  Various *advanced* configuration options flags.

  --skip-modules <mod1,mod2,...>
                        Load and use all the default plugins (cloudstorage, clusterextension),
                        except for these. Comma-separated list.
  --only-these-modules <mod1,mod2,...>
                        Out of all default plugins, load and use only these. Comma-separated
                        list.
  --dev                 Enables additional command line arguments
  --on-error-action {debug,remotedebug,undo,abort}
                        Upon encountering a critical error, instead of asking the user for choice,
                        setup will undo (revert) the deployment stages.
  --output-remote-execution-runner
                        Format output for CMDaemon
  --json Use json formatting for log lines printed to stdout
  --no-distro-checks    Disable distribution checks based on ds.json
  --min-reboot-timeout <reboot_timeout_seconds>
                        How long to wait for nodes to finish reboot (default and minimum allowed:
                        300 seconds).

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

  --remove              Remove definitions of all objects required for cluster extension,
                        e.g. cloud nodes, directors, cloud networks and cloud interfaces
  --terminate-instances Terminate all non-terminated VMs.
  --remove-fsx-instances
                        Remove FSX instances.
  --force               Skip interactive confirmation for --remove
  --yes-i-know-this-is-dangerous-for-this-cluster <headnode_hostname>
                        Additional confirmation

testing cluster extension:
  Flags which can be used for troubleshooting

  --test-networking     Perform networking checks (e.g. check if API endpoints are reachable)
  --test-environment    Run environment checks (e.g. if proper RPMs are installed)
  --test-configuration  Run configuration checks, which check if cluster extension is properly
                        configured (e.g. if cloud director has correct interfaces, if cloud
                        credentials are valid, if CMDaemon can create/delete objects in the
                        cloud)
  --test-everything     Run all of the abovementioned checks.

cluster extension to Bright OpenStack:
  Options specific to this cloud type.

  --enable-external-network-connectivity
                        Enable external network connectivity for cloud nodes. Note that this
                        disables security groups for the cloud director, which may be a security
                        risk. Requires Neutron Port Security extension driver.


examples:
  cm-cluster-extension                             (start interactive menu, wizard)
  cm-cluster-extension -c <config>                 (configure bursting to AWS)

  cm-cluster-extension --remove                    (remove bursting)
  cm-cluster-extension --remove --force --yes-i-know-this-is-dangerous-for-this-cluster <hostname>
    (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 it up beforehand.
   cm-cluster-extension --test-everything

This tool looks for the following environment variables, and uses them if found:
   AWS_USERNAME, AWS_ACCOUNT_ID, AWS_ACCESS_KEY_ID, AWS_SECRET_ACCESS_KEY
   AZURE_SUBSCRIPTION_ID, AZURE_TENANT_ID, AZURE_CLIENT_ID, AZURE_CLIENT_SECRET
```

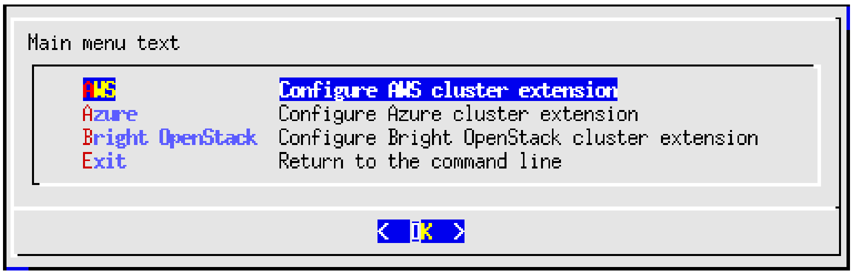
It can be run with the options directly (some output skipped):

Example

```
[root@bright90 ~]# cm-cluster-extension --test-networking
Please wait...
Found an optional config file, '/root/cm-setup.conf'. Will attempt to load it.
Executing 26 stages
################### Starting execution for 'Running networking checks'
Connecting to CMDaemon
  - cloudstorage
  - clusterextension
#### stage: clusterextension: Testing tcp connection to ec2.us-east-1.amazonaws.com:443
#### stage: clusterextension: Testing tcp connection to ec2.us-west-1.amazonaws.com:443
...
#### stage: clusterextension: Testing udp OpenVPN connectivity

Took:     00:09 min.
################### Finished execution for 'Running networking checks', status: completed

Running networking checks finished!
```

Running The cm-cluster-extension Ncurses Dialog

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



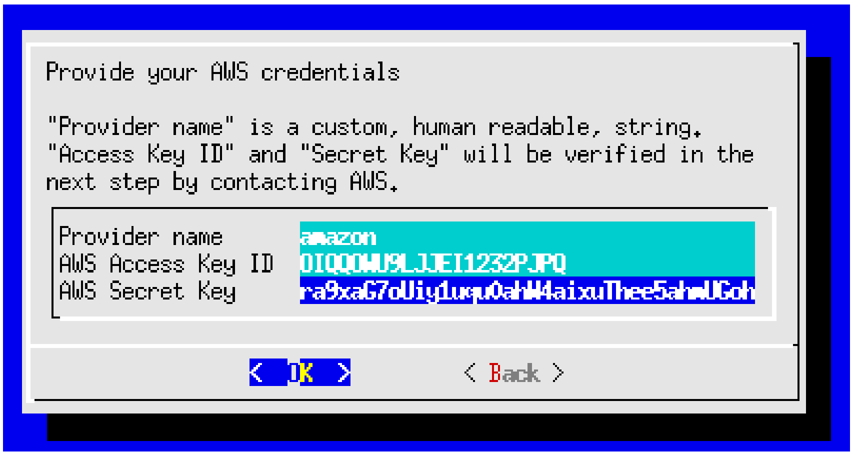
```
Main menu text

    AWS              Configure AWS cluster extension
    Azure            Configure Azure cluster extension
    Bright OpenStack Configure Bright OpenStack cluster extension
    Exit             Return to the command line

                           < OK >
```

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

Cluster extension cloudbursting deployment can be carried out by selecting `AWS` (described in this chapter), `Azure` (Chapter 5), or `Bright OpenStack` (Chapter 6), from the main screen.

After AWS is selected, a new AWS provider can be set if none is already set up. Testing only the network connectivity to the various AWS regions is also possible.

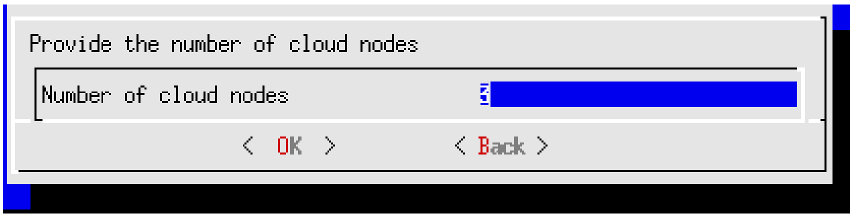
If a new AWS provider is selected, then a screen comes up asking for the credentials for Amazon (figure 4.2):



```
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      amazon
 AWS Access Key ID  0IQQOWU9LJJEI1232PJPQ
 AWS Secret Key     ra9xaG7oUiy1uwu0ahW4aixuThee5ahwUGoh

          < OK >            < Back >
```

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

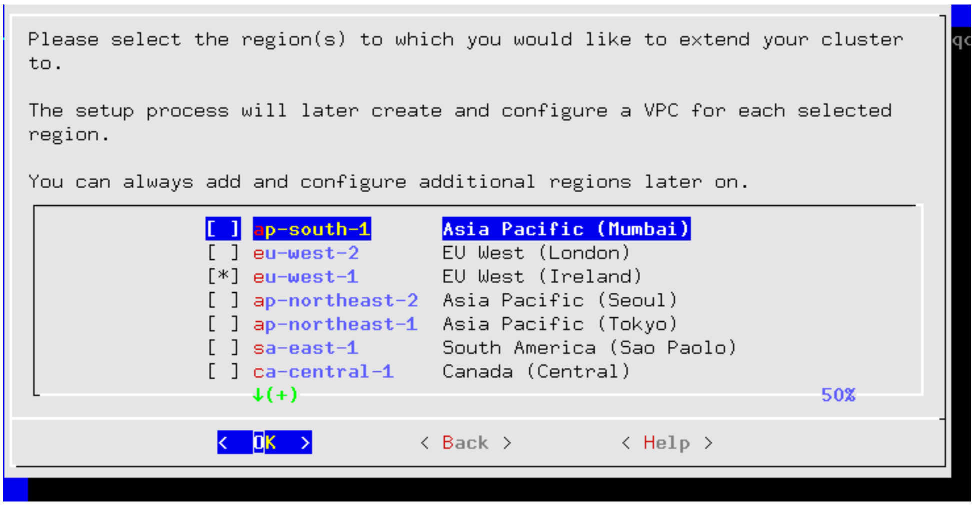
After checking the credentials, the initial number of cloud nodes to be set up in the cloud can be set (figure 4.3). A default of 3 is suggested.



```
Provide the number of cloud nodes

 Number of cloud nodes             3

          < OK >            < Back >
```

Figure 4.3: Configuration Processing With `cm-cluster-extension`: Setting The Initial Number Of Cloud Nodes

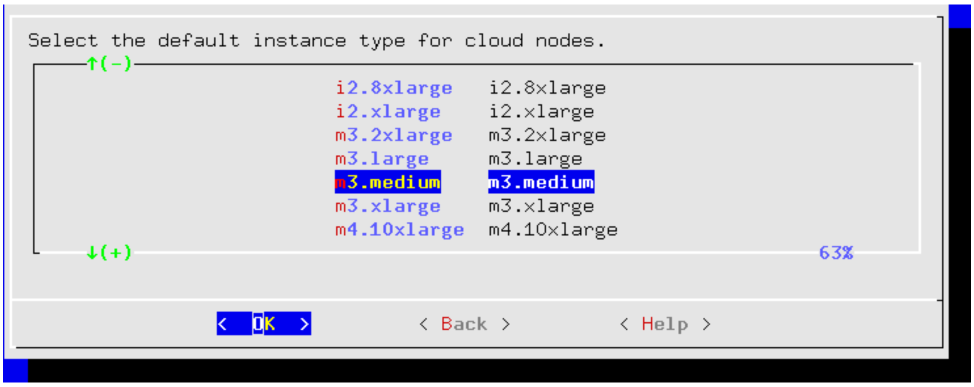
After setting an initial number of cloud nodes, the available regions into which these can be deployed are displayed (figure 4.4):



```
Please select the region(s) to which you would like to extend your cluster
to.

The setup process will later create and configure a VPC for each selected
region.

You can always add and configure additional regions later on.

                [ ] ap-south-1       Asia Pacific (Mumbai)
                [ ] eu-west-2        EU West (London)
                [*] eu-west-1        EU West (Ireland)
                [ ] ap-northeast-2   Asia Pacific (Seoul)
                [ ] ap-northeast-1   Asia Pacific (Tokyo)
                [ ] sa-east-1        South America (Sao Paolo)
                [ ] ca-central-1     Canada (Central)
                    ↓(+)                                       50%

              <  OK  >          < Back >          < Help >
```

Figure 4.4: Configuration Processing With `cm-cluster-extension`: Regions Selection

After selecting one or more regions, a default instance type must be set for the regular cloud nodes. `m3.medium` (3.75GB RAM, 4GB SSD, 3 EC2 compute units) is the suggested default (figure 4.5):

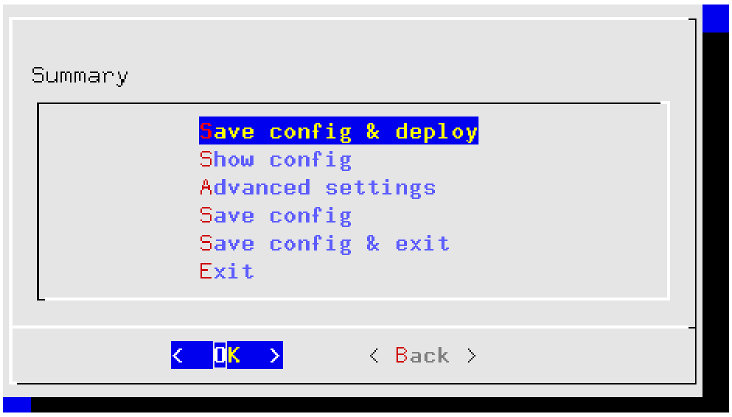


```
Select the default instance type for cloud nodes.
    ↑(-)
                          i2.8xlarge    i2.8xlarge
                          i2.xlarge     i2.xlarge
                          m3.2xlarge    m3.2xlarge
                          m3.large      m3.large
                          m3.medium     m3.medium
                          m3.xlarge     m3.xlarge
                          m4.10xlarge   m4.10xlarge
    ↓(+)                                                       63%

              <  OK  >          < Back >          < Help >
```

Figure 4.5: Configuration Processing With `cm-cluster-extension`: Default Instance Type

A similar default instance type screen asks for the cloud director node type, and `m3.medium` is again the suggested default.

The summary screen (figure 4.6) is a screen to let the administrator look things over before deployment:



```
Summary

              Save config & deploy
              Show config
              Advanced settings
              Save config
              Save config & exit
              Exit

         <  OK  >          < Back >
```

Figure 4.6: Configuration Processing With `cm-cluster-extension`: Summary Screen

The summary screen allows the following:

- An administrator can just go ahead, save the configuration, and deploy the cluster extension. This is usually the expected action.
- The configuration settings YAML file can be viewed. To scroll, the PageUp and PageDown keys are used.
- The advanced configuration settings screen can be accessed in addition to the standard settings. The advanced settings are usually left alone.
- The configuration file, <*configuration file*>, can be saved and the Ncurses dialog can be exited. By default, the value of <*configuration file*> is set to cm-cluster-extension.conf in the home directory of the user. On exiting the Ncurses dialog, deployment with that configuration can be carried out manually by running:

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

After cm-cluster-extension has carried out a successful deployment, the cloud nodes (the cloud director and regular cloud nodes) can be launched.

4.1.2 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 Bright View 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 for AWS can be listed with:

Example

```
cmsh -c "device; list -c aws-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 Bright View event viewer. The status can also be queried via the status command in device node. For example, a watch instruction such as:

```
[root@bright90 ~]# 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)
eu-west-1-director [ INSTALLER_CALLINGINIT ] (switching to local root)
eu-west-1-director ....... [    UP    ]
```

4.2 Launching The Cloud Nodes

Once the cloud director is up on the cloud provider, the regular cloud nodes can also be powered up. This does however first require that the corresponding 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.

Bright Cluster Manager's cluster extension utilities create 3 cloud node objects by default (figure 4.4, page 47). Cloning them is an easy way to extend the number of deployable cloud nodes.

With Bright View, this can be done with the `Clone` command to assign properties to the clone that match the original (section 3.3), but advance the relevant IP addresses by 1. In `cmsh`, the `clone` command works the same way.

To launch a cloud node that has an object, a command can be run as follows:

```
[bright90->device[cnode001]->interfaces]% device power on -n cnode001
```

4.2.1 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`.

Earlier on in this section, starting from page 45, an Ncurses session was run that ended up creating

- the cloud director `eu-west-1-director` and
- regular node objects `eu-west-1-cnode001` up to `eu-west-1-cnode003`.

Continuing with the end result of that session, cloning many further regular cloud nodes can now be carried out by cloning `eu-west-1-cnode003`:

Example

```
[bright90->device]% foreach --clone eu-west-1-cnode003 -n eu-west-1-cnode0[04-12] ()
Warning: The Ethernet switch settings were not cloned, and have to be set manually
...
[bright90->device*]% commit
Successfully committed 9 Devices
[bright90->device]%
```

As a reminder, the node range option `-n eu-west-1-cnode004..eu-west-1-cnode012` would also be valid for the preceding example, and perhaps easier to comprehend, although longer.

The IP addresses are assigned to the cloud nodes via heuristics based on the value of `eu-west1-cnode003` and its cloud director.

Powering up many cloud nodes can carried out using `cmsh` with the node range option as follows:

Example

```
[bright90->device]% power on -n eu-west-1-cnode0[02-10]
```

4.3 Submitting Jobs With `cmjob` And Cloud Storage Nodes, For Cluster Extension Clusters

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

Example

```
[root@bright90 ~]# cmsh
[bright90]% user use henry
[bright90->user[henry]]% set profile cloudjob; commit
```

If the cmjob 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.

Cloud storage nodes are powered up automatically if cmjob has been installed and configured. They must however be powered down explicitly, and this must be done before the cloud director that it depends on is powered down.

4.3.1 Installation And Configuration of cmjob 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 cmjob has not yet been set up, or if it needs reconfiguration, then the following steps should be carried out:

1. The cmdaemon-cmjob 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@bright90 ~]# yum install cmdaemon-cmjob
   [...]
   [root@bright90 ~]# yum --installroot /cm/images/default-image install cmdaemon-cmjob
   [...]
   ```

2. The cm-cloud-storage-setup utility is run. Example runs are provided later, starting on page 51, 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 cmjob properties
   - creates
     - *templates for cloud storage nodes*
     - *storage policies* for cmjob

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 Bright View. Actual cloud storage nodes, on the other hand, can be powered on by the cluster manager, so that they can be used to store cloud job data.

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

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

- `Name`: the name set for the policy
- `Bucket Name`: the S3 bucket used for cloud jobs to transfer input and output job data
- `Default job output size`: specifies the default free storage space that will be provisioned for the result that a job produces
- `Storage node name prefix`: specifies a prefix for how storage nodes are to be named. The prefix is `cstorage` by default. The number suffix scheme is as for regular nodes. Thus, by default, the storage nodes are `cstorage001`, `cstorage002` and so on.
- `Template for cloud nodes`: the template to use as the prototype for storage nodes

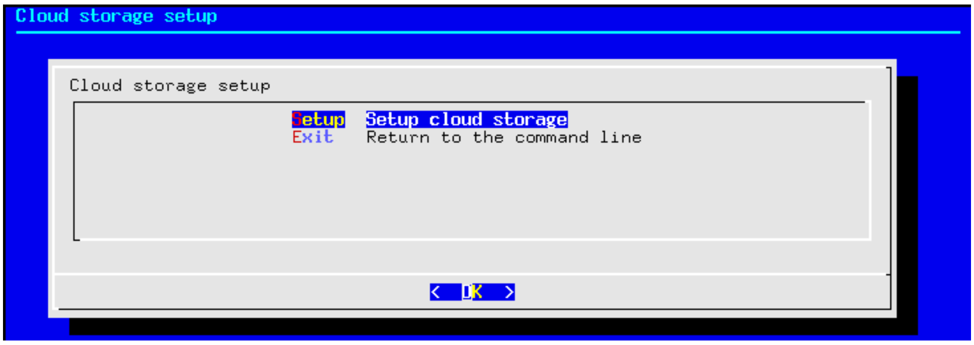
Example

Configuration Of `cmjob` Properties With `cm-cloud-storage`

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

```
[root@bright90 ~]# cm-cloud-storage-setup -h
Please wait...
usage: Cloud storage setup cm-cloud-storage-setup [-v] [-h] [-c <config_file>]
                                                  [--dev]
                                                  [--on-error-action
                                                            {debug,remotedebug,undo,abort}]
                                                  [--output-remote-execution-runner]
                                                  [--json]
                                                  [--no-distro-checks]
                                                  [--min-reboot-timeout <reboot_timeout_seconds>]
                                                  [--skip-reboot] [--remove]

optional arguments:
  --skip-reboot         Don't reboot the nodes

common:
  Common arguments

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

advanced:
  Various *advanced* configuration options flags.

  --dev                 Enables additional command line arguments
  --on-error-action {debug,remotedebug,undo,abort}
                        Upon encountering a critical error, instead of asking the user for
                        choice,setup will undo (revert) the deployment stages.
  --output-remote-execution-runner
                        Format output for CMDaemon
  --json                Use json formatting for log lines printed to stdout
  --no-distro-checks
  --min-reboot-timeout  <reboot_timeout_seconds>
                        How long to wait for nodes to finish reboot (default and minimum allowed:
                        300 seconds).

Remove storage:
  --remove              Cleanup storage setup
```

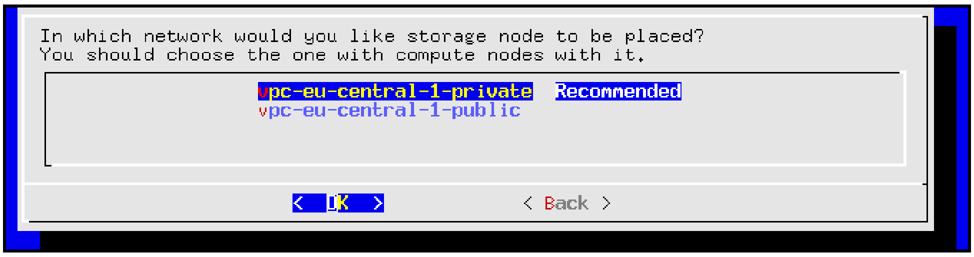
The administrator is usually expected to run cm-cloud-storage-setup without arguments. This brings up the Ncurses-based dialog, which starts with an introductory page (figure 4.7):



```
Cloud storage setup

Cloud storage setup

Setup   Setup cloud storage
Exit    Return to the command line
```

Figure 4.7: Cloud Storage Configuration Processing With cm-cloud-storage: Main Screen

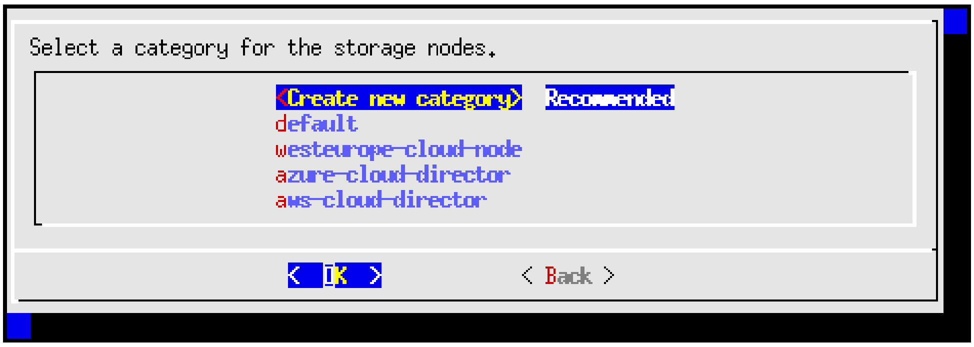
Continuing on brings up the network selection screen, which sets the network in which the cloud storage is to be placed (figure 4.8):



```
In which network would you like storage node to be placed?
You should choose the one with compute nodes with it.

vpc-eu-central-1-private  Recommended
vpc-eu-central-1-public
```

Figure 4.8: Cloud Storage Configuration Processing With cm-cloud-storage: Network Selection

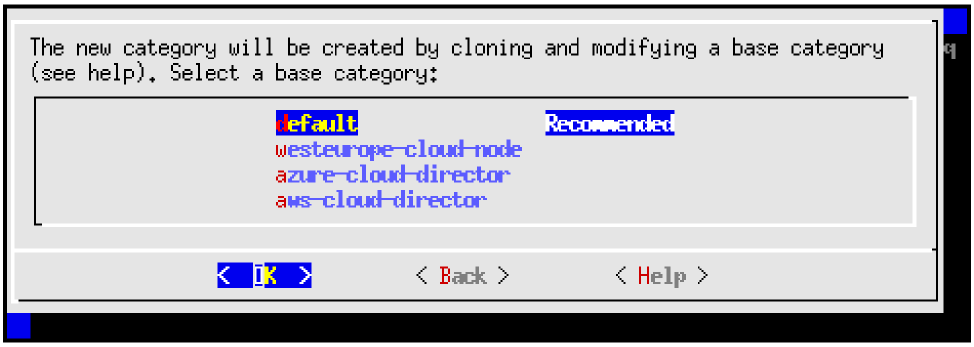
After having selected the network, a category for the storage nodes is set (figure 4.9):



Select a category for the storage nodes.

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

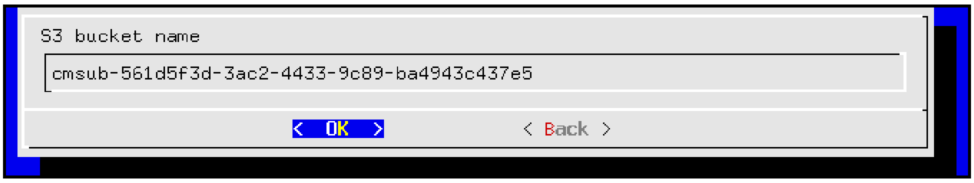
It is recommended that a new category be created (figure 4.10):



The new category will be created by cloning and modifying a base category (see help). Select a base category:

Figure 4.10: Cloud Storage Configuration Processing With `cm-cloud-storage`: Category Creation

A bucket name can be set (figure 4.11):

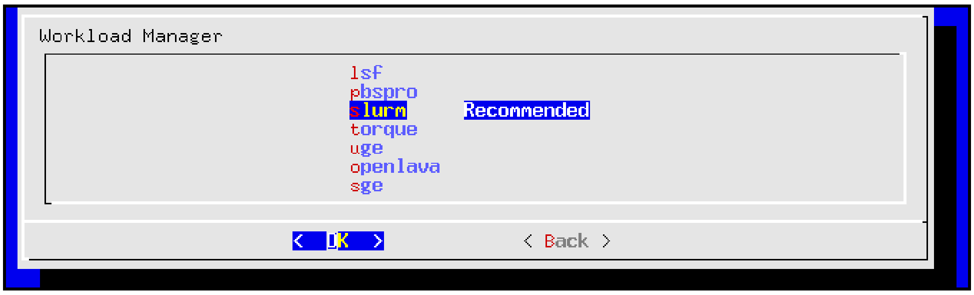


S3 bucket name

cmsub-561d5f3d-3ac2-4433-9c89-ba4943c437e5

Figure 4.11: Cloud Storage Configuration Processing With `cm-cloud-storage`: S3 Bucket Entry

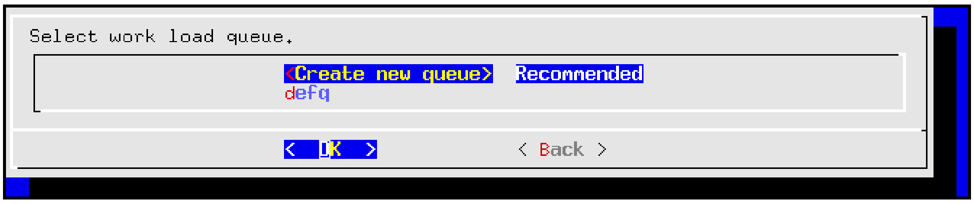
A workload manager is set for the cloud storage (figure 4.12):



Workload Manager

Figure 4.12: Cloud Storage Configuration Processing With `cm-cloud-storage`: Workload Manager Selection

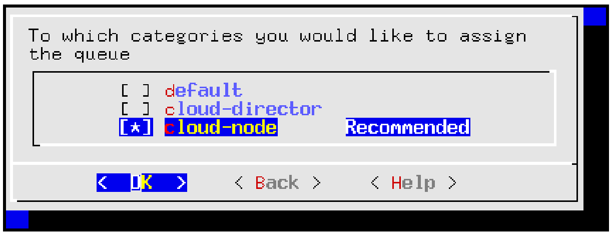
It is recommended that a new queue be created for jobs that use the storage (figure 4.13):



```
Select work load queue.
```

Figure 4.13: Cloud Storage Configuration Processing With `cm-cloud-storage`: Queue Creation

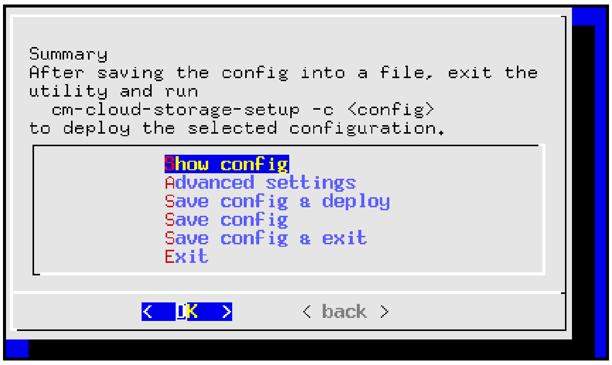
The queues can be assigned to the cloud category (figure 4.14):



```
To which categories you would like to assign
the queue
```

Figure 4.14: Cloud Storage Configuration Processing With `cm-cloud-storage`: Setting The Queue Category

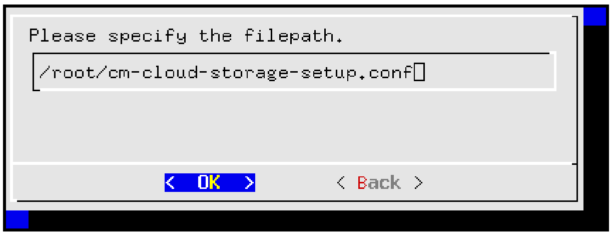
The summary screen allows the configuration to be saved and to be deployed (figure 4.15):



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

Figure 4.15: Cloud Storage Configuration Processing With `cm-cloud-storage`: Summary Screen

If the configuration is to be saved, then the file path should be specified (figure 4.16):



```
Please specify the filepath.
/root/cm-cloud-storage-setup.conf
```

Figure 4.16: Cloud Storage Configuration Processing With `cm-cloud-storage`: Save & Deploy Screen

`/root/cm-cloud-storage-setup.conf` is the suggested default. On exit, the saved configuration can be run with:

Example

```
[root@bright90 ~]# cm-cloud-storage-setup -c cm-cloud-storage-setup.conf
```

Configuring cmjob Properties With cmsh

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

```
[root@bright90 ~]# cmsh
[bright90]% cmjob
[bright90->cmjob[cmjob]]% storagenodepolicies
[bright90->cmjob[cmjob]->storagenodepolicies]% list
Name (key)        Template for cloud nodes
----------------- ---------------------------
us-east-1-policy  us-east-1-storage-template
[bright90->cmjob[cmjob]->storagenodepolicies]% use us-east-1-policy
[bright90->cmjob[cmjob]->storagenodepolicies[us-east-1-policy]]% show
Parameter                        Value
-------------------------------- ------------------------------------------------
Default job output size          30.0GiB
Exported directories             home
Intermediate storage             <submode>
Max download time                2h
Max jobs per node                10
Max storage nodes                5
Max upload time                  2h
Minimum Storage volume size      30.0GiB
Name                             us-east-1-policy
Revision
Storage node idle time limit     15m
Storage node name prefix         us-east-1-cstorage
Storage volume filesystem        ext3
Template for cloud nodes         us-east-1-storage-template
Tunnel IP start address          0.0.100.0
[bright90->cmjob[cmjob]->storagenodepolicies[us-east-1-policy]]% intermediatestorage
[bright90->cmjob[cmjob]->storagenodepolicies[us-east-1-policy]->intermediatestorage]% show
Parameter                             Value
------------------------------------- ------------------------------------------------
Bucket name                           bright901b86bdc32219494f9a21
Max object lifetime                   4w 2d
Region                                us-east-1
Revision
Type                                  AWSIntermediateStorage
SecGroupFSx                           sg-0f1fe4fc6d3d49e66
Default FSx Instance Capacity (GiB)   1200
Max FSx Instance Capacity (GiB)       7200
Max FSx Instance Count Per User       5
[bright90->cmjob[cmjob]->storagenodepolicies[us-east-1-policy]->intermediatestorage]%
```

By default the S3 bucket storage expires after 30 days.

Cloud jobs running under cmjob are listed under the cloudjobs submode:

```
[root@bright90 ~]# cmsh
[bright90]% cmjob
[bright90->cmjob[cmjob]]% cloudjobs
[bright90->cmjob[cmjob]->cloudjobs]% list
Name (key)  jobStatus                                        storageNode            user
----------- ------------------------------------------------ ---------------------- ----
slurm-35    Error: Job failed. Exit code: 0. Status: FAILED  us-east-1-cstorage001  fred
slurm-36    Error: Failed to acquire storage node: Failed t+                        fred
slurm-37    Running...                                       us-east-1-cstorage001  fred
```

4.3.2 Integration Of cmjob With AWS FSx For Lustre

FSx for Lustre is a high-performance highly scalable distributed file system that is available as a cloud service within some AWS regions. A Bright cluster that has burst into such a region can use FSx for Lustre to create a shared storage volume that can be read from, and can be written to, by many compute nodes simultaneously.

On a cluster that has burst into such a region, cmjob can provide workload managers with an FSx for Lustre instance to store input and output data.

Sequential workload manager jobs can then continue to use the same FSx for Lustre instance. This means that the output of one job can immediately become the input of the next one without having to transmit the data to and from an S3 bucket, or to and from the head node.

Additionally, workload manager jobs that run on multiple compute nodes in parallel can obtain their shared input from the same FSx for Lustre instance.

Providing shared storage to cloud compute nodes via FSx for Lustre is an alternative to providing it via cloud storage nodes (section 4.3). The storage node approach is not sufficiently scalable when there are more than several dozen compute nodes working simultaneously with the same storage node. FSx for Lustre is significantly more scalable and far more performant than storage nodes—although at a higher cost.

Bright Cluster Manager currently offers three different methods of integrating cmjob with FSx for Lustre:

1. *On-demand FSx*: An FSx file system is created on a per-job basis and is deleted automatically when the job completes.

2. *User-managed FSx*: A user creates an FSx instance and then submits one or more jobs that use that same FSx instance. These jobs can execute in sequence or simultaneously. When the last job has finished, the user is responsible for deleting the FSx instance.

3. *Admin-managed FSx*: An administrator creates an FSx instance and shares it with one or more users. These users are able to use the instance in the same way as with User-managed FSx, but they cannot delete the instance or see each other's files.

Prerequisites

To be able to use the integration of cmjob with FSx for Lustre, the following requirements need to be met:

- The cluster must be bursting into an AWS region that supports FSx for Lustre. AWS does not offer this feature in all regions. The AWS documentation at https://aws.amazon.com/about-aws/global-infrastructure/regional-product-services/ describes the regions that support FSx for Lustre.

- AWS needs to offer Lustre installation packages for the operating system and kernel that is used to extend into AWS. While the necessary Lustre package could perhaps be obtained directly from the Lustre project, it cannot be guaranteed that these packages are compatible with the FSx for Lustre file systems that are offered by AWS. The AWS packages are built and tested to work only with specific kernel versions.

- At the time of writing (May 2020), the supported operating systems are CentOS and Redhat 7.5, 7.6, 7.7. A list of supported operating systems as well as the packages for installing the Lustre client for such systems can be found at https://docs.aws.amazon.com/fsx/latest/LustreGuide/install-lustre-client.html.

Enabling cmjob integration with FSx for Lustre:

The integration of cmjob with FSx for Lustre can be accomplished in two ways, either:

- through the cm-cloud-storage-setup wizard (section 4.3.1)

  or

- manually

The cm-cloud-storage-setup wizard can be used if the preceding prerequisites have been met. In any case, during the wizard interaction, the administrator is asked to choose if FSx support should be enabled. If it is chosen, then:

- If FSx support is not available, then the administrator is informed that one of the requirements was not met.
- If FSx support is available, then no further action is required from the administrator.

After the deployment has finished, all users belonging to the cloudjob profile are able to create user-managed and on-demand FSx volumes through cmjob.

Enabling cmjob integration manually: The manual integration approach should be followed when cmjob has already been configured on a cluster. That is, if the cm-cloud-storage-setup tool has already been run but the cluster has been running without FSx support so far.

Two separate actions need to be executed to manually add FSx for Lustre integration:

1. **Installation of the required packages to the images**

   The AWS documentation should mention the packages that are required to install the Lustre Client. Often these two packages are needed: kmod-lustre-client and lustre-client. Care must be taken to match the package version to the Linux kernel version of the images. The packages must be installed to the images under /cm/images that are used by the director and by all compute nodes within that cluster extension.

   Example

   At the time of writing (May 2020), for a CentOS 7.7 system, with a 3.10 kernel, the instructions at https://docs.aws.amazon.com/fsx/latest/LustreGuide/install-lustre-client.html suggested the following steps:

```
[root@bright90 ~]# cm-chroot-sw-img /cm/images/<image used by director and compute nodes>
...
[root@bright90 /]# wget https://fsx-lustre-client-repo-public-keys.s3.amazonaws.com/\
fsx-rpm-public-key.asc -O /tmp/fsx-rpm-public-key.asc
...
[root@bright90 /]# wget https://fsx-lustre-client-repo.s3.amazonaws.com/el/7/\
fsx-lustre-client.repo -O /etc/yum.repos.d/aws-fsx.repo rpm --import /tmp/fsx-rpm-public-key.asc
...
[root@bright90 /]# vi /etc/yum.repos.d/aws-fsx.repo

    change references from el/7/ to el/7.7/ and exit out of editor

[root@bright90 /]# yum clean all
...
[root@bright90 /]# yum install -y kmod-lustre-client lustre-client
...
[root@bright90 /]# exit
```

2. **Addition of the FSx tokens to the user profiles**

   Profiles (section 6.4 of the *Administrator Manual*) can be set for FSx users. Every user that should be able to create FSx for Lustre instances should have one or both of the follwing FSx tokens appended to their profile:

   - ON_DEMAND_FSX_TOKEN
   - USER_MANAGED_FSX_TOKEN.

   Example

   A user, fred is already using cluster extension with AWS, but without FSx. Now the user would like to launch and manage FSx storage on demand.

   The existing profile of fred can be cloned in profile mode. The tokens needed can be appended to the new profile, and the modified profile can then be set for fred. The following cmsh session suggests how this can be carried out:

```
[bright90->user[fred]]% get profile
cloudjob
[bright90->user[fred]]% profile
[bright90->profile]% clone cloudjob cloudjobfsx
[bright90->profile*[cloudjobfsx*]]% get tokens
SUBMIT_CLOUD_JOB_DESCRIPTION_TOKEN
GET_CLOUD_JOB_DESCRIPTION_TOKEN
[bright90->profile*[cloudjobfsx*]]% append tokens ON_DEMAND_FSX_TOKEN USER_MANAGED_FSX_TOKEN
[bright90->profile*[cloudjobfsx*]]% get tokens
SUBMIT_CLOUD_JOB_DESCRIPTION_TOKEN
GET_CLOUD_JOB_DESCRIPTION_TOKEN
ON_DEMAND_FSX_TOKEN
USER_MANAGED_FSX_TOKEN
[bright90->profile*[cloudjobfsx*]]% commit
[bright90->profile[cloudjobfsx]]% user use fred
[bright90->user[fred]]% set profile cloudjobfsx
[bright90->user*[fred*]]% commit
```

When the two preceding actions have been carried out, the director and all compute nodes should be rebooted. A user should then be able to create and submit jobs with a user-managed FSx instance, or submit jobs with an OnDemand FSx instance, depending on which tokens were assigned to the profile of the user.

Configuration

Through cmsh, an administrator can set profile tokens (section 6.4 of the *Administrator Manual*) to control how users can work with FSx for Lustre. An administrator can also set quotas that control how many FSx instances a user can have simultaneously, and how large these FSx instances can be. The aim of this is to help manage costs.

Profile tokens: The following profile tokens are available for user management in FSx for Lustre:

- ON_DEMAND_FSX_TOKEN: allows a user to use the --on-demand-fsx flag when submitting jobs with cmjob.
- USER_MANAGED_FSX_TOKEN: allows a user to create, manage and delete FSx instances.
- DELETE_ANY_FSX_INSTANCE_TOKEN: allows a user to delete FSx instances that are owned by other users. Normally reserved for root only.

- LIST_ALL_FSX_INSTANCES_TOKEN: allows a user to see FSx instances owned by other users that are not shared with that user. Normally reserved for root only.
- SHARE_FSX_INSTANCE_TOKEN: allows a user to share FSx instances with other users. Only the owner is allowed to share it. Normally reserved for root only.

Settings: The following cmsh navigation path:

cmsh→cmjob→storagenodepolicies→use *<policy>*→intermediatestorage

leads to these storage parameters:

- Max FSx Instance Capacity (GiB)
- Max FSx Instance Count Per User

which control quota limits for FSx instances.

Each quota affects both on-demand and user-managed FSx instances. So if a user has already reached the maximum number of user-managed FSx instances, then the user cannot submit a job that uses an OnDemand FSx instance.

The same navigation path also leads to the storage parameter:

- Default FSx Instance Capacity (GiB)

which controls the default capacity when a user or admin creates a user-managed or admin-managed FSx instance.

Usage

As listed earlier, the three methods that Bright Cluster Manager provides for cmjob integration with FSx for Lustre are:

1. on-demand FSx,
2. user-managed FSx, and
3. admin-managed FSx.

How to run these methods using cmjob is covered in the next sections.

Using on-demand FSx: When using cmjob to submit a job, a user can now choose whether to use EBS-backed storage nodes or an FSx for Lustre file system to host the input data and output data. For a user there is little difference between how two shared storage options are used, besides their performance.

The steps are:

1. an EBS volume or FSx for Lustre file system is created as shared storage,
2. the input data is copied from the head node to this shared storage
3. all compute nodes chosen by the workload manager mount this shared storage, and then run their jobs,
4. storing their output data on the same shared storage.
5. the output data is uploaded from the shared storage to the head node
6. the EBS volume or FSx for Lustre file system is deleted.

Submitting a job to run with storage nodes is the default.

If a user wants a job to use FSx for Lustre, then the user must set the `--on-demand-fsx` flag when submitting the job:

Example

```
cmjob submit --on-demand-fsx job.sh
```

The capacity of the on-demand FSx instance is determined by doubling the size of the input data. This calculation takes into account both the data uploaded from the head node, and labeled data downloaded from an S3 bucket. If the user thinks that the calculated capacity is not large enough to hold the output data (the output includes temporary data), then the capacity can be increased with the `--expected-output-size` option. The specified size is combined with the size of the input data and rounded up to the nearest valid FSx volume size. The option also works for EBS storage.

Using user-managed FSx: `cmjob` with a user-managed FSx file system operates differently from an on-demand system. With user-managed FSx, the user is responsible for creating and deleting the FSx file system.

In some cases this can be more expensive than using the on-demand approach, especially if the user forgets to delete an FSx instance after no longer needing it.

However with user-managed FSx a user can run multiple concurrent jobs with the same FSx file system. It is also possible to run multiple jobs in sequence, each using the output of the previous job as input, without having the overhead of copying files over from the FSx file system to an S3 bucket, and vice versa. Depending on the size of the workload, this option may be cheaper, or more desirable, than on-demand FSx.

To create an FSx instance, the user executes `cmjob` with the `create-fs-instance` option as follows:

Example

```
cmjob create-fsx-instance <name> --capacity <capacity>
```

<name> can be a sequence of alphanumeric characters and dashes, and *<capacity>* is the total size of the FSx file system in gigabytes and is ideally set to a multiple of 1200, to prevent rejection by AWS. If not specified, the default value is used. The name does not have to be unique.

To delete an FSx instance, the user can run `cmjob` with the `delete-fsx-instance` option:

Example

```
cmjob delete-fsx-instance <name or FSx ID>
```

If the name is not unique, then the user can always specify the FSx ID. The ID can be found using the `list-fsx-instances` option. This lists all existing FSx instances, their names, unique IDs and statuses:

Example

```
cmjob list-fsx-instances
```

Once the FSx instance has reached a status of `Available` (which can take a few minutes), it is possible to submit a job with this instance.

Example

```
cmjob submit job.sh --fsx-instance <name or FSx ID>
```

Using admin-managed FSx: Using cmjob with an admin-managed file system is very similar to using it with a user-managed file system. The main difference is that the admin is responsible for creating and deleting the file system, and that the file system of the admin is shared with specific users. To share the file system, the share-fsx-instance option can be run by the admin, together with the --with option, as follows:

Example

```
cmjob share-fsx-instance <name or FSx ID> --with <user names>
```

Users do not need FSx-specific tokens to submit a job with an FSx instance. Using this approach for user-managed FSx instances gives the cluster administrator more control over the creation and deletion of FSx instances. By managing profiles, the administrator is free to divide users into a group of users who are allowed to create and delete their own instances, and a group of users who are only allowed to submit jobs with instances that are shared with them.

To stop sharing an FSx instance, the admin can run the --stop-sharing option:

Example

```
cmjob share-fsx-instance <name or FSx ID> --stop-sharing
```

Tracking FSx costs: All FSx instances created via cmjob have a BCM Owner tag assigned to them. This tag allows the cluster administrator to track the FSx costs on a per-user basis using AWS's cost management capabilities.

4.4 Miscellaneous Cloud Tools

4.4.1 Setting Exclude Lists With excludelistsnippets

The excludelistsnippets submode of cmsh in Bright Cluster Manager 9.1 onwards allows extra exclude list entries to be created and configured for a provisioned file system. In Bright Cluster Manager 9.0 the 9.1 implementation has not been fully backported, although the entries can be implemented using cmsh with a little extra work.

The Bright Cluster Manager 9.1 implementation is described first in this section, and the implementation for Bright Cluster Manager 9.0 is then explained.

These extra exclude list entries, or snippets, are added to the regular exclude lists described in section 5.6 of the *Administrator Manual*. The addition of these exclude list snippets to the regular lists is done by setting a mode parameter to the snippets. The mode parameter sets the exclude list that is associated with an exclude list snippet, as indicated by the following table:

Mode	Exclude list
sync	excludelistsyncinstall (active by default)
full	excludelistfullinstall
update	excludelistupdate (active by default)
grab	excludelistgrab
grab new	excludelistgrabnew

An exclude list snippet with an associated mode parameter behaves as if its entries are run along with the regular exclude list that is associated with it.

For example, to exclude the files /useless/test1 and /useless/test2, in Bright Cluster Manager version 9.1 onwards, a snippet called test may be created as follows:

Example

```
[bright90->fspart]% use /cm/shared
[bright90->fspart[/cm/shared]]% excludelistsnippets
[bright90->fspart[/cm/shared]->excludelistsnippets]%
[bright90->fspart[/cm/shared]->excludelistsnippets]% add test
[bright90->fspart*[/cm/shared*]->excludelistsnippets*[test*]]% set modefull yes
[bright90->fspart*[/cm/shared*]->excludelistsnippets*[test*]]% set excludelist
[bright90->fspart*[/cm/shared*]->excludelistsnippets*[test*]]% set excludelist /useless/test1
[bright90->fspart*[/cm/shared*]->excludelistsnippets*[test*]]% append excludelist /useless/test2
[bright90->fspart*[/cm/shared*]->excludelistsnippets*[test*]]% show

Parameter                         Value
-------------------------------- ------------------------------------------------
Lines                             2
Name                              test
Revision
Exclude list                      /useless/test1,/useless/test2
Disabled                          no
No new files                      no
Mode sync                         yes
Mode full                         yes
Mode update                       yes
Mode grab                         no
Mode grab new                     no
```

When the test snippet is used, its corresponding .rsync file has the following configuration:

```
[root@bright90 cmd]# grep useless /var/spool/cmd/*shared.rsync

- /useless/test1
- /useless/test2
```

In Bright Cluster Manager 9.0, there is no full implementation of excludelistsnippets mode in cmsh. However, it is available as a free text field:

Example

```
[bright90->fspart[/cm/shared]]% set excludelist
...[excludelistsnippet is defined]...
[bright90->fspart*[/cm/shared*]]% get excludelist
- /useless//test1
- /useless//test2
[bright90->fspart*[/cm/shared*]]% commit
[bright90->fspart[/cm/shared]]%
```

4.4.2 The provisioningassociations Mode

The provisioningassociations mode is not strictly restricted to cloud use, because it can also be used outside the cloud.

It allows direct access to provisioning associations via cmsh.The provisioningassociations mode can be used to set properties for the following file systems:

1. /cm/shared: as used by the cloud director
2. /cm/shared: as used by the edge director
3. /tftpboot: as used by the boot role
4. /cm/node-installer: as used by the boot role

5. <*image*>: for nodes with a provisioning role: for the image-to-image rsync to other provisioning nodes

The exclude lists for standard image-to-node sync to a regular (non-provisioning) node cannot be altered this way, and should be done in the normal category exclude list way (section 5.6 of the *Administrator Manual*), or via excludelistsnippets (section 4.4.1).

The provisioning associations properties can be accessed for an edge director as follows:

Example

```
[bright90]% device use edge-director
[bright90->device[edge-director]]% roles
[bright90->device[edge-director]->roles]% use edgedirector
[bright90->device[edge-director]->roles[edgedirector]]%
provisioningassociations
[bright90->device[edge-director]->roles[edgedirector]->provisioningassociations]% list
FSPart (key)     Sync point       Disabled
---------------- ---------------- ----------
/cm/shared                         no
[bright90->device[edge-director]->roles[edgedirector]->provisioningassociations]% show /cm/shared
Parameter                        Value
-------------------------------- ------------------------------------------------
Revision
Sync point
Type                             FSPartBasicAssociation
FSPart                           /cm/shared
On shared storage                no
Disabled                         no
Backup directory
Is root                          no
```

The trigger command in fspart mode triggers an update for a non-image partition. It is not needed for images under /cm/image, such as item 5 in the exclude list items that the provisioningassociations mode can be used for (page 63).

4.5 Connecting To AWS With Direct Connect Or A Hardware VPN

For simple configurations, Bright Cluster Manager recommends, and provides, OpenVPN by default for cluster extension cloudbursting VPN connectivity. If there is a wish to use Direct Connect or a hardware VPN (for example, an IPSec tunnel), then Bright Cluster Manager can be configured to work with those.

The AWS cluster extension always runs in an AWS Virtual Private Cloud (VPC). In the default deployment scenario, the head node communicates with the cloud nodes using an OpenVPN connection between the head node and the cloud director. In the case of a Direct Connect connection or a hardware VPN, the head node can be configured to communicate directly with the cloud director and cloud nodes.

Setting up Direct Connect or a VPN for a cluster extension can be carried out according to these three steps:

1. VPC creation (section 4.5.1). This step can be skipped if an existing VPC is to be used.

2. Connecting the local network to the VPC (section 4.5.2). The connection can be with, for example, Direct Connect, or a hardware VPN. This step can be skipped if the local network is already connected to an existing VPC via a Direct Connect or a hardware VPN connection.

3. Configuring and deploying the cluster extension (section 4.5.3).

4.5.1 Creating a VPC

The Amazon Virtual Private Cloud (VPC) is a logically isolated section of the AWS cloud. A VPC allows complete control over the networking environment for cloud resources used by the cluster extension. The VPC enables the cloud director and cloud nodes to securely communicate with each other and can be extended to the local network of the cluster. Documentation for Amazon VPC can be found at:

`https://docs.aws.amazon.com/vpc/latest/userguide/what-is-amazon-vpc.html`

A new VPC can be created and configured for the cluster extension as follows:

1. After logging in to the AWS management console, `https://console.aws.amazon.com/console/`, the following clickpath can be followed:

   `Services`→`VPC`→`VPC Dashboard`→`VPCs`→`Create VPC`.

2. An IPv4 CIDR block can be set to a desired range. This range should not conflict with the address space used on-premises. A possible range could be, for example: `10.42.0.0/16`

3. Once the VPC range is set, a subnet can be set via the navigation options under:

   `VIRTUAL PRIVATE CLOUD`→`Subnets`→`Create subnet`.

4. The VPC created in step 2 is selected as the VPC during the `Create subnet` dialog. An IPv4 CIDR block that is a subnet of the VPC range must also be defined in the `Create subnet` dialog. A possible subnet range would be, for example: `10.42.0.0/24`

4.5.2 Connecting The Local Network To The VPC

Amazon offers two options to connect the local network to the VPC: Direct Connect and VPN.

Connecting Via Direct Connect

To connect the local network to the VPC via Direct Connect requires a private virtual interface. Amazon's instructions to use AWS Direct Connect to access a VPC are at:

`https://docs.aws.amazon.com/directconnect/latest/UserGuide/Welcome.html`

Connecting Via A Site-To-Site Connection Using A VPN

Connecting an on-premises network to the virtual network using a VPN requires an *Amazon Site-to-Site connection*. Amazon's instructions for configuring a site-to-site VPN connection are at:

`https://docs.aws.amazon.com/vpn/latest/s2svpn/SetUpVPNConnections.html`

The site-to-site connection consists of 4 components:

1. a customer gateway (routes traffic from VPC to local network)

2. a target gateway (routes traffic from local network to VPC)

3. a security group

4. a connection

The target gateway can either be a virtual private gateway or a transit gateway, depending on the configuration of the other AWS resources.

If the customer gateway device does not support BGP, then the site-to-site connection needs to be configured for static routing. The default Static IP Prefixes are: `10.141.0.0/16`, `192.168.200.0/24`.

4.5.3 Configuring And Deploying The Cluster Extension

Once IP connectivity from on-prem to the AWS virtual network is running, the final step is creating the cluster extension using the newly created site-to-site connection.

Getting Through Shorewall

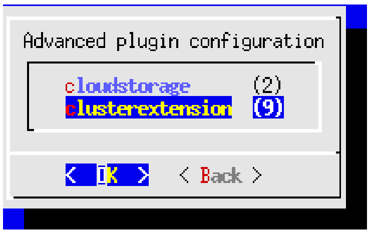
First, the firewall rules on the head node must be adjusted to accept traffic from the subnet. The file `/etc/shorewall/rules` can be edited so that the `net` section allows packets from the CIDR subnet. A quick and dirty way to do it is to append to the file with:

```
[root@bright90 ~]# echo "ACCEPT net:<subnet CIDR> fw - -" >> /etc/shorewall/rules
[root@bright90 ~]# shorewall reload
```

Cluster Extension Advanced Settings Configuration

A cluster extension can now be created using the `cm-cluster-extension` utility in Ncurses mode as explained in section 4.1.1, page 45.

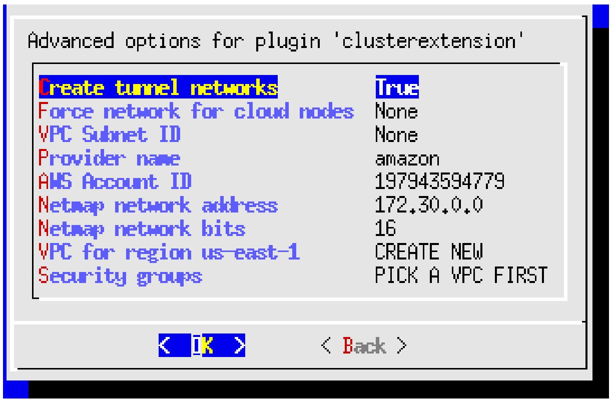
However, on reaching the summary screen (figure 4.6, page 47), the cluster administrator should not immediately select the `Save config & deploy` option, but should first go to the `Advanced settings` option, which opens up an `Advanced plugin configuration` screen (figure 4.17):



```
Advanced plugin configuration

  cloudstorage        (2)
  clusterextension    (9)
```

Figure 4.17: Cluster Extension Configuration Processing: Advanced Plugins Screen

The `clusterextension` option should be selected, which opens up an advanced options settings screen (figure 4.18):



```
Advanced options for plugin 'clusterextension'

Create tunnel networks          True
Force network for cloud nodes   None
VPC Subnet ID                   None
Provider name                   amazon
AWS Account ID                  197943594779
Netmap network address          172.30.0.0
Netmap network bits             16
VPC for region us-east-1        CREATE NEW
Security groups                 PICK A VPC FIRST
```

Figure 4.18: Cluster Extension Configuration Processing: Advanced Plugins For 'clusterextension' Options Screen

In this screen:

- the `Create tunnel networks` option should be set to `False`
- the `VPC for region` *<region>* should be set to the VPC created for the cluster extension. The cluster extension is what is being connected to via Direct Connect or via a site-to-site connection
- The `Security groups` to use should be set for the cloud nodes and the cloud director.

Custom Security Groups Configuration

For the security group it is important to realize that the default security groups, as created by the cluster extension utility, do not accept traffic from the IPSec tunnel. It is recommended to create a custom security group, and to use that for both the director and the nodes. To create this security group:

1. From the AWS management console, the following clickpath is followed:

   `VPC Dashboard→Security Groups→Create security group`

2. The cluster extension VPC is selected

3. A new inbound rule is added, to accept all traffic from the cluster and the VPC. For example: `192.168.200.0/24` and `10.42.0.0/16`.

The Ncurses advanced settings screens can be backed out of by selecting `Back` twice. The option `Save config & deploy` can then be selected to create the cluster extension.

Cloud Node Certificate Autosigning

By default Bright Cluster Manager does not issue certificates for nodes on the external network. This means that for cloud nodes the certificates need to be issued manually, once for every new cloud node.

Alternatively, to automatically sign certificate requests by cloud nodes, autosign can be enabled by the administrator for external networks. Autosigning may be a security concern, as this allows anyone on the external network to request a node certificate. Autosign can be enabled on externalnet in `cmsh` as follows:

```
[root@bright90~]# cmsh
[bright90]% network
[bright90->network]% set externalnet allowautosign always
[bright90->network]% commit
```

The cluster extension can now be deployed as explained in section 4.1.2.

5

Cluster Extension Cloudbursting With Azure

5.1 Introduction To Cluster Extension Cloudbursting With Azure

Cluster extension cloudbursting with AWS is covered in Chapter 3, where a GUI approach is described, and is also covered in section 4.1, where a text interface approach is described,

Cluster extension cloudbursting with Microsoft Azure is covered in this chapter (Chapter 5). The procedure is somewhat similar to that for AWS:

- The prerequisites to cloudburst into Azure are the same as those of cloudbursting into AWS, and are as previously described on page 25.

  In summary, the prerequisites are as follows:

  - an activated cluster license should be ensured
  - an Azure account should exist
  - Bright Cluster Manager must be registered as an Azure AD application (page 68)
  - UDP port 1194 should be open

- The techniques to cloudburst into Azure are also the same as that of cloudbursting into AWS, and are as previously described on page 26.

  In summary, the techniques are as follows:

  - a cloud director is set up in the cloud then started up
  - cloud nodes are then provisioned from the cloud director

- The deployment of cluster extension cloudbursting for Azure is carried out in a similar way to how it is done for AWS.

  In summary, the tools used to deploy cluster extension cloudbursting for Azure are as follows:

  - the Ncurses `cm-cluster-extension` utility, run from the command line (section 5.2)
  - the `Azure Wizard`, run from Bright View.

5.2 Cluster Extension Into Azure

Section 4.1.1 introduces the `cm-cluster-extension` Ncurses wizard, which is run on the head node when configuring a cluster extension for Azure or AWS. After the cluster extension configuration is completed, the cluster is capable of extending into the cloud by having cloud nodes power up into the cloud. This section (section 5.2) covers how `cm-cluster-extension` can be run for Azure, and how clouds nodes can be deployed for Azure.

There is also a Bright View browser-based wizard for cluster extension into Azure. The browser wizard is accessible via the clickpath: `Cloud`→`Azure`→`Azure Wizard`. If the browser wizard is used, then the documentation here (section 5.2) for `cm-cluster-extension` can be followed since it is a very similar procedure.

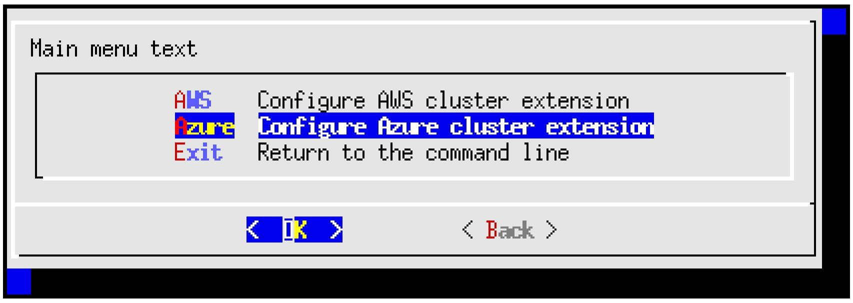
Running The `cm-cluster-extension` Command Line Options As A Shell Dialog

The `cm-cluster-extension` utility can be run as a dialog from the command line environment, as described in the section starting from page 43. Running it as an Ncurses dialog is however easier, and is described next.

Running The `cm-cluster-extension` Ncurses Dialog For Cluster Extension Into Azure

The `cm-cluster-extension` utility can be run as a more user-friendly Ncurses session within the text environment. In a session described starting from page 45, an AWS cluster extension configuration is generated and deployed. In the session that is now described here, an Azure cluster extension configuration is generated and deployed instead:

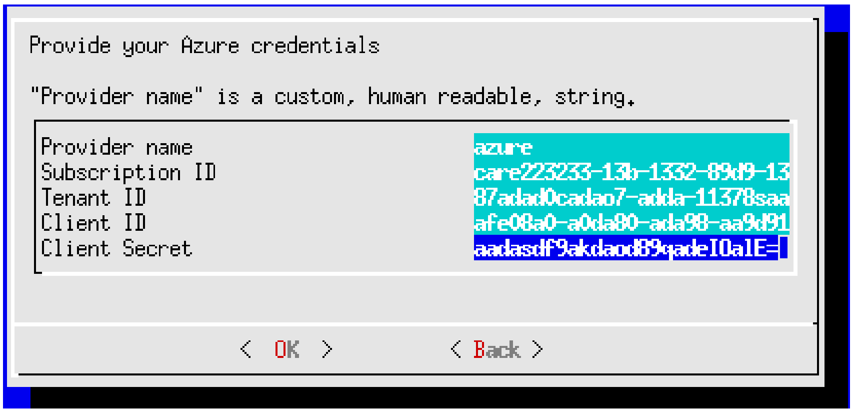
As in the AWS case, the `cm-cluster-extension` script is run without options, to bring up the Ncurses main screen (figure 5.1):



```
Main menu text

          AWS     Configure AWS cluster extension
          Azure   Configure Azure cluster extension
          Exit    Return to the command line

               <  OK  >          < Back >
```

Figure 5.1: Configuration Processing With `cm-cluster-extension`: Azure Selection

The Azure option is selected in this session instead of the AWS option. The next screen is then the Azure credentials screen (figure 5.2):



```
Provide your Azure credentials

"Provider name" is a custom, human readable, string.

Provider name                     azure
Subscription ID                   care223233-13b-1332-89d9-13
Tenant ID                         87adad0cadao7-adda-11378saa
Client ID                         afe08a0-a0da80-ada98-aa9d91
Client Secret                     aadasdf9akdaod89qadeI0alE=

               <  OK  >          < Back >
```

Figure 5.2: Configuration Processing With `cm-cluster-extension`: Azure Credentials

The inputs that are required here are Azure credentials, and exist for an activated Azure account which has had Bright Cluster Manager registered as an application.

How Bright Cluster Manager can be registered as an Azure application: Registration of an Azure application can be carried out with the Azure portal at `https://portal.azure.com`. The portal is accessible with an active Azure account. After logging in, navigating to locations via clickpaths described next is possible. The steps to ensure a registration are then as follows:

- User settings should first be checked to see if users can register applications. A clickpath to view this is:

  `Azure Active Directory→User settings→Users can register applications`

  The state should be set to `yes`.

- The subscriptions should be checked for permissions. The clickpath to view subscriptions is simply:

  `Subscriptions`

  Within the subscription display the role can be viewed to determine if the account has adequate permissions to assign an AD application to a role. The account must have `Microsoft.Authorization/*/Write` access to assign an Azure AD application to a role. Assigning the `Contributor` role allows this access. Role-based access control (RBAC) is discussed at `https://docs.microsoft.com/en-us/azure/active-directory/role-based-access-control-manage-access-rest`

- The user, for example, `<fred>`, should be checked for permissions. A suitable clickpath would be:

  `Azure Active Directory→Users and groups→<fred>→Azure resources`

  The Azure resources for the user, who is assigned the subscription, should show the role and assignment value. Suitable settings would be:

  ```
  ROLE: Contributor
  ASSIGNED TO: <fred>
  ```

- `Network`, `Compute`, and `Storage` namespaces must be registered.

  A convenient way to check that this is the case, is to use the Azure CLI tool from the head node. Instructions for installing it are available at `https://docs.microsoft.com/en-us/cli/azure/install-azure-cli`.

  After installation, a list of namespaces can be seen by running:

  ```
  az provider list --query "[].{Provider:namespace, Status:registrationState}" --out table
  ```

  If the tool is run for the first time, then the tool gives the user a code and a URL. Using these, the user can authenticate the head node via a web browser.

  The required namespaces can be registered, if needed, with:

  ```
  az provider register --namespace Microsoft.Network --wait
  az provider register --namespace Microsoft.Compute --wait
  az provider register --namespace Microsoft.Storage --wait
  az provider register --namespace Microsoft.ADHybridHealthService --wait
  az provider register --namespace Microsoft.Authorization --wait
  az provider register --namespace Microsoft.Billing --wait
  az provider register --namespace Microsoft.ClassicSubscription --wait
  az provider register --namespace Microsoft.Commerce --wait
  az provider register --namespace Microsoft.Consumption --wait
  az provider register --namespace Microsoft.Features --wait
  az provider register --namespace Microsoft.MarketplaceOrdering --wait
  az provider register --namespace Microsoft.Resources --wait
  az provider register --namespace Microsoft.support --wait
  ```

- Create Azure Active Directory application:

  With all the permissions in place, the application can now be registered via the clickpath: `Azure Active Directory`→`App registrations`

  The application name and application URL values can be arbitrary since they are not actually used by `cm-cluster-extension`. The application type should be set to: `Web app / API`

- The `Client ID` and `Client Secret` values are only available to Azure admin users, or the Azure application owners. Regular users cannot obtain these values.

  If the security settings allow Azure users to define their own Azure applications, then they can in theory create their own Azure application under the subscription, and use the data for that Azure application to get a `Client ID` and `Client Secret`.

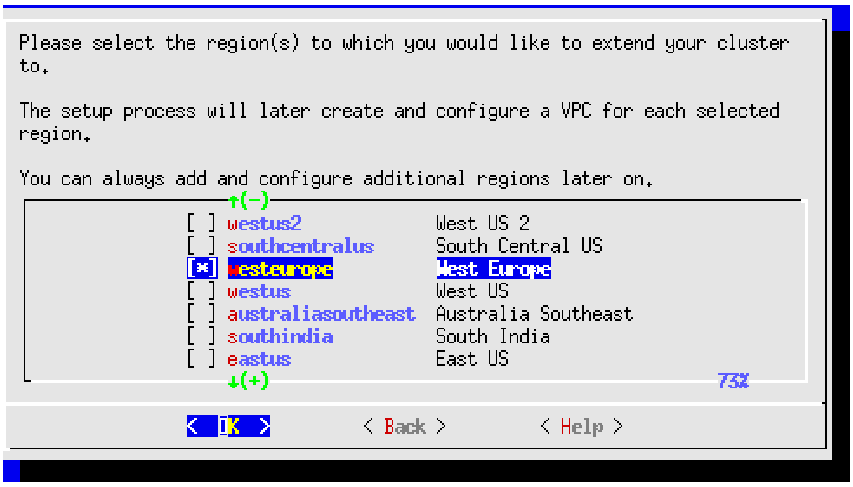
The credentials can now be picked up from the Azure portal account via the clickpaths shown in the following table:

Ncurses	Clickpath From Azure Portal Menu After Azure Portal Login
`Subscription ID`	`Subscriptions`→`SUBSCRIPTION ID`
`Tenant ID`	`Azure Active Directory`→`Properties`→`Directory ID`
`Client ID`	`Azure Active Directory`→`App registrations`→`APPLICATION ID`
`Client Secret`	`Azure Active Directory`→`App registrations`→`APPLICATION ID`→`Keys`→`[`*the generated key must be noted*`]`*

*After filling in the `DESCRIPTION` and `EXPIRES` fields at the end of this clickpath, and saving the values, the key is generated, and displayed once. The key must be noted down by the user because it cannot be retrieved.

The `Provider Name` in figure 5.2 can be set to any user-defined value. For Azure, a sensible, if unimaginative value, is simply `azure`.

After the credentials have been accepted, then Azure regions can be selected (figure 5.3):

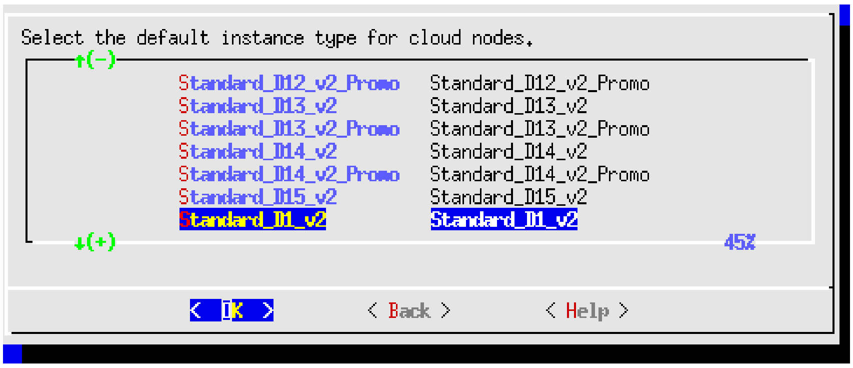


```
Please select the region(s) to which you would like to extend your cluster
to.

The setup process will later create and configure a VPC for each selected
region.

You can always add and configure additional regions later on.

                    [ ] westus2              West US 2
                    [ ] southcentralus       South Central US
                    [*] westeurope           West Europe
                    [ ] westus               West US
                    [ ] australiasoutheast   Australia Southeast
                    [ ] southindia           South India
                    [ ] eastus               East US
```

Figure 5.3: Configuration Processing With `cm-cluster-extension`: Azure Regions

Azure regions are regional data centers, and the cloud director for a region helps manage the regular cloud nodes in that region when the cluster is extended into there.

The default instance type for the regular cloud nodes is then set (figure 5.4):



```
Select the default instance type for cloud nodes.
 ↑(-)
          Standard_D12_v2_Promo   Standard_D12_v2_Promo
          Standard_D13_v2         Standard_D13_v2
          Standard_D13_v2_Promo   Standard_D13_v2_Promo
          Standard_D14_v2         Standard_D14_v2
          Standard_D14_v2_Promo   Standard_D14_v2_Promo
          Standard_D15_v2         Standard_D15_v2
          Standard_D1_v2          Standard_D1_v2
 ↓(+)                                                   45%

       < OK >         < Back >          < Help >
```

Figure 5.4: Configuration Processing With `cm-cluster-extension`: Azure Default Instance Type For Cloud Nodes

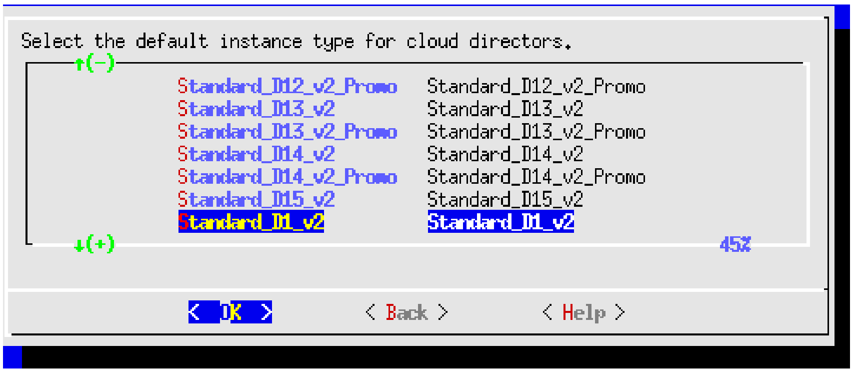
A default Azure virtual machine type that works well for general cloud node purposes is the `D1_v2` type. There are many possible machine types, and they are documented online at `https://docs.microsoft.com/en-us/azure/virtual-machines/windows/sizes`. A summary listing of the supported types can be viewed in `cmsh` with:

```
[root@b80 ~]# cmsh -c "cloud use azure ; types ; list"
```

or via the Bright View clickpath:

`Cloud→Azure→Azure VM Sizes`

The default instance type for the cloud directors is then set (figure 5.5):

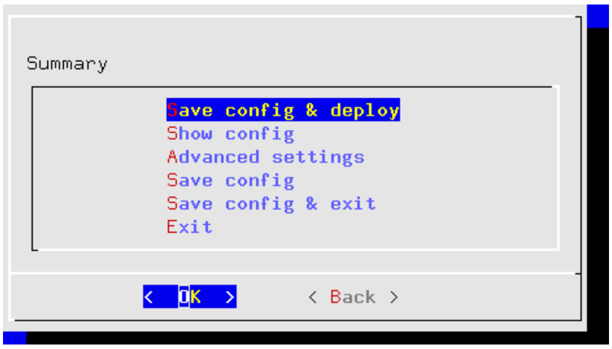


```
Select the default instance type for cloud directors.
 ↑(-)
          Standard_D12_v2_Promo   Standard_D12_v2_Promo
          Standard_D13_v2         Standard_D13_v2
          Standard_D13_v2_Promo   Standard_D13_v2_Promo
          Standard_D14_v2         Standard_D14_v2
          Standard_D14_v2_Promo   Standard_D14_v2_Promo
          Standard_D15_v2         Standard_D15_v2
          Standard_D1_v2          Standard_D1_v2
 ↓(+)                                                   45%

       < OK >         < Back >          < Help >
```

Figure 5.5: Configuration Processing With `cm-cluster-extension`: Azure Default Instance Type For Cloud Directors

The same default size of the `D1_v2` type that works for regular cloud nodes is typically adequate for cloud director nodes too, for small clusters.

The summary screen (figure 5.6) allows the administrator to look over the configuration before deployment:



Summary

Figure 5.6: Configuration Processing With `cm-cluster-extension`: Azure Options Summary Screen

As in the AWS summary screen, the Azure summary screen allows the following:

- An administrator can just go ahead, save the configuration, and deploy the cluster extension. This is usually the expected action.
- The configuration settings YAML file can be viewed. To scroll, the PageUp and PageDown keys are used.
- An advanced configuration settings screen can be accessed in addition to the standard settings. The advanced settings are usually left alone.
- The configuration file, <*configuration file*>, is `cm-cluster-extension.conf` by default. The file can be saved, by default to the home directory of the user. On exiting the Ncurses dialog, deployment with that configuration can be carried out manually by running:

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

Deployment Of An Azure Configuration Created With `cm-cluster-extension`

During configuration deployment, as the configuration is processed, text output indicates the progress. At the end of processing, the message

```
 Azure Cloud extension configuration finished
```

indicates that the cluster has been extended successfully.

No nodes are activated yet within Azure. To start them up, the components of the cluster extension service for Azure must be started up by

- powering up the cloud directors, as introduced for AWS in section 3.2. The procedure for Azure is similar.
- powering on the cloud nodes after the cloud directors are up. This may require first creating new cloud nodes, as introduced for AWS in section 3.3. The procedure for Azure is similar.

When powering up, the cloud director can be installed from scratch (section 3.2), or from a snapshot. For example, running the `power on` command from the `device` mode of `cmsh` on a head node shows amongst others the following states (some output elided or ellipsized):

Example

```
[b80->device]% power on westeurope-director
cloud .................... [   ON    ] westeurope-director
... [notice] b80: westeurope-director [ PENDING ] (Instance has started)
... [notice] b80: New certificate request with ID: 9
... [notice] b80: westeurope-director [     INSTALLING      ] (node installer started)
... [notice] b80: New certificate request with ID: 10 (ldaps)
... [notice] b80: westeurope-director [ INSTALLER_CALLINGINIT ] (switching to local root)
...
... [notice] b80: westeurope-director [   UP   ]
```

Example

```
[root@bright90 ~]# ps uww -C rsync | grep -o ' /cm/.*$'
 /cm/shared/ syncer@172.21.255.251::target//cm/shared/
```

Tracking Cloud Director Startup From cmsh

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

Example

```
[root@bright90 ~]# cmsh -c "softwareimage provisioningstatus"
...
+ westeurope-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

```
+ westeurope-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@bright90 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s):        4
Source node:          bright90
Source path:          /cm/images/default-image
Destination node:     westeurope-director
Destination path:     /cm/images/default-image
...
```

After some time, when the shared filesystem is being provisioned, then an indication of progress is shown by the Request ID incrementing, and the source and destination paths changing to the /cm/shared directory:

```
[root@bright90 ~]# cmsh -c "softwareimage provisioningstatus -a"
Request ID(s):        5
Source node:          bright90
Source path:          /cm/shared
Destination node:     westeurope-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. The instances can be started up from scratch (section 3.2), or from snapshot (section 3.4).

Cluster Extension Cloudbursting Logging

All Azure logging goes to the CMDaemon log in `/var/log/cmdaemon`, where the `CLOUD` tag is used to indicate cloud-related operations.

5.3 Cluster Extension Into Azure: Cloud Node Startup From Scratch

This section discusses the configuration of regular cloud node startup from scratch.[1]

To *configure* regular cloud nodes in Azure from scratch 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 153 of the *Administrator Manual*) values, in order to create a provisioning hierarchy.

Similarly to how it is done in AWS, the creation and configuration of regular cloud node objects in Azure is conveniently carried out by cloning another regular cloud node, from one of the default cloud nodes already created by the cluster extension wizard (section 5.2). A clickpath to do this cloning in Bright View is:

`Devices`→`Cloud Nodes`→<*cloud node hostname*>→↓`Clone`

Cloud node objects can also be created in `cmsh` as described in section 4.2.

5.4 Cluster Extension Into Azure: `shutdown` *Vs* `power off`

An Azure cloud node has two stopped states:

1. `stopped`: A node running within Azure can be set to this state by running the `shutdown` command:
   - within the `device` mode of `cmsh`
   - with Bright View, using the clickpath:
     `Devices` → `Cloud Nodes` → <*cloud node hostname*>→↓`OS`→ `Shutdown`
   - Or by clicking the `stop` button for that node within the Azure web portal, once.
2. `stopped (deallocated)`: A node running within Azure can be set to this state by running the `power off` command:
   - within the `device` mode of `cmsh`
   - with Bright View, using the clickpath:
     `Devices`→`Cloud Nodes`→<*cloud node hostname*>→↓`Power`→`Off`
   - Or by clicking on the `stop` button within the Azure web portal, twice.

Carrying out a `power off` command is like a hard power off command, which can under some unusual conditions cause filesystem corruption. It is therefore safer to run the `shutdown` command first, wait for the node to shut down via the OS. After that, running the `power off` command ensures that the node is deallocated.

From a financial point of view when using Azure, a node that is shut down but not deallocated continues to incur costs. However, a node that is deallocated does not continue to incur costs.

[1] The configuration of cloud director and node startup from snapshot is also possible. How to do this for AWS is discussed in section 3.4. Doing this for Azure is rather more complicated and confusing. At the time of writing (August 2017), configuring this is therefore planned as a wizard-assisted option for a future version of Bright Cluster Manager, with a priority that depends on the level of interest for this feature from customers.

5.5 Submitting Jobs With `cmjob` And Cloud Storage Nodes, For Azure Cluster Extension Clusters

The `cmjob` utility, a job submission wrapper for end users for cluster extension clusters, is introduced and documented for AWS cluster extension in section 4.3. As a summary, its configuration procedure consists of:

- Making sure the `cmdaemon-cmjob` package is installed on the head node and the cloud image
- Ensuring the users that are to use `cmjob` have the `cloudjob` profile
- Making sure that cloud storage nodes are set up. The administrator can run `cm-cloud-storage-setup` to configure the cloud storage nodes.

The details of the configuration procedure for `cmjob` for Azure cluster extension is almost identical to that for AWS. The configuration procedure documented in section 4.3 can therefore also be followed for Azure.

How the end user can use `cmjob` is documented in section 4.7 of the *User Manual*.

5.5.1 Integration Of `cmjob` With Azure NetApp Files

Azure NetApp Files (ANF) is a high-performance highly scalable network file service that is available as a cloud service within most Azure regions. A Bright cluster that has burst into such a region can use ANF to create a shared storage volume that can be read from, and can be written to, by many compute nodes simultaneously.

On a cluster that has burst into such a region, `cmjob` can provide workload managers with an ANF volume to store input and output data.

Sequential workload manager jobs can use the same ANF volume. This means that the output of one job can immediately become the input of the next one without having to transmit the data to and from Azure cloud storage, or to and from the head node.

Additionally, workload manager jobs that run on multiple compute nodes in parallel can obtain their shared input from the same ANF volume.

Providing shared storage to cloud compute nodes via ANF is an alternative to providing it via via cloud storage nodes (section 4.3). The storage node approach is not sufficiently scalable when there are more than several dozen compute nodes working simultaneously with the same storage node. ANF is significantly more scalable and far more performant, although at a higher cost.

Bright Cluster Manager currently offer three different methods of integrating `cmjob` with Azure NetApp Files:

1. *On-Demand ANF*: An ANF file system is created on a per-job basis and is deleted automatically when the job completes.
2. *User-managed ANF*: A user creates an ANF volume and then submits one or more jobs that use that same ANF volume. These jobs can execute in sequence or simultaneously. When the last job has finished, the user is responsible for deleting the ANF volume.
3. *Admin-managed ANF*: An administrator creates an ANF volume and shares it with one or more users. These users are able to use the volume in the same way as with user-managed ANF, but they cannot delete the volume or see each other's files.

Prerequisite

To be able to use the integration of `cmjob` with ANF NetApp Files, the cluster must be bursting into an Azure region that supports Azure NetApp Files. Azure does not offer this feature in all regions. The Azure documentation should be checked to see if a region offers ANF for Azure.

Enabling cmjob Integration With Azure NetApp

The integration of cmjob with ANF can be accomplished in two ways, either:

- through the cm-cloud-storage-setup wizard (section 4.3.1)

  or

- manually

During the cm-cloud-storage-setup wizard run, when the guidance for the Azure extension is being carried out, the administrator is asked if ANF support should be enabled. If the administrator agrees to this, then ANF support is set up. After the deployment has finished, all users that have the cloudjob profile can then create user-managed and on-demand ANF volumes through cmjob.

Enabling cmjob integration manually: The manual integration approach should be followed when cmjob has already been configured on a cluster. That is, if the cm-cloud-storage-setup tool has been run, but the cluster has been running without ANF support so far.

To add cmjob integration with ANF manually, the following manual action is all that is needed:

Every user that should be able to create ANF volumes should have one or both of these tokens set on their profile (profiles are explained in section 6.4 of the *Administrator Manual*):

- ON_DEMAND_ANF_TOKEN
- USER_MANAGED_ANF_TOKEN.

Example

A user, fred is already using cluster extension with Azure, but without ANF. Now the user would like to be able to launch and manage ANF storage on demand.

To allow fred to do that, the steps that are carried out could be as follows: The existing profile of fred can be cloned in profile mode. The tokens needed can be appended to the new profile, and the modified profile can then be set for fred.

The following cmsh session shows these steps:

```
[bright90->user[fred]]% get profile
cloudjob
[bright90->user[fred]]% profile
[bright90->profile]% clone cloudjob cloudjobanf
[bright90->profile*[cloudjobanf*]]% get tokens
SUBMIT_CLOUD_JOB_DESCRIPTION_TOKEN
GET_CLOUD_JOB_DESCRIPTION_TOKEN
[bright90->profile*[cloudjobanf*]]% append tokens ON_DEMAND_ANF_TOKEN USER_MANAGED_ANF_TOKEN
[bright90->profile*[cloudjobanf*]]% get tokens
SUBMIT_CLOUD_JOB_DESCRIPTION_TOKEN
GET_CLOUD_JOB_DESCRIPTION_TOKEN
ON_DEMAND_ANF_TOKEN
USER_MANAGED_ANF_TOKEN
[bright90->profile*[cloudjobanf*]]% commit
[bright90->profile[cloudjobanf]]% user use fred
[bright90->user[fred]]% set profile cloudjobanf
[bright90->user*[fred*]]% commit
```

No directors need to be updated or rebooted when the necessary user profiles have been updated. All users with profiles with those ANF tokens should then be able to create and submit jobs with a user-managed ANF volume, or submit jobs with an on-demand ANF volume, depending on which tokens were assigned to the profile of the user.

Configuration

Through cmsh, an administrator can use profile tokens (section 6.4 of the *Administrator Manual*) to control how users can work with ANF. An administrator can also set quotas that control how many ANF volumes a user can have simultaneously and how large these ANF volumes can be. The aim of this is to help manage costs.

Profile tokens:

- ON_DEMAND_ANF_TOKEN: allows a user to use the --on-demand-anf flag when submitting jobs with cmjob.
- USER_MANAGED_ANF_TOKEN: allows a user to create, manage and delete ANF volumes.
- DELETE_ANY_ANF_VOLUME_TOKEN: allows a user to delete ANF volumes that are owned by other users. Normally reserved for root only.
- LIST_ALL_ANF_VOLUMES_TOKEN: allows a user to see ANF volumes owned by other users. Normally reserved for root only.
- SHARE_ANF_VOLUME_TOKEN: allows a user to share ANF volumes with other users. Only the owner is allowed to share it. Normally reserved for root only.

Settings: The following cmsh navigation path

cmsh→cmjob→storagenodepolicies→use <*policy*>→intermediatestorage

leads to these storage parameters:

- Max ANF Volume Capacity (TiB)
- Max ANF Volume Count Per User

which control quota limits for ANF volumes for the number and size of ANF volumes, for when a user or an administrator creates a user-managed or administrator-managed ANF volume.

The count is combined. If a user has already reached the maximum number of user-managed ANF volumes, then the user cannot submit a job that uses an on-demand ANF volume.

Also in the same navigation path is the storage parameter:

- Default ANF Volume Capacity (TiB)

which controls the default capacity when a user or admin creates a user-managed or admin-managed ANF volume.

Usage

As listed earlier, the three methods that Bright Cluster Manager provides for cmjob integration with ANF are:

1. on-demand ANF,
2. user-managed ANF, and
3. admin-managed ANF.

How to run these methods using cmjob is covered in the next sections.

Using on-demand ANF: When using `cmjob` to submit a job, a user can choose whether to use an Azure storage volume or an ANF file system to host the input data and output data. For a user there is little difference between the ways in which the two shared storage options are used, beside performance.

The steps are:

1. an Azure storage volume or an ANF file system is created as shared storage,
2. the input data is copied from the head node to this shared storage
3. all compute nodes chosen by the workload manager mount this shared storage, and then run their jobs,
4. storing their output data on the same shared storage.
5. the output data is uploaded from the shared storage to the head node
6. the Azure volume or ANF file system is deleted.

Submitting a job to run with Azure storage nodes is the default.

If a user wants a job to use ANF, then the user must set the `--on-demand-anf` flag when submitting the job:

Example

```
cmjob submit --on-demand-anf job.sh
```

The capacity of the OnDemand ANF volume is determined by doubling the size of the input data. This calculation takes into account both the data uploaded from the head node, and labeled data downloaded from the Azure cloud storage. If the user thinks that the calculated capacity is not large enough to hold the output data (the output includes temporary data), then the user can increase the capacity with the `--expected-output-size` parameter. The specified size is combined with the size of the input data and rounded up to the nearest valid ANF volume size.

Using user-managed ANF `cmjob` with a user-managed ANF file system operates differently from an on-demand system. With user-managed ANF, the user is responsible for creating and deleting the ANF file system.

In some cases, this can be more expensive than using the on-demand approach, especially if the user forgets to delete the ANF volume after no longer needing it.

However, with user-managed ANF a user can run multiple concurrent jobs with the same ANF file system. It is also possible to run multiple jobs in sequence, each using the output of the previous job as input, without having the overhead of the files being copied from the ANF file system to Azure cloud storage, and vice versa. Depending on the size of the workload, this option may be cheaper, or more desirable, than on-demand ANF.

To create an ANF volume, the user can execute `cmjob` with the `create-anf-volume` option:

Example

```
cmjob create-anf-volume <name or ID> --capacity <capacity>
```

Here:

- *<name or ID>* can be a sequence of alphanumeric characters and dashes. It does not have to be unique.
- *<capacity>* is the total size of the ANF file system in terabytes. If not specified, the default value is used. The default value can be managed via:
  `cmsh→cmjob→storagenodepolicies→use <policy>→intermediatestorage`.

To delete an ANF volume, a user can run `cmjob` with the `delete-anf-volume` option:

Example

```
cmjob delete-anf-volume <name or ID>
```

To obtain a list of all existing ANF volumes with their names and statuses, the user can run `cmjob` with the `list-anf-volumes` option:

Example

```
cmjob list-anf-volumes
```

Once the ANF volume has reached a status of `AVAILABLE` (which can take a few minutes), it is possible to submit a job with this volume name or ID with the `--anf-volume` option.

Example

```
  cmjob submit job.sh --anf-volume <name or ID>
```

Using admin-managed ANF Using `cmjob` with an admin-managed file system is very similar to using it with a user-managed file system. The main difference is that the administrator is responsible for creating and deleting the file system, and that the file system of the administrator is shared with specific users. To share the file system, the `share-anf-volume` option can be run by the administrator, together with the `--with option`, as follows:

Example

```
cmjob share-anf-volume <name or ID> --with <user names>
```

With admin-managed ANF, users do not need any ANF-specific tokens to submit a job with an ANF volume. Using admin-managed ANF volumes instead of user-managed ANF volumes gives the administrator more control over the creation and deletion of ANF volumes. By managing profiles, the administrator is free to divide users into a group of users that are allowed to create and delete their own volumes, and a group of users that are only allowed to submit jobs with volumes that are shared with them.

To stop sharing the ANF volume, the admin can run the `--stop-sharing` option:

Example

```
cmjob share-anf-volume <name or ID> --stop-sharing
```

Tracking NetApp costs: All Azure NetApp Files capacity pools created via `cmjob` have a `BCM Owner` tag assigned to them. This tag allows the cluster administrator to track the NetApp costs on a per-user basis using Azure's cost management capabilities.

5.6 Creating An Azure Cluster Extension Using ExpressRoute Or A Hardware VPN

For simple configurations, Bright Cluster Manager recommends, and provides, OpenVPN by default for cluster extension cloudbursting VPN connectivity. If there is a wish to use Direct Connect or a hardware VPN (for example, an IPSec tunnel), then Bright Cluster Manager can be configured to work with those.

The Azure cluster extension always runs in an Azure Virtual Network. In the default deployment scenario, the head node communicates with the cloud nodes using an OpenVPN connection between the head node and the cloud director. In the case of an ExpressRoute connection or a hardware VPN, the head node can be configured to communicate directly with the cloud director and cloud nodes.

Setting up ExpressRoute or a VPN for a cluster extension can be carried out according to these three steps:

1. Virtual network creation (section 5.6.1). This step can be skipped if an existing virtual network is to be used.

2. Connecting the local network to the virtual network (section 5.6.2). The connection can be with, for example, ExpressRoute, or a hardware VPN. This step can be skipped if the local network is already connected to an existing virtual network via an ExpressRoute or a hardware VPN connection.

3. Configuring and deploying the cluster extension (section 5.6.3).

5.6.1 Creating A Virtual Network

The Azure virtual network is the fundamental building block for building private networks in Azure. A virtual network allows the cloud director and cloud nodes to communicate with each other securely, and can be extended to the on-premise networks. Documentation for creating a virtual network can be found at:

`https://docs.microsoft.com/en-us/azure/virtual-network/quick-create-portal`

A new virtual network can be created and configured for the cluster extension as follows:

1. After logging in to the Azure portal, `https://portal.azure.com`, from the home page, `https://portal.azure.com/#home`, the following clickpath can be followed:

   `+ Create a resource→Azure Marketplace→Networking→Virtual network`

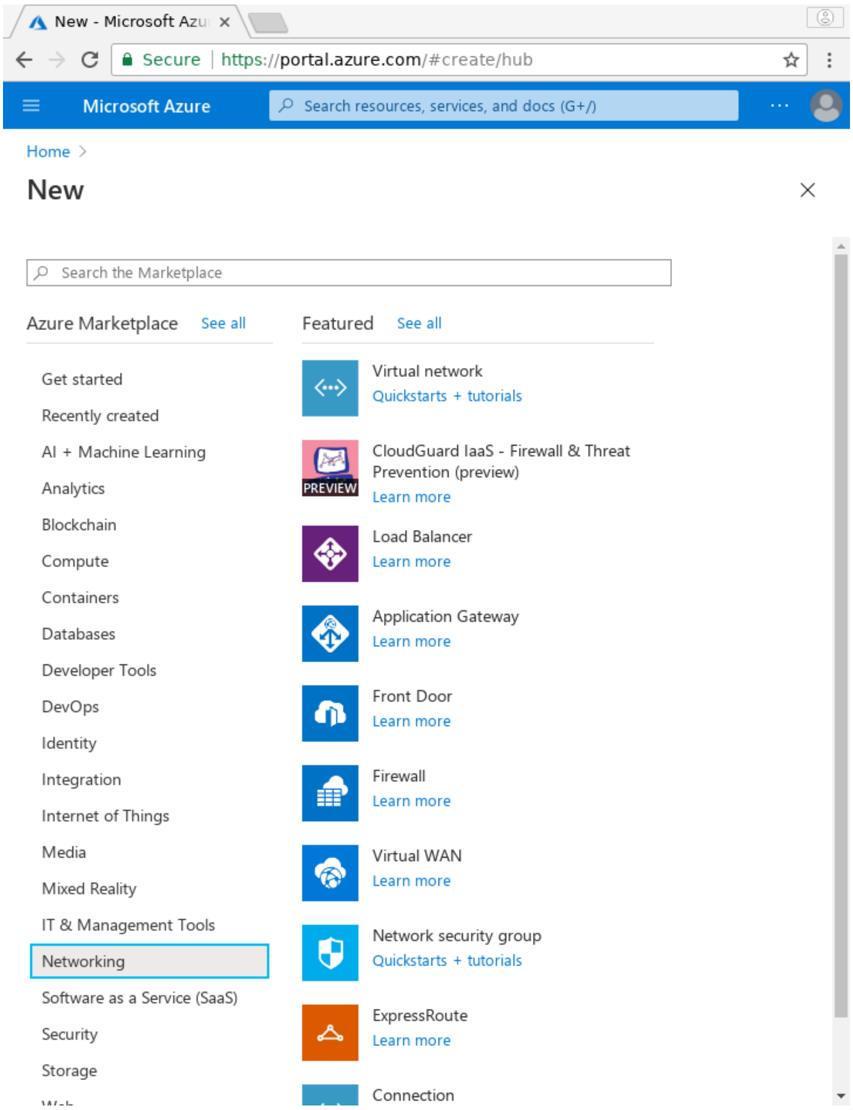
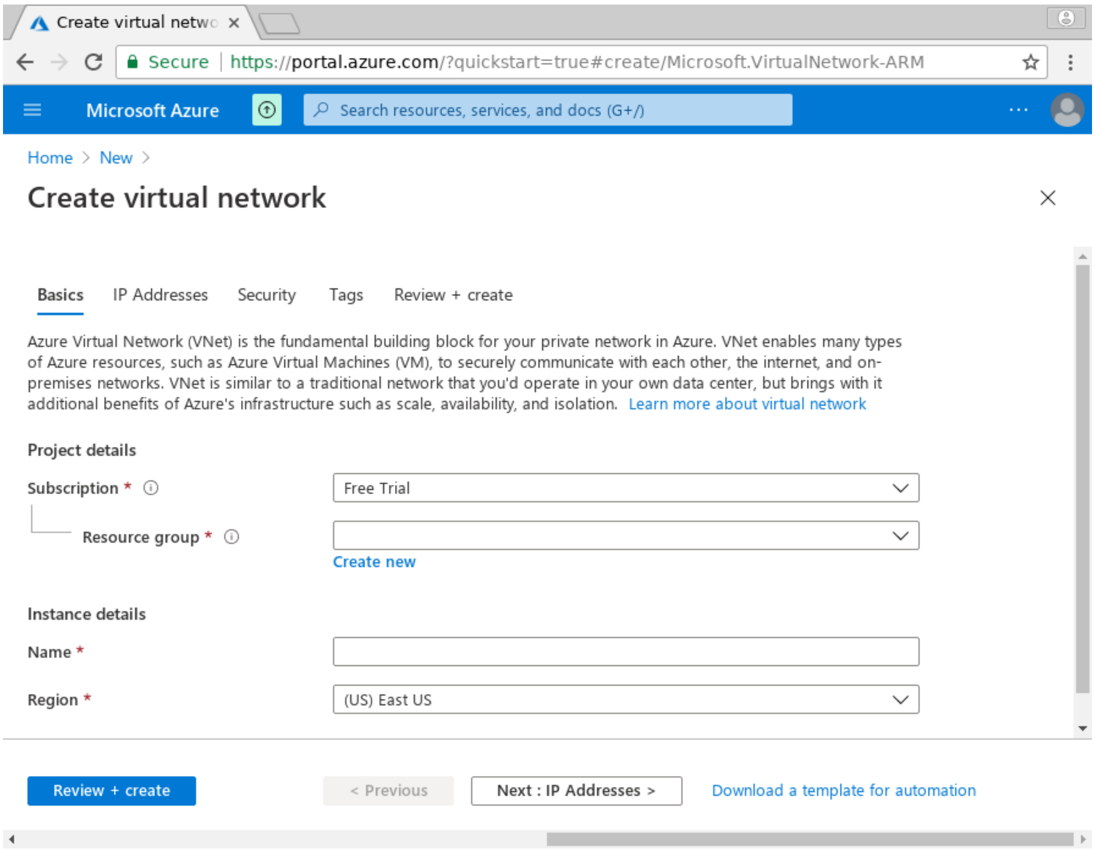


Figure 5.7: Azure Marketplace Networking Screen

2. A resource group should be selected or a new resource group should be created for the virtual network in the `Basics` tab:



Create virtual network

Basics | IP Addresses | Security | Tags | Review + create

Azure Virtual Network (VNet) is the fundamental building block for your private network in Azure. VNet enables many types of Azure resources, such as Azure Virtual Machines (VM), to securely communicate with each other, the internet, and on-premises networks. VNet is similar to a traditional network that you'd operate in your own data center, but brings with it additional benefits of Azure's infrastructure such as scale, availability, and isolation. Learn more about virtual network

Project details

Subscription * Free Trial

Resource group *

Create new

Instance details

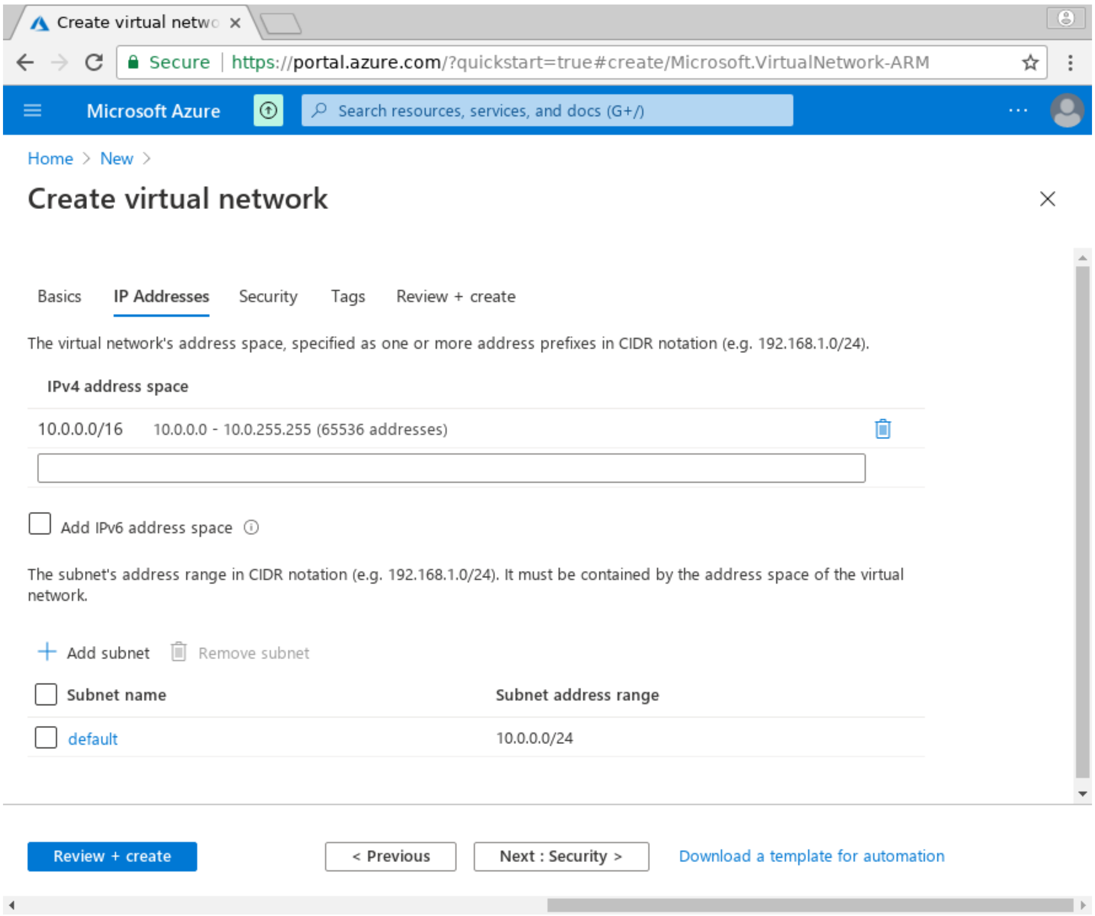
Name *

Region * (US) East US

Create virtual netwo
Secure
https://portal.azure.com/?quickstart=true#create/Microsoft.VirtualNetwork-ARM
Microsoft Azure
Search resources, services, and docs (G+/)
Home > New >
Review + create
< Previous
Next : IP Addresses >
Download a template for automation

Figure 5.8: Creating A Resource Group In The `Basics` Tab

3. An IPv4 CIDR block can be set to a desired range via the `IP Addresses` tab, reached by clicking on the `Next: IP Addresses` button:



https://portal.azure.com/?quickstart=true#create/Microsoft.VirtualNetwork-ARM

Create virtual network

The virtual network's address space, specified as one or more address prefixes in CIDR notation (e.g. 192.168.1.0/24).

IPv4 address space

10.0.0.0/16 10.0.0.0 - 10.0.255.255 (65536 addresses)

□ Add IPv6 address space

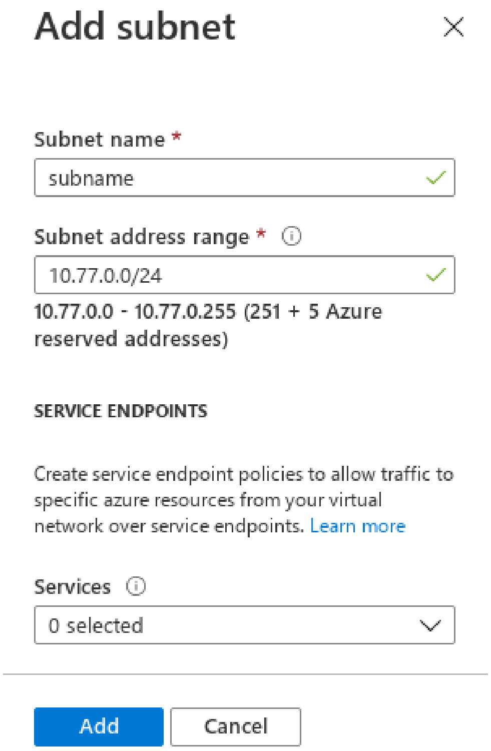
The subnet's address range in CIDR notation (e.g. 192.168.1.0/24). It must be contained by the address space of the virtual network.

□ Subnet name	Subnet address range
□ default	10.0.0.0/24

Figure 5.9: Creating IP Address Ranges In The `IP Addresses` Tab

This range should not conflict with the address space used on-premises. A possible range could be, for example, `10.77.0.0/16`

4. Once the virtual network range is set, a subnet can be entered via the `+ Add subnet` option, which opens up a dialog.



Add subnet

Subnet name *

subname

Subnet address range *

10.77.0.0/24

10.77.0.0 - 10.77.0.255 (251 + 5 Azure reserved addresses)

SERVICE ENDPOINTS

Create service endpoint policies to allow traffic to specific azure resources from your virtual network over service endpoints. Learn more

Services

0 selected

Figure 5.10: Creating IP Address Ranges In The `IP Addresses` Tab: Subnet Addition

A possible subnet could be, for example, `10.77.0.0/24`. The `Add` button then adds it.

5. The clickpath:

   `Review + create`→`Create`

   goes on to deploy the virtual network.

5.6.2 Connecting The Local Network To The Virtual Network

Azure offers two virtual network gateway types to connect the local network to the virtual network: ExpressRoute and VPN.

Connecting Via ExpressRoute

To connect the local network to the virtual network via ExpressRoute requires using an *ExpressRoute circuit connection*. Azure's instructions for this are at:

`https://docs.microsoft.com/en-us/azure/expressroute/expressroute-howto-linkvnet-portal-resource-manager`

Connectng Via A Site-To-Site Connection Using A VPN

Connecting an on-premises network to the virtual network using a VPN requires an Azure site-to-site connection. Azure's instructions for configuring a site-to-site IPsec VPN connection are at:

`https://docs.microsoft.com/en-us/azure/vpn-gateway/vpn-gateway-howto-site-to-site-resource-manager-portal`

In Azure this consists of three components:

1. a virtual network gateway (routes traffic from local network to virtual network)
2. a local network gateway (routes traffic from virtual network to local network)
3. a connection

The local network gateway needs to define the address ranges of the local network. The default address ranges for the local network are: `10.141.0.0/16`, `10.2.0.0/16`, and `192.168.200.0/24`.

The virtual network gateway requires a gateway subnet. The address range for the gateway subnet should be a subnet of the virtual network that does not overlap with the subnet address range for the cluster extension, for example: `10.77.1.0/24`.

5.6.3 Configuring And Deploying The Cluster Extension

Once IP connectivity from on-prem to the Azure virtual network is running, the final step is creating the cluster extension using the newly created site-to-site connection.

Getting Through Shorewall

First, the firewall rules on the head node must be adjusted to accept traffic from the virtual network. The file `/etc/shorewall/rules` can be edited so that the `net` section allows packets from the CIDR subnet. A quick-and-dirty way to do it is to append to the file with:

```
[root@bright90 ~]# echo "ACCEPT net:<subnet CIDR> fw - -" >> /etc/shorewall/rules
[root@bright90 ~]# shorewall reload
```

Cluster Extension Advanced Settings Configuration

A cluster extension can now be created using the `cm-cluster-extension` utility in Ncurses mode as explained in section 5.2.

However, on reaching the summary screen (figure 5.6, page 72), the cluster administrator should not immediately select the `Save config & deploy` option, but should first go to the `Advanced settings` option, which opens up an `Advanced plugin configuration` screen (figure 5.11):

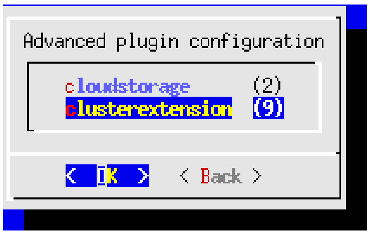


Figure 5.11: Cluster Extension Configuration Processing: Advanced Plugins Screen

The `clusterextension` option should be selected, which opens up an advanced options settings screen for Azure (figure 5.12):

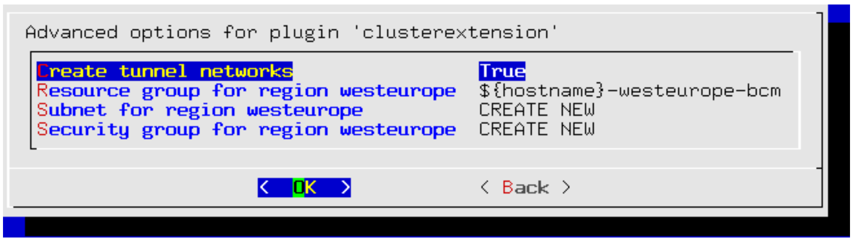

```
Advanced options for plugin 'clusterextension'

Create tunnel networks                   True
Resource group for region westeurope     ${hostname}-westeurope-bcm
Subnet for region westeurope             CREATE NEW
Security group for region westeurope     CREATE NEW
```

Figure 5.12: Cluster Extension Configuration Processing: Advanced Plugins For 'clusterextension', Azure Options Screen

In this screen:

- the `Create tunnel networks` option should be set to `False`
- the `Subnet for region` *<region>* should be set to the subnet that has been created for the cluster extension. The cluster extension is what is being connected to via ExpressRoute or via site-to-site connection

The Ncurses advanced settings screens can be backed out of by selecting `Back` twice. The option `Save config & deploy` can then be selected to create the cluster extension.

Cloud Node Certificate Autosigning

By default Bright Cluster Manager does not issue certificates for nodes on the external network. This means that for cloud nodes the certificates need to be issued manually, once for every new cloud node.

Alternatively, to automatically sign certificate requests by cloud nodes, autosign can be enabled by the administrator for external networks. Autosigning may be a security concern, as this allows anyone on the external network to request a node certificate. Autosign can be enabled on externalnet in `cmsh` as follows:

```
[root@bright90~]# cmsh
[bright90]% network
[bright90->network]% set externalnet allowautosign always
[bright90->network]% commit
```

The cluster extension can now be deployed as explained on page 72.

6

Cluster Extension Cloudbursting With OpenStack

6.1 Introduction

6.1.1 Cluster Extension In General

If Bright OpenStack is running on a cluster (the host cluster) that a user can access and run OpenStack instances on, then the user can become an administrator of a local OpenStack Bright cluster instance (the client cluster) running within the host cluster.

Users, instead of using up resources on their own local client cluster, may sometimes wish to extend into a second, remote, Bright OpenStack, cluster. This second cluster can then be regarded as a cloud service host that provides Bright OpenStack services.

This kind of setup is a case of running a cluster within a cloud service.

Thus, for this case, the cloud service is provided by Bright OpenStack. Analogous setups where the cloud service is provided by AWS or Azure can also be managed with Bright Cluster Manager (Chapter 3). In Bright jargon these cluster extension setups are conveniently abbreviated as:

- CX-OS, for cluster extension into OpenStack
- CX-AWS, for cluster extension into Amazon Web Services
- CX-Azure, for cluster extension into Microsoft Azure

This chapter explains cluster extension into OpenStack.

6.1.2 Overview Of Carrying Out Cluster Extension Into OpenStack

Bright provides a client, `cm-cluster-extension`, to set up and launch a CX-OS. It is run from the head node of a client cluster. Bursting in Bright Cluster Manager version 8.2 is possible into Bright Cluster Manager host clusters of versions 8.0, 8.1, and 8.2 that are running Bright OpenStack.

The `cm-cluster-extension` client is provided by default with Bright Cluster Manager as part of the `cm-setup` package. Its CLI options are covered in Chapter 4.1.

Running it without CLI options is recommended, and brings up an Ncurses dialog, which provides an easier option to deploy a CX-OS (section 6.2).

Another option to deploy CX-OS is via a Bright View wizard (section 6.3).

6.2 Deploying A Cluster Extension Into OpenStack Via An Ncurses Dialog

The sequence of screens that follows shows the Ncurses-based procedure for CX-OS deployment. It has some parallels with the Ncurses-based procedure for CX-AWS deployment (page 45).

Figure 6.1 shows the introductory window after running `cm-cluster-extension` as root:

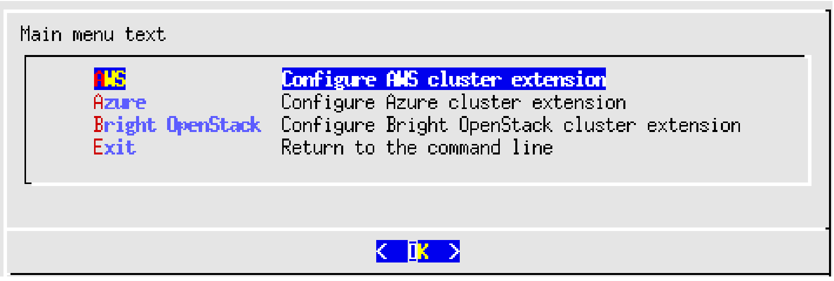

Main menu text
AWS Configure AWS cluster extension
Azure Configure Azure cluster extension
Bright OpenStack Configure Bright OpenStack cluster extension
Exit Return to the command line
< OK >

Figure 6.1: Ncurses Dialog

The type of cloud provider can be chosen. For this chapter, it means selecting Bright OpenStack as the cloud provider.

The provider instance can be added in figure 6.2. Previously added providers can also be removed in this screen (figure 6.2):

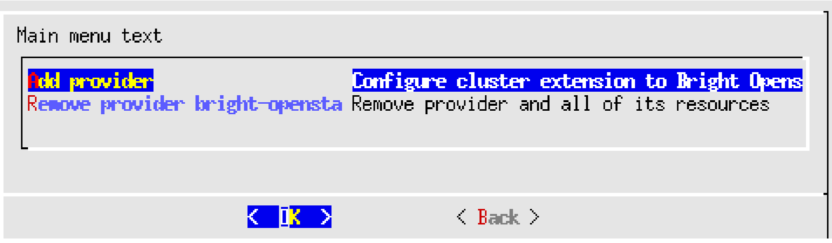

Main menu text
Add provider Configure cluster extension to Bright Opens
Remove provider bright-opensta Remove provider and all of its resources
< OK >
< Back >

Figure 6.2: Ncurses Dialog: Add/Remove Provider

Credentials to the OpenStack instance can be configured in the screen in figure 6.3:

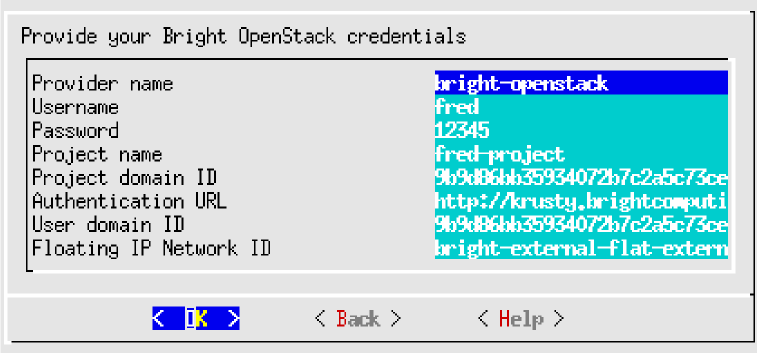
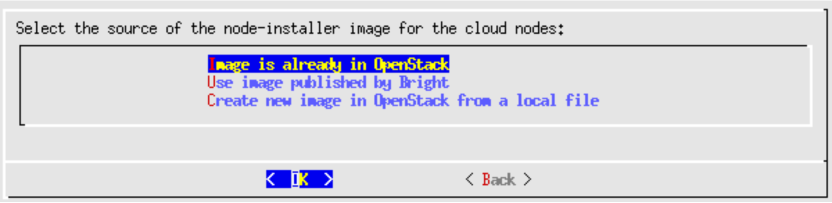

```
Provide your Bright OpenStack credentials

Provider name              bright-openstack
Username                   fred
Password                   12345
Project name               fred-project
Project domain ID          9b9d86bb35934072b7c2a5c73ce
Authentication URL         http://krusty.brightcomputi
User domain ID             9b9d86bb35934072b7c2a5c73ce
Floating IP Network ID     bright-external-flat-extern
```

Figure 6.3: Ncurses Dialog: Add Bright OpenStack Credentials

The associated values of `Authentication URL` and `Floating IP Network ID`, in figure 6.3 are not credentials *per se*. These values should be obtained from the administrator of the Bright OpenStack cloud provider into which the bursting is being done.

A node-installer image source location should be set. This can be an image published by Bright, which if used causes the setup to download a latest node-installer image from the Bright image repository hosted on Amazon's S3 service. Another possibility is to select `Image is already in OpenStack`, which uses an image that is on the OpenStack host, if images have already set up there by the tenant (figure 6.4), or if set up there by another tenant and made public:

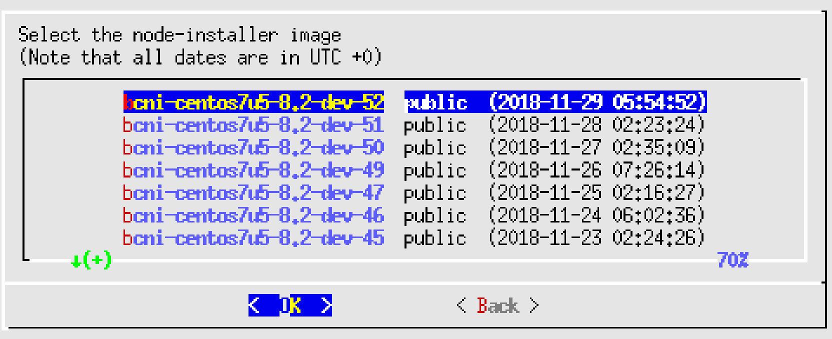


Select the source of the node-installer image for the cloud nodes:

Image is already in OpenStack
Use image published by Bright
Create new image in OpenStack from a local file
< OK >
< Back >

Figure 6.4: Ncurses Dialog: Select Node-installer Image Source

The node-installer image can be set (figure 6.5):

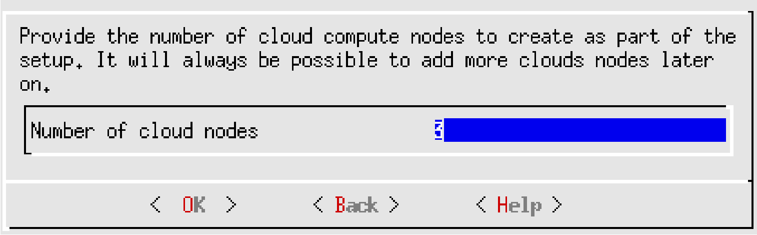


Select the node-installer image
(Note that all dates are in UTC +0)

```
bcni-centos7u5-8.2-dev-52  public  (2018-11-29 05:54:52)
bcni-centos7u5-8.2-dev-51  public  (2018-11-28 02:23:24)
bcni-centos7u5-8.2-dev-50  public  (2018-11-27 02:35:09)
bcni-centos7u5-8.2-dev-49  public  (2018-11-26 07:26:14)
bcni-centos7u5-8.2-dev-47  public  (2018-11-25 02:16:27)
bcni-centos7u5-8.2-dev-46  public  (2018-11-24 06:02:36)
bcni-centos7u5-8.2-dev-45  public  (2018-11-23 02:24:26)
```

Figure 6.5: Ncurses Dialog: Select Node-installer Image

The number of cloud compute nodes available from the OpenStack host can be set (figure 6.6):

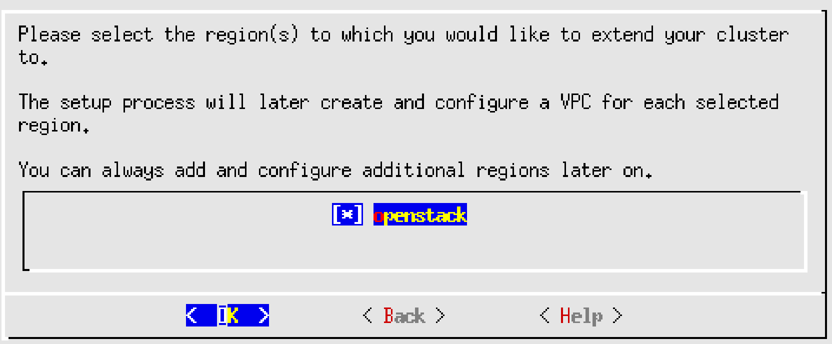


Provide the number of cloud compute nodes to create as part of the setup. It will always be possible to add more clouds nodes later on.

Number of cloud nodes 3

Figure 6.6: Ncurses Dialog: Setting The Number Of Cloud Compute Nodes

The cloud region (the host or hosts into which the extension takes place) can be set (figure 6.7):



Please select the region(s) to which you would like to extend your cluster to.

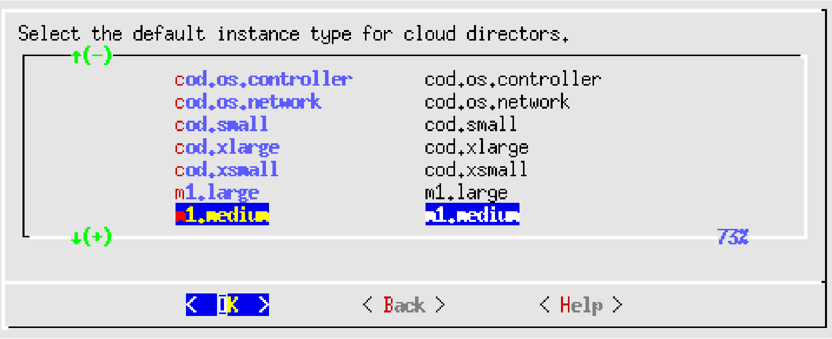
The setup process will later create and configure a VPC for each selected region.

You can always add and configure additional regions later on.

☒ openstack

Figure 6.7: Ncurses Dialog: Cloud Region Selection

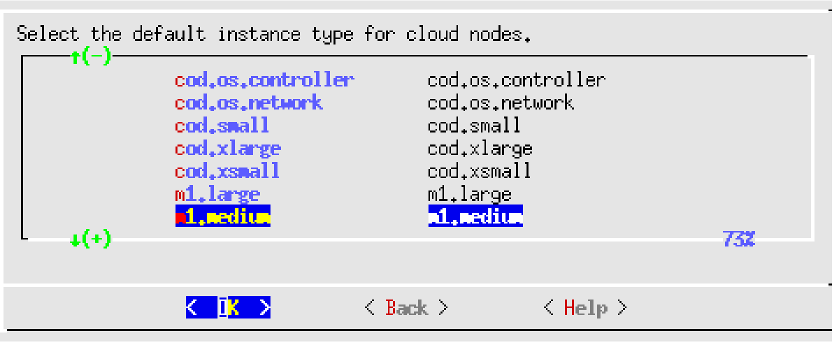
The default cloud director type can be set (figure 6.8):



```
Select the default instance type for cloud directors.
         cod.os.controller      cod.os.controller
         cod.os.network         cod.os.network
         cod.small              cod.small
         cod.xlarge             cod.xlarge
         cod.xsmall             cod.xsmall
         m1.large               m1.large
         m1.medium              m1.medium
                                                   73%
```

Figure 6.8: Ncurses Dialog: Default Cloud Director Instance Type

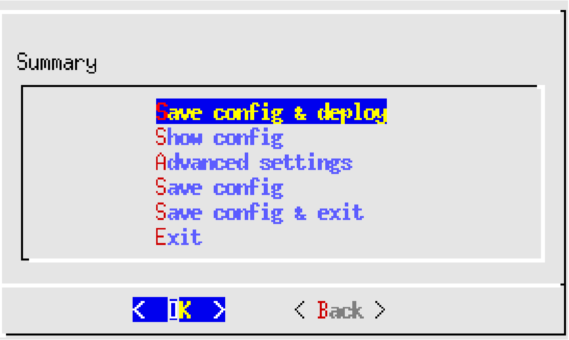
The default cloud node instance type can be set (figure 6.9):



```
Select the default instance type for cloud nodes.
         cod.os.controller      cod.os.controller
         cod.os.network         cod.os.network
         cod.small              cod.small
         cod.xlarge             cod.xlarge
         cod.xsmall             cod.xsmall
         m1.large               m1.large
         m1.medium              m1.medium
                                                   73%
```

Figure 6.9: Ncurses Dialog: Default Cloud Node Instance Type

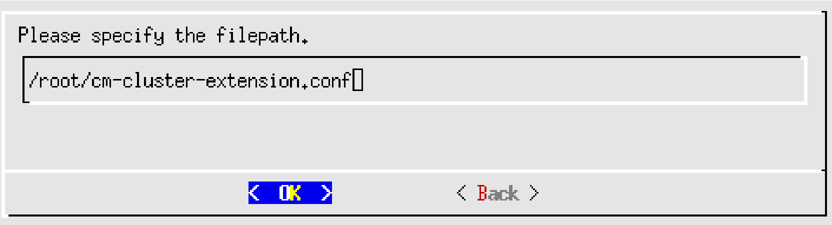
A summary of the configuration that has been done is displayed before committing (figure 6.10):



```
Summary
         Save config & deploy
         Show config
         Advanced settings
         Save config
         Save config & exit
         Exit
```

Figure 6.10: Ncurses Dialog: Summary

The configuration can be stored into a file (figure 6.11), so that it can be reused later:



```
Please specify the filepath.
/root/cm-cluster-extension.conf
```

Figure 6.11: Ncurses Dialog: Setting Configuration File Location

The session then finishes with output showing the progress as the configuration is carried out.

Example

```
Executing 18 stages
################### Starting execution for 'Cluster Extension'
  - cloudstorage
  - clusterextension
## Progress: 0
#### stage: clusterextension: Fill Out Aliases In Config
## Progress: 5
#### stage: clusterextension: Check Subnet Configuration
Connecting to CMDaemon
## Progress: 11
#### stage: clusterextension: Create Provider
## Progress: 16
#### stage: clusterextension: Wait For Provider Data
## Progress: 33
#### stage: clusterextension: Create Netmap Network
NETMAP network 'netmap' already exists. Skipping
## Progress: 38
#### stage: clusterextension: Create Tunnel Networks
## Progress: 44
#### stage: clusterextension: Create Cloud Network
## Progress: 50
#### stage: clusterextension: Configure Headnodes
Configuring tunnel interfaces for headnode
Configuring roles for headnode
Adding CloudGatewayRole to bright90
## Progress: 55
#### stage: clusterextension: Configure Regular Nodes For VPC
## Progress: 61
#### stage: clusterextension: Enable Management On Tunnel Interface
## Progress: 66
#### stage: clusterextension: bright-openstack-cloud-director
## Progress: 72
#### stage: clusterextension: Create Extension
Heat Stack 4b5d2e21-8d65-412a-8a60-6eb457772d62 is being created...
## Progress: 77
#### stage: clusterextension: Create Security Groups
Creating security group 'bright90-bright-openstack-openstack-director-sg'
Creating security group 'bright90-bright-openstack-openstack-cnode-sg'
## Progress: 83
#### stage: clusterextension: Create Director
Adding FSExport for '/cm/shared' to hosts '10.42.0.0/16' to cloud director openstack-director
Adding FSExport for '/home' to hosts '10.42.0.0/16' to cloud director openstack-director
## Progress: 88
#### stage: clusterextension: Configure Node Categories
## Progress: 94
#### stage: clusterextension: Create Cloud Node
Processing node 'openstack-cnode001'
Processing node 'openstack-cnode002'
Processing node 'openstack-cnode003'
## Progress: 100

Took:     00:05 min.
```

```
Progress: 100/100
################### Finished execution for 'Cluster Extension', status: completed

Cluster Extension finished!
```

After the cloud director and associated cloud compute nodes are configured, they can be powered up (some output elided):

Example

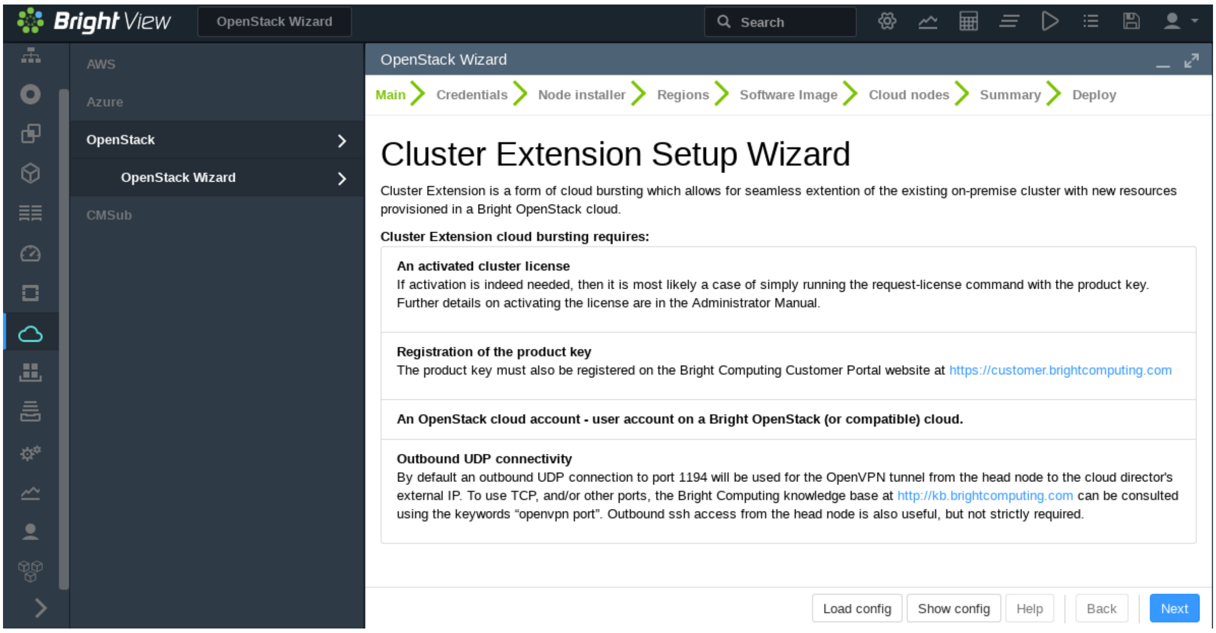
```
[root@bright90 ~]# cmsh
[bright90]% device
[bright90->device]% list
Type         Hostname (key)      Category                         Ip              Status
------------ ------------------- -------------------------------- --------------- ----------
CloudNode    openstack-cnode001  openstack-cloud-node             172.16.0.1      [  DOWN  ]
CloudNode    openstack-cnode002  openstack-cloud-node             172.16.0.2      [  DOWN  ]
CloudNode    openstack-cnode003  openstack-cloud-node             172.16.0.3      [  DOWN  ]
CloudNode    openstack-director  bright-openstack-cloud-director  172.16.255.251  [  DOWN  ]
...
[bright90->device]% power on openstack-director
cloud .................... [ PENDING ] openstack-director (Powering on)
Thu Nov 29 18:04:55 2018 [notice] bright90: openstack-director [ PENDING ] (Instance has started)
...
Thu Nov 29 18:10:33 2018 [notice] bright90: openstack-director [   UP   ]
[bright90->device]% power on -n openstack-cnode00[1-3]
cloud .................... [ PENDING ] openstack-cnode001 (Powering on)
cloud .................... [ PENDING ] openstack-cnode002 (Powering on)
cloud .................... [ PENDING ] openstack-cnode003 (Powering on)
...
Fri Nov 30 12:55:37 2018 [notice] bright90: openstack-cnode002 [ PENDING ] (Instance has started)
Fri Nov 30 12:55:37 2018 [notice] bright90: openstack-cnode001 [ PENDING ] (Instance has started)
Fri Nov 30 12:55:37 2018 [notice] bright90: openstack-cnode003 [ PENDING ] (Instance has started)
...
Fri Nov 30 13:00:33 2018 [notice] bright90: openstack-cnode003 [   UP   ]
Fri Nov 30 13:00:34 2018 [notice] bright90: openstack-cnode002 [   UP   ]
Fri Nov 30 13:01:04 2018 [notice] bright90: openstack-cnode001 [   UP   ]
```

6.3 Deploying A Cluster Extension Into An OpenStack Instance Via A Bright View Wizard

Bright View can be used to deploy a cluster extension into OpenStack via a wizard that can be run from the clickpath:

`Cloud→OpenStack→OpenStack Wizard`

This then brings up the following display:



Cluster Extension Setup Wizard

Cluster Extension is a form of cloud bursting which allows for seamless extention of the existing on-premise cluster with new resources provisioned in a Bright OpenStack cloud.

Cluster Extension cloud bursting requires:

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.

Registration of the product key
The product key must also be registered on the Bright Computing Customer Portal website at https://customer.brightcomputing.com

An OpenStack cloud account - user account on a Bright OpenStack (or compatible) cloud.

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.

Figure 6.12: Bright View Wizard: Cluster Extension Into OpenStack Wizard Main Page

The procedure from here on is sufficiently similar to the Ncurses installation in section 6.2 that further elaboration here is not needed.

6.4 Connectivity To The Internet For OpenStack Compute Nodes

OpenStack cluster extension compute nodes are routed via a cloud director sNAT gateway. However for this to work in a OpenStack environment, the port security plugin needs to be enabled for Neutron, followed by disabling the port security setting on the cloud director ports. By default, the port security plugin is disabled for Neutron, while the port security setting is in an enabled state.

Disabling the security setting causes the security groups to be no longer applied in the cloud director. This means anyone with Layer-3 (IP) access to the cloud director could try to establish a connection to any of the cloud director ports.

Therefore, by default for CX-OS, the port security plugin is left disabled, and the port security setting left enabled. To enable it, `cm-cluster-extension` can be run as follows:

```
cm-cluster-extension --enable-external-network-connectivity
```

For the option to work, the OpenStack instance which the cluster is being extended into should also have its Neutron ML2 port security plugin enabled:

Example

```
[clustername]% openstack; settings; networking
[clustername->openstack[default]->settings->networking]% set enableml2portsecurityplugin yes
[clustername->openstack*[default*]->settings*->networking*]% commit
```

7

Cloud Considerations And Choices With Bright Cluster Manager

7.1 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*.

7.2 Hardware And Software Availability

Bright Computing head node AMIs are available for the following distributions: RHEL7 and CentOS7.

AMIs with GPU computing instances are available with Amazon cloud computing services, and 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 Bright View 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.

7.3 Reducing Running Costs

7.3.1 Spot Pricing

The spot price field is a mechanism to take advantage of cheaper pricing made available at irregular[1] 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.

7.3.2 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

```
[bright90]% device cloudsettings eu-west-1-director
[bright90->device[eu-west-1-director]->cloudsettings]% storage
[bright90->...->cloudsettings->storage]% set ebs size 15GB; commit
[bright90->...->cloudsettings->storage]% device cloudsettings cnode001
[bright90->device[cnode001]->cloudsettings]% storage
[bright90->...->cloudsettings->storage]% set ebs size 5GB; commit
```

The value for the cloud node EBS storage can also be set via Bright View, using the clickpath:

`Devices→Cloud Nodes→Edit→Settings→Cloud settings→STORAGE→Storage→ebs→Edit→size`

7.4 Ignoring Prepaid Node Limits With Pay-Per-Use Images

By default a user is restricted by the cloud licence from running more VMs in the cloud than a limit set within the license. This is a wise default, because as a general principle cluster administrators wish to keep costs within a planned budget.

However, there are times when a cluster administrator may wish to ignore this restriction. Ignoring the restriction is possible—at a price.

A use case for this might be a cluster that uses only a regular amount of cloudbursting most of the time, but on certain rare days it may need to burst beyond this regular amount.

Another use case might be an IT department that runs a cluster, suddenly finds itself with a large amount of unused budget, and it turns out that it is sensible to use the budget up on bursting runs.

How to allow bursting past the prepaid limit is described in the following sections for AWS (section 7.4.1) and for Azure (section 7.4.2).

[1] 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`

7.4.1 Bursting Past The Prepaid Limit In AWS

Node-installer Image Types For AWS Cloud Nodes

Bright Cluster Manager version 9.0 introduced a way to set the node-installer image type for AWS cloud nodes. The possible cloud node node-installer image types provided by Bright Cluster Manager are:

- prepaid image type: a free node-installer image type, used to power on all nodes within the license limit. The license limit is the maximum number of images that can be run, and is the value of `Pre-paid nodes` in the output of the `licenseinfo` command (section 4.1.2 of the *Installation Manual*).
- pay-per-use image type: a paid node-installer image type, used to power on all nodes beyond the license limit. Using this as the node-installer image incurs additional hourly costs for the licensing part as well as for the AWS infrastructure.

Default Policy For Node-installer Image Type For AWS Cloud Nodes

A default policy to set the cloud node node-installer image type can be defined at cloud provider level using `usepaidmarketplaceamis`.

Example

```
[root@bright90 ~]# cmsh
[bright90]% cloud
[bright90->cloud[amazon]]% show
Parameter                        Value
-------------------------------- ------------------------------------------------
Access key ID                    *********
Account ID                       197943594779
Billing access key ID            < not set >
Cloud job tagging                no
Default AMI                      latest:brightinstaller-42
Default director type            m3.medium
Default region                   eu-west-1
Default type                     m3.medium
Name                             amazon
Revision
Secret access key                *********
Secret billing access key        < not set >
Tags                             COD_PREFIX=PJ,BCM Bursting=extension,Name=bright90
Type                             ec2
Use paid Market place AMIs       NEVER
Username                         krusty-clusters
VPCs                             <1 in submode>
[bright90->cloud[amazon]]% set usepaidmarketplaceamis <TAB><TAB>
always     as_needed  never
[bright90->cloud[amazon]]% set usepaidmarketplaceamis as_needed
[bright90->cloud*[amazon*]]% commit
```

There are 3 possible values for `usepaidmarketplaceamis`:

1. `never`: paid marketplace images are never used. Any attempt to power on any extra cloud nodes beyond the license limit fails.
2. `always`: The paid marketplace image is always used when powering on cloud nodes.
3. `as_needed`: The free image is used as a default so long as the prepaid node count limit has not been exceeded. Beyond the prepaid node count limit, all additional cloud nodes use the paid marketplace image.

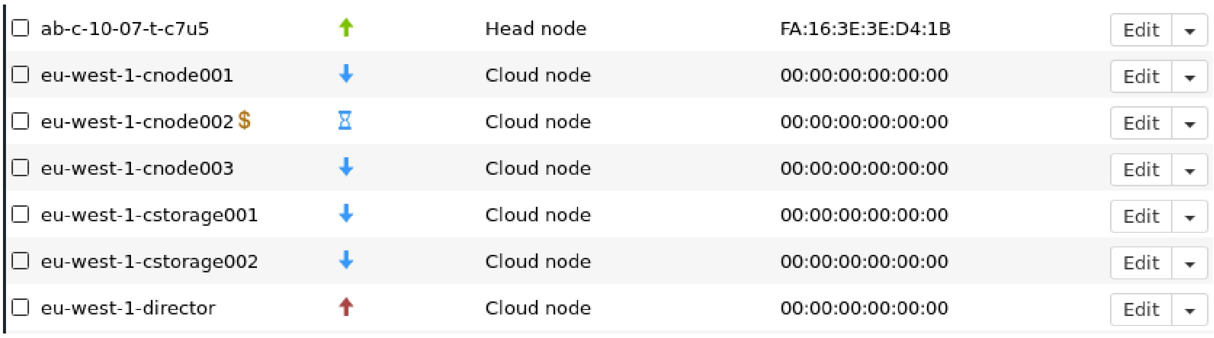
It should be noted that once a cloud node is up, and using a paid marketplace image, then it continues to run as a paid node, even if the node count goes under the prepaid node count limit after some time. The node running a paid marketplace image only stops running as a paid node when it is terminated.

Indication that the node is a paid marketplace image: In cmsh, if one of the cloud nodes is using a paid marketplace image, then it is displayed tagged with the text additional cost, as seen in the following for eu-west-1-cnode002:

Example

```
[bright90->device[eu-west-1-cnode002]->cloudsettings]% ds
eu-west-1-cnode001 ....... [  UP    ]
eu-west-1-cnode002 ....... [ PENDING ] (Instance has started), additional cost
eu-west-1-cnode003 ....... [  DOWN  ]
eu-west-1-director ....... [   UP   ]
node001 .................. [   UP   ]
node002 .................. [   UP   ]
bright90 ................. [   UP   ]
```

In Bright View, following the clickpath Devices, a cloud node running a paid marketplace image is tagged with a $ sign (figure 7.1):



□ ab-c-10-07-t-c7u5	↑	Head node	FA:16:3E:3E:D4:1B	Edit ▾
□ eu-west-1-cnode001	↓	Cloud node	00:00:00:00:00:00	Edit ▾
□ eu-west-1-cnode002 $	⧗	Cloud node	00:00:00:00:00:00	Edit ▾
□ eu-west-1-cnode003	↓	Cloud node	00:00:00:00:00:00	Edit ▾
□ eu-west-1-cstorage001	↓	Cloud node	00:00:00:00:00:00	Edit ▾
□ eu-west-1-cstorage002	↓	Cloud node	00:00:00:00:00:00	Edit ▾
□ eu-west-1-director	↑	Cloud node	00:00:00:00:00:00	Edit ▾

Figure 7.1: A cloud node, eu-west-1-cnode002, seen running a marketplace image

First-time Use Of A Marketplace Node-installer Image For AWS Cloud Nodes

Before a marketplace image can be used for the first time, the terms of the offer must be accepted, and subscribed to.

If this is not done, then, if the administrator tries to power on a cloud node using a marketplace image via cmsh, an error message similar to the following appears:

Example

```
[device[eu-west-1-director]]% power on

cloud .................... [ FAILED ] eu-west-1-director
                           (An error occurred (OptInRequired) when calling the RunInstances
                           operation: In order to use this AWS Marketplace product you need to
                           accept terms and subscribe. To do so please visit
                           https://aws.amazon.com/marketplace/pp?sku=<some string>
```

The URL that appears in the error message can be visited. At that URL the terms can be accepted and a subscription started. Then the attempt to power on a cloud node can be made once more.

7.4.2 Bursting Past The Prepaid Limit In Azure

Node-installer Image Types For Azure Cloud Nodes

In Azure, as for AWS, the possible cloud node node-installer image types provided by Bright Cluster Manager are:

- prepaid image type: a free node-installer image type, used to power on all nodes within the license limit. The license limit is the maximum number of images that can be run, and is the value of `Pre-paid nodes` in the output of the `licenseinfo` command (section 4.1.2 of the *Installation Manual*).

- pay-per-use image type: a paid node-installer image type, used to power on all nodes beyond the license limit. Using this as the node-installer image incurs additional hourly costs for the licensing part as well as for the Azure infrastructure.

Default Policy For Node-installer Image Type For Azure Cloud Nodes

In Azure a default policy to set the cloud node node-installer image type can be defined at cloud provider level using `usepaidmarketplaceimages`.

Example

```
[root@bright90 ~]# cmsh
[bright90]% cloud
[bright90->cloud[azure]]% show
Parameter                        Value
-------------------------------- ------------------------------------------------
Client ID                        afe23456-06b9-4241-80a9-17ba71ccb911
Client secret                    *********
Default Cloud Director VM Size   Standard_D2_v3
Default Location                 germanywestcentral
Default VM Size                  Standard_D2_v3
Default node-installer image     https://brightimages.blob.core.windows.net/images/
Extensions                       <1 in submode>
Name                             azure
Revision
Subscription ID                  2b8fad2b-aaf1-425a-bf45-36cfd495107e
Tags                             COD_PREFIX=PJ,BCM Bursting=extension
Tenant ID                        8cb88849-6e18-46d6-b0fa-551a47a31681
Type                             azure
Use paid Marketplace images      NEVER


[bright90->cloud[azure]]% set usepaidmarketplaceimages <TAB><TAB>
always     as_needed  never
[bright90->cloud[azure]]% set usepaidmarketplaceimages as_needed
[bright90->cloud*[azure*]]% commit
```

In an Azure cloud, just as for the AWS case for `usepaidmarketplaceamis`, there are 3 possible values for `usepaidmarketplaceimages` at the cloud provider level:

1. `never`: paid marketplace images are never used. Any attempt to power on any extra cloud nodes beyond the license limit fails.

2. `always`: The paid marketplace image is always used when powering on cloud nodes.

3. `as_needed`: The free image is used as a default so long as the prepaid node count limit has not been exceeded. Beyond the prepaid node count limit, all additional cloud nodes use the paid marketplace image.

Setting A Node-installer Image For Azure Cloud Nodes

It is possible to set an Azure cloud node, for example `germanywestcentral-cnode001`, to follow a different policy by specifying it in the `cloudsettings` submode within the `device` mode:

Example

```
[root@bright90 ~]# cmsh
[bright90]% device
[bright90->device]% use <TAB><TAB>
germanywestcentral-cnode001  germanywestcentral-cnode003  master    node002
germanywestcentral-cnode002  germanywestcentral-director  node001   bright90
[bright90->device]% use germanywestcentral-cnode001
[bright90->device[germanywestcentral-cnode001]]% cloudsettings
[bright90->device[germanywestcentral-cnode001]->cloudsettings]% get usepaidmarketplaceimages
Never (azure)
[bright90->device[germanywestcentral-cnode001]->cloudsettings]% set usepaidmarketplaceimages <TAB><TAB>
always            as needed        follow provider   never
[bright90->device[germanywestcentral-cnode001]->cloudsettings]% set usepaidmarketplaceimages always
[bright90->device*[germanywestcentral-cnode001*]->cloudsettings*]% commit
```

This overrides the policy set at the cloud provider level, until the instance is terminated.

First-time Use Of A Marketplace Image Provided By Bright For Azure Cloud Nodes

Before using the Azure marketplace image provided by Bright for the first time, the legal terms of the subscription must be agreed to. This is done via the Azure CLI.

The Azure CLI must therefore be installed.

The agreement process is then carried out by running the following command:

```
$ az vm image accept-terms --urn <publisher>:<offer>:<sku>:<version>
```

There are 4 items of information that need to be supplied to the command:

1. *publisher*: `brightcomputing`

2. *offer*:

   In order to obtain this item of information, the available offers published by the publisher `brightcomputing` should be listed first:

   Example

   ```
   $ az vm image list-offers --location westus --publisher brightcomputing --output table

   Location    Name
   ----------  ---------------
   westus      bcmni-azure-9-0
   ```

   From the list, the item corresponding to the version of the product in use should be used. Here the version is the one corresponding to Bright Cluster Manager version 9.0, and the offer is `bcmni-azure-9-0`.

3. *sku*: In a similar way to the previous step, the SKU is listed, and the corresponding version selected:

   Example

```
$ az vm image list-skus --location westus --publisher brightcomputing --offer bcmni-azure-9-0
--output table

Location    Name
----------  ----------------
westus      bcm-ni-azure-9-0
```

Here the SKU is `bcm-ni-azure-9-0`.

4. *version*: `latest`

The agreement command in this case would then be:

Example

```
$ az vm image accept-terms --urn brightcomputing:bcmni-azure-9-0:bcm-ni-azure-9-0:latest
```

7.5 Address Resolution In Cluster Extension Networks

7.5.1 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.

7.5.2 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 3.3.9 of the *Installation Manual*), the head node is connected to `internalnet`. When a cloud service is configured, the head node is also "connected" to the CMDaemon-managed NetMap "network". It is useful to think of NetMap as a special network, although it is actually a network mapping from the cloud to `internalnet`. That is, it connects (maps) from the nodes in one or more cloud networks such as the `us-east-1` network provided by Amazon, to IP addresses provided by `netmap`. The mapping is set up when a cloud extension is set up. With this mapping, packets using NetMap go from the cloud, via an OpenVPN connection to the NetMap IP address. Once the packets reach the OpenVPN interface for that address, which is actually on the head node, they are forwarded via Shorewall's IPtables rules to their destination nodes on `internalnet`.

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

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

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

- The nodes within all available cloud networks (all networks such as for example, us-east-1, us-west-1, and so on) are given CMDaemon-assigned addresses in the cloud node space range 172.16.0.0–172.29.255.255. In CIDR notation that is: 172.16.0.0/12 (172.16.0.0–172.31.255.255), except for 172.31.0.0/15 (172.30.0.0–172.31.255.255).
- The network address space 172.30.0.0/16 (172.30.0.0–172.30.255.255) is taken by the CMDaemon-assigned NetMap network, explained shortly.
- Each node in a cloud network is also assigned an address in the network addressing space provided by Amazon VPC networking. The assignment of IP addresses to nodes within the 10.0.0.0/8 range is decided by Amazon via DHCP.

  The VPC networks for regular cloud nodes and cloud director nodes are subnets in this range.
- The netmap "network" (figure 7.2) 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.

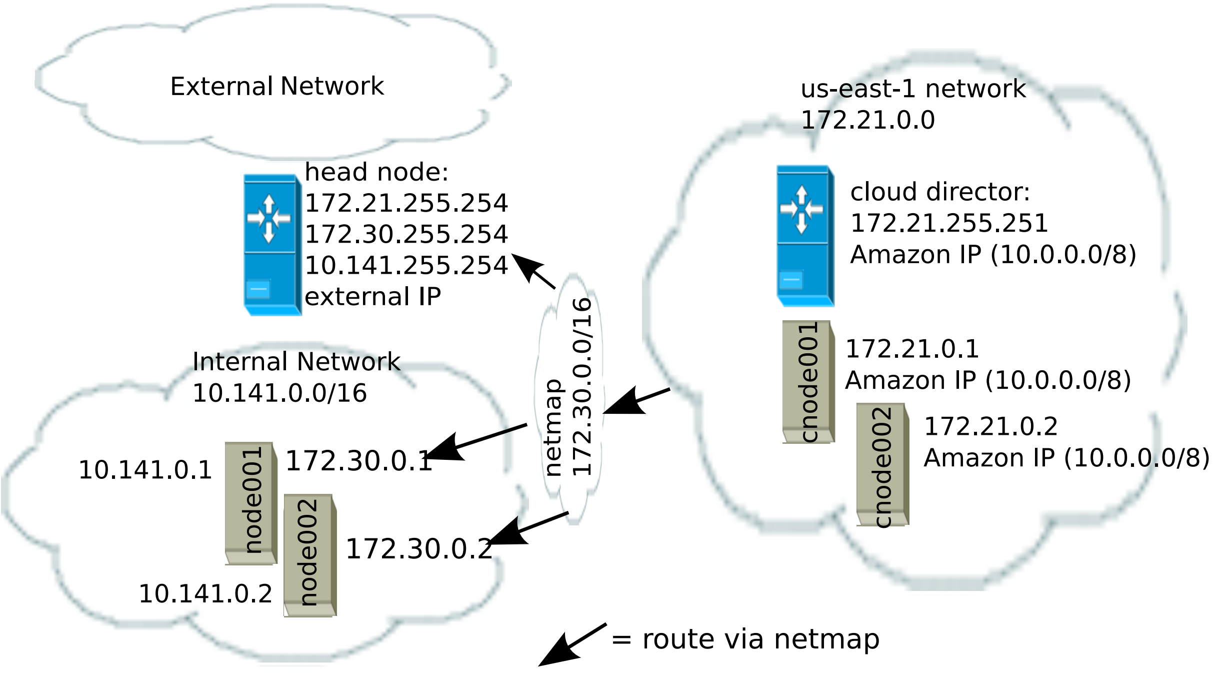


Figure 7.2: NetMap In Relation To The General Network Scheme

As pointed out in the introduction to this section (7.5), 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.

7.6 Internet Connectivity For Cloud Nodes

If a cloudbursting setup is connected to the internet with the default settings, then only the CX-OS cloud compute nodes have no access to the internet.

Cloud compute node types in the other cloudbursting setups—CX-AWS, CX-Azure, COD-AWS, COD-Azure, and COD-OS—can all access the internet by default.

This is elaborated upon in table 7.6:

Table 7.6: Cloud compute node access to internet

Cloud node type	Internet access by default?	Details

CX-AWS	Yes	Cloud compute nodes are routed via an sNAT gateway cloud director node. They therefore do not normally require assignment of Elastic IPs (section 7.8.1). If assigning an Elastic IP to a node is required, then such a cloud node should be created on the ’public’ VPC subnet (by default cloud compute nodes are created on the ’private’ VPC subnet).
		To allocate a public IP to a node, the cloud setting `allocatepublicip` is set to `yes` before creating the node. By default, cloud directors are configured to be allocated public IP addresses:
		Example
		`[bright90->device[us-east-1-director]->cloudsettings]% get allocatepublicip`
		`yes`

CX-Azure	Yes	Cloud compute nodes use the built-in NAT capabilities of Azure’s gateway when accessing the internet.
CX-OS	No	Cloud compute nodes are routed via a cloud director sNAT gateway. However for this to work in a OpenStack environment, the port security plugin needs to be enabled for Neutron, followed by disabling the port security setting on the cloud director ports (section 6.4). By default, the port security plugin is disabled for Neutron, while the port security setting is in an enabled state. Disabling the security setting causes the security groups to be no longer applied in the cloud director. This means anyone with Layer-3 (IP) access to the cloud director could try to establish a connection to any of the cloud director’s ports. Therefore, by default for CX-OS, the port security plugin is left disabled, and the port security setting left enabled.
COD-AWS	Yes	Cloud compute nodes use the head node as an sNAT gateway. If the head node is overloaded with network traffic, then an AWS NAT gateway can be added to the VPC, and configure that device to be the default gateway for a private subnet by modifying the routing table of that subnet.
COD-Azure	Yes	Cloud compute nodes can access the internet via TCP/UDP using the Azure Load Balancer. ICMP packets are silently discarded. ICMP traffic can only be allowed by associating a public IP address to the compute node. Microsoft advises its users to use an alternative to ping for connectivity testing that works using TCP packets, and tries to connect to a specific port.
COD-OS	Yes	Cloud compute nodes are routed via an sNAT gateway head node.

7.7 Passing Kernel Parameters To Cloud Nodes

If a cluster administrator configures a non-cloud cluster, then kernel parameters can be set for a particular software image used by the regular nodes. For example, in `cmsh`, if a software image <*image name*> is used, then kernel parameters such as `root=/dev/sda2 rootdelay=10 pti=auto` can be set via the navigation path:

```
cmsh→softwareimage→use <image name>→set kernelparams "root=/dev/sda2 rootdelay=10 pti=auto"
```

However, kernel parameters are not passed to cloud nodes via this mechanism at the time of writing (November 2019). If there is a need to pass kernel parameters to cloud nodes, then Bright Computing support should be contacted.

7.8 Setting Up And Creating A Custom VPC

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

Custom VPC for Bright Cluster Manager 9.0 subnet allocation, and allocation of EIPs (External IPs, public IP addresses) is described in sections 7.8.1–7.8.3.

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

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 can 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 "public IPs" in the cloud context. When allocating a public 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.

7.8.2 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 in `cmsh` to `Cloud (VPC)`, or in Bright View set to `CLOUD`.

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

Two series of valid network ranges could be:

Example

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

The `sipcalc` command (page 65 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.

7.8.3 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 `Advanced settings` options in the `clusterextension` plugin options, in the command line `cm-cluster-extension` utility (section 4.1),
2. by using the Bright View private cloud creation wizard (section 3.1),
3. by manually creating and configuring the `private cloud` object using `cmsh`.

Option 3 is tedious, but does show to the reader some of what the `cm-cluster-extension` utility and cloud creation wizard do. To create and configure a private cloud as in option 3, the following example sessions show how a private cloud can be built with `cmsh`. In the sessions, the subnets to be used for the custom VPC are created first, before creating the private cloud:

- **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

  ```
  [bright90->network]% add vpc-0-sn-0
  [bright90->network*[vpc-0-sn-0*]]% set type cloud
  [bright90->network*[vpc-0-sn-0*]]% set baseaddress 10.0.0.0
  [bright90->network*[vpc-0-sn-0*]]% set netmaskbits 24
  [bright90->network*[vpc-0-sn-0*]]% commit
  ```

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

  Example

  ```
  [bright90->network]% clone vpc-0-sn-0 vpc-0-sn-1
  [bright90->network*[vpc-0-sn-1*]]% set baseaddress 10.0.1.0
  [bright90->network*[vpc-0-sn-1*]]% commit
  ```

- **Custom VPC creation:** The following example session in the `vpc` submode of the `cloud` mode, creates a private cloud called `vpc-0`. The private cloud is actually a custom VPC, and belongs to a network that contains the two subnets specified earlier.

Example

```
[bright90->cloud[Amazon EC2]->vpcs]%
[bright90->...->vpcs]% add vpc-0
[bright90->...->vpcs*[vpc-0*]]% set region eu-west-1
[bright90->...*[vpc-0*]]% set baseaddress 10.10.0.0
[bright90->...*[vpc-0*]]% set netmaskbits 16
[bright90->...*[vpc-0*]]% set subnets vpc-0-sn-0 vpc-0-sn-1
[bright90->...*[vpc-0*]]% commit
```