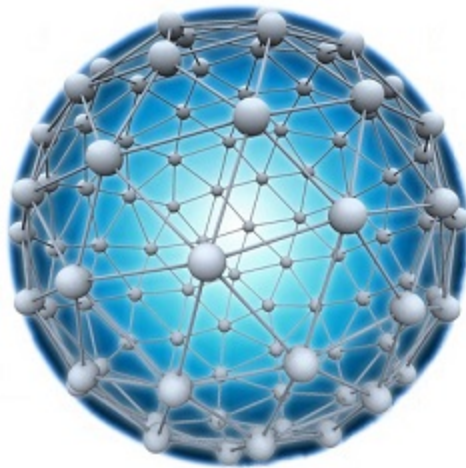


Moab NODUS Cloud OS User Guide 2.0.0

September 2020



Contents

Welcome	3
Legal Notices	3
Revision History	4
Related Documentation	4
Chapter 1: Moab NODUS Cloud Bursting	5
1.1 Moab NODUS Cloud Bursting Overview	5
1.2 Moab NODUS Cloud Bursting Architecture	6
1.3 Securing Data Transmissions	7
Chapter 2: Installing Moab, Viewpoint, and NODUS	8
2.1 Installing Moab	8
2.2 Installing Viewpoint	8
2.3 Installing NODUS	8
Chapter 3: Moab NODUS Cloud OS Configuration	9
3.1 Deploying the Bursting Cluster	9
3.2 Enabling MOAB to use NODUS as a Remote Resource Manager	10
3.3 Configuration	10
3.4 Contrib SSH Key	10
3.5 Obtaining NODUS Details	11
3.6 Configuring Moab to Connect to NODUS	11
3.7 NODUS Use Cases	12
3.8 Starting Moab NODUS Cloud OS	13
Glossary	13
Index	16

Welcome

The Moab NODUS Cloud OS User Guide will show you how to install and use the Moab NODUS Cloud OS environment.

This guide is intended for Moab NODUS Cloud OS system administrators.

Moab NODUS Cloud OS is a highly flexible and extendable solution that enables HPC systems to burst scheduled workloads to an external cloud on-demand. It can provision a full stack across multiple cloud environments, and can be customized for multiple use cases and scenarios. Access to unlimited HPC compute resources is available in the cloud from multiple cloud service providers.

For pricing information, contact us at sales@adaptivecomputing.com.

For support, contact us at support@adaptivecomputing.com.

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Revision History

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April 2020	Moab NODUS Cloud OS 1.0.0
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Related Documentation

- *Moab HPC Suite Installation and Configuration Guide for SUSE 12-Based Systems*
<http://docs.adaptivecomputing.com/9-1-3/installGuide/SUSE12/installSUSE12.htm>
- *Moab HPC Suite Installation and Configuration Guide for Red Hat 6-Based Systems*
<http://docs.adaptivecomputing.com/9-1-3/installGuide/hpcSuiteInstallGuideRH6-9.1.3.pdf>
- *Moab HPC Suite Installation and Configuration Guide for Red Hat 7-Based Systems*
<http://docs.adaptivecomputing.com/9-1-3/installGuide/hpcSuiteInstallGuideRH7-9.1.3.pdf>
- *Moab Viewpoint Reference Guide*
<http://docs.adaptivecomputing.com/9-1-3/Viewpoint/Viewpoint-9.1.3.pdf>
- *Moab Workload Manager Administrator Guide*
<http://docs.adaptivecomputing.com/9-1-3/MWM/Moab-9.1.3.pdf>
- *NODUS Cloud OS User Guide*
<http://docs.adaptivecomputing.com/nodus/UserGuide.pdf>
- *Torque Resource Manager Administrator Guide*
<http://docs.adaptivecomputing.com/torque/6-1-2/adminGuide/torqueAdminGuide-6.1.2.pdf>

Chapter 1: Moab NODUS Cloud Bursting

This chapter provides information about Moab NODUS cloud bursting.

In this chapter:

1.1 Moab NODUS Cloud Bursting Overview	5
1.2 Moab NODUS Cloud Bursting Architecture	6
1.3 Securing Data Transmissions	7

1.1 Moab NODUS Cloud Bursting Overview

During the course of operation, the number of job submissions will increase and decrease. Under some circumstances, the job backlog may increase to the point where additional resources are required to complete the job backlog in a reasonable time frame. In this scenario, jobs are held until resources become available.

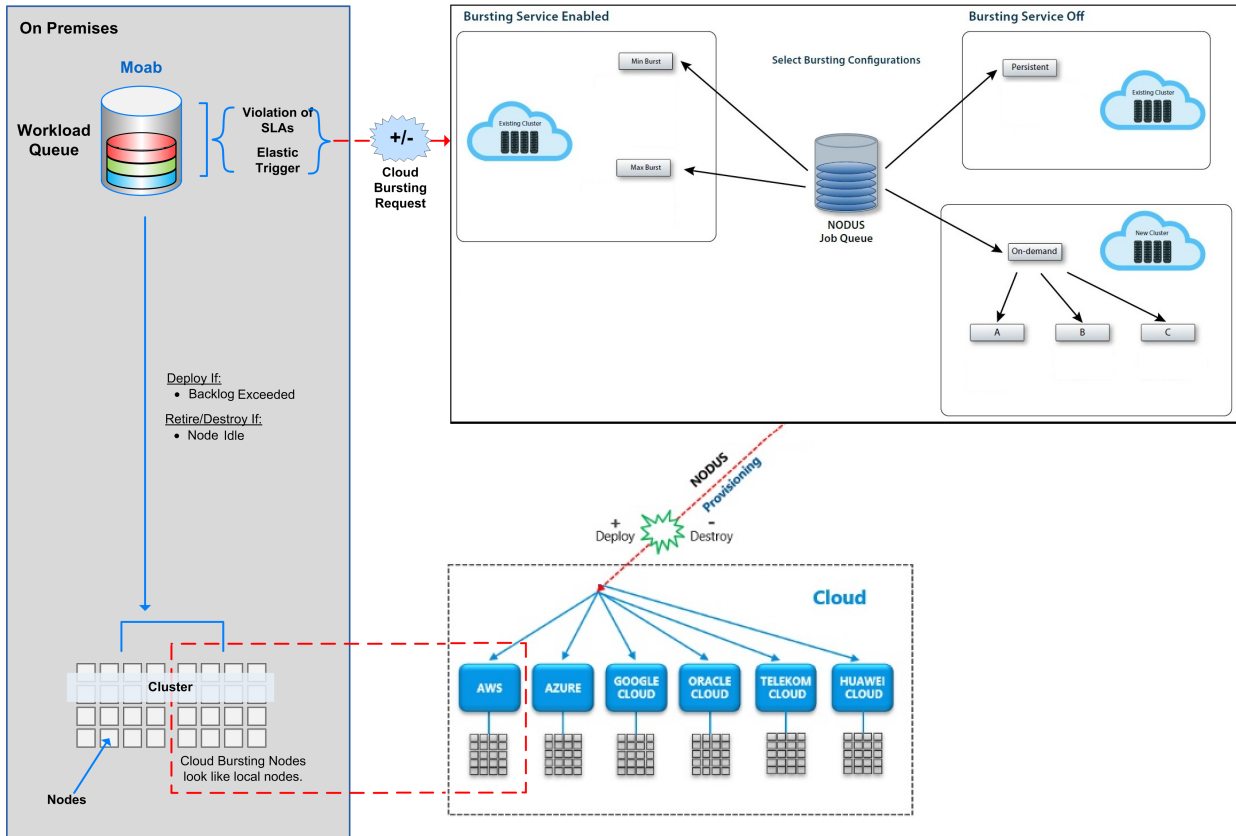
The Moab NODUS Cloud OS solution enables MOAB to use NODUS as a Remote Resource Manager (Native Resource Manager). The Native Resource Manager communicates with NODUS directly. Moab controls job submission as before, using on-premises nodes first and then passes on jobs submitted to available NODUS nodes when a backlog occurs.

All functions are being managed by NODUS after receiving instruction from Moab that there is a job awaiting a resource to be able to run. If there is already an available NODUS node, it uses this node first to run a job against. If there are more jobs waiting to run (backlog), the NODUS Remote Resource Manager communicates directly with NODUS Cloud OS to assist in making resources available for a waiting job on Moab, and manages all bursting requirements on NODUS. When jobs complete using a NODUS node, based on the configuration set on NODUS (bursting options), NODUS manages the removal of unused nodes. With the available NODUS functionality (being heterogeneous), NODUS can be configured to access multiple cloud service providers.

1.2 Moab NODUS Cloud Bursting Architecture

Moab NODUS Cloud OS is a solution based on Moab's Remote Resource Manager framework, using the NODUS Cloud OS to launch instances in your cloud service provider account. Elastic Computing with Moab NODUS Cloud OS is triggered based on the size of the job backlog.

This diagram depicts the Moab NODUS Cloud OS solution:



When a job backlog occurs, Moab uses NODUS as a Remote Resource Manager to utilize the NODUS bursting capabilities to spin up the required nodes for jobs to run being delayed due to a backlog. Using the NODUS bursting functionality, NODUS automatically spins up, takes offline, or shuts down nodes depending on the total requirements for the job queue. If there are not enough online nodes to run all jobs, bursting brings on as many nodes as needed. If there are more nodes than needed, the excess nodes are taken offline. If the job queue is empty, all nodes are shut down after a specified period of time.

Min Burst spins up the minimum number of compute nodes required to complete all jobs in the queue, which is ideal for budgeting and controlling cloud costs.

Max Burst spins up enough compute nodes to complete all the jobs in the queue immediately; this gets results as fast as possible. Max Burst is limited by the size of the cluster and will not create new nodes.

Persistent bursting spins up all or a portion of the licensed instances in a cluster that remain persistent for a period of time and brings nodes online or shuts them down as needed.

On-demand bursting spins up the number of nodes required to run one job now; this is an isolated cluster, not for sharing with other jobs. The on-demand types are: Destroy Compute Nodes (the head node stays active and the compute nodes are destroyed), Offline Compute Nodes (the head node stays active and the compute nodes go offline), and Destroy Full Cluster (the full cluster is destroyed including the head node).

1.3 Securing Data Transmissions

Because jobs can be run off-site, it is paramount that the transfer of data is done securely.

There are three ways to create a secure connection from your network to your cloud service provider account:

- Create a point-to-point VPN connection from your network to a Virtual Private Cloud (VPC) in your cloud service provider account. Your cloud service provider does charge for this capability, but this enables one single secure line of communication between your network and your cloud service provider account. Transfer speeds are based on your internet bandwidth and the distance from your network to the Region and Availability Zone you are bursting to. See VPN connection information in your cloud service provider documentation for how this is to be configured.
- Use your cloud service provider's direct connection options to configure a dedicated network connection from your network directly to your cloud service provider account. Because it is a private connection that does not go over the public internet, there is no need for a VPN, and speeds between 1 Gbps to 10 Gbps are possible. This solution comes at a considerably higher price than a cloud service provider VPN, but with the advantage of a more predictable network speed.
- Install a VPN client into your cloud service provider image to connect to a VPN server on your network when the cloud service provider's instance is launched. Although this solution requires the most up-front configuration, it enables the cloud service provider's instances to connect to your network securely with no cost from your cloud service provider. This solution uses one VPN connection per cloud service provider instance, so there is a potential for excessive network overhead. Transfer speeds are also based on your internet bandwidth and the distance from your network to the Region and Availability Zone to which you are bursting.

Chapter 2: Installing Moab, Viewpoint, and NODUS

To interface Moab with NODUS, the installation of Moab, Viewpoint, and NODUS is required.

2.1 Installing Moab

For instructions, see the following documents for your operating system:

- Red Hat 6-based systems - [Moab HPC Suite Installation and Configuration Guide 9.1.3 for Red Hat 6-Based Systems](#)
- Red Hat 7-based systems - [Moab HPC Suite Installation and Configuration Guide 9.1.3 for Red Hat 7-Based Systems](#)
- SUSE 12-based systems - [Moab HPC Suite Installation and Configuration Guide 9.1.3 for SUSE 12-Based Systems](#)

2.2 Installing Viewpoint

For instructions, see the [Moab Viewpoint Reference Guide](#).

2.3 Installing NODUS

For instructions, see the [NODUS Cloud OS User Guide](#).

Chapter 3: Moab NODUS Cloud OS Configuration

Now that you have Moab, Viewpoint, and NODUS installed and accessible, complete the steps in this chapter to configure your Moab NODUS Cloud OS environment. The configuration steps below apply to any cloud service provider.

Note: All commands must be run as `root`.

In this chapter:

3.1	Deploying the Bursting Cluster	9
3.2	Enabling MOAB to use NODUS as a Remote Resource Manager	10
3.3	Configuration	10
3.4	Contrib SSH Key	10
3.5	Obtaining NODUS Details	11
3.6	Configuring Moab to Connect to NODUS	11
3.7	NODUS Use Cases	12
3.8	Starting Moab NODUS Cloud OS	13

3.1 Deploying the Bursting Cluster

1. Deploy your bursting cluster from the NODUS GUI. Refer to the [NODUS Cloud OS User Guide](#) for instructions.
2. After successful deployment of your cluster, complete the sections below. The steps are done on NODUS or Moab as indicated.

3.2 Enabling MOAB to use NODUS as a Remote Resource Manager

1. Untar `moab-nodus-connect.tar.gz` (supplied by Adaptive Computing) at the directory outside `$MOABHOMEDIR`, assuming `MOABHOMEDIR=/opt/moab`. We want the `.tar` to be at `/opt`.

```
sudo cp moab-nodus-connect.tar.gz /opt
```

```
cd /opt
```

```
sudo tar -xvf moab-nodus-connect.tar.gz
```

3.3 Configuration

1. Add the following lines to your `$MOABHOMEDIR/etc/moab.cfg` file:

```
RMCFG [nodus] TYPE=NATIVE
RMCFG [nodus] CLUSTERQUERYURL=exec://$HOME/contrib/nodus/clusterquery
RMCFG [nodus] WORKLOADQUERYURL=exec://$HOME/contrib/nodus/workloadquery
RMCFG [nodus] JOBSUBMITURL=exec://$HOME/contrib/nodus/jobsubmit
RMCFG [nodus] JOBSTARTURL=exec://$HOME/contrib/nodus/jobstart
RMCFG [nodus] JOBCANCELURL=exec://$HOME/contrib/nodus/jobcancel
RMCFG [nodus] JOBMODIFYURL=exec://$HOME/contrib/nodus/jobmodify
RMCFG [nodus] JOBQUEUEURL=exec://$HOME/contrib/nodus/jobqueue
RMCFG [nodus] JOBSUSPENDURL=exec://$HOME/contrib/nodus/jobsuspend
RMCFG [nodus] JOBRESUMEURL=exec://$HOME/contrib/nodus/jobresume
RMCFG [nodus] NODEPOWERURL=exec://$HOME/contrib/nodus/nodepower
RMCFG [nodus] NODEMODIFYURL=exec://$HOME/contrib/nodus/nodemodif
RMCFG [nodus] SYSTEMMODIFYURL=exec://$HOME/contrib/nodus/systemmodify
RMCFG [nodus] RESOURCECREATEURL=exec://$HOME/contrib/nodus/resourcecreate
RMCFG [nodus] JOBMIGRATEURL=exec://$HOME/contrib/nodus/jobmigrate

JOBNODEMATCHPOLICY EXACTNODE
```

3.4 Contrib SSH Key

1. Create a new SSH key for `moab-nodus-connect`. It can be anywhere, but we suggest it be at `$MOABHOMEDIR/contrib/nodus/.ssh`.

2. Then make the private key readable by everyone. We suggest using these commands:

```
# mkdir -p $MOABHOMEDIR/contrib/nodus/.ssh
# ssh-keygen -t rsa -b 4096 -f $MOABHOMEDIR/contrib/nodus/.ssh/id_rsa -C
moab-nodus-connect
# chmod 644 $MOABHOMEDIR/contrib/nodus/.ssh/id_rsa
```

3.5 Obtaining NODUS Details

This section assumes that you have read the NODUS Cloud OS documentation ([NODUS Cloud OS User Guide](#)) and are familiar with creating and deploying clusters in NODUS.

1. Log in to the NODUS GUI with the username that will contain the NODUS cluster you want to connect to.
2. Left-click the **User** button at the top right corner of the screen.
3. Select **SSH Key** and transfer the `.pem` file to the Moab server.
4. Create and deploy a cluster (if you have not done so already). Remember the cluster name for use in the next section.

3.6 Configuring Moab to Connect to NODUS

With the information collected from the previous section, perform the following operations as the root user.

1. Run the command `cd $MOABHOMEDIR/contrib/nodus/`.
2. Create an environment file by running the command `cp template.env .env`.
3. Edit the `.env` file:
 - Replace `<user@nodus_server_ip>` with the following:
 - `user` = The username that you logged onto the NODUS server with in the previous section.
 - `nodus_server_ip` = The URL or IP address of the NODUS server.The line should look like `NODUS=centos@192.168.1.10`.
 - Replace `<cluster_name_deployed_on_nodus>` with the name of the cluster defined in the previous section.

4. Enable the Moab system to connect to NODUS via SSH by running this command:
ssh-copy-id -i \$MOABHOMEDIR/contrib/nodus/.ssh/id_rsa.pub <user@nodus_server_ip>

Where: <user@nodus_server_ip> is the value you entered into the .env file.

3.7 NODUS Use Cases

Select one of the following two options to manage backlog jobs:

- [Backlog Management Option 1](#)
- [Backlog Management Option 2](#)

Backlog Management Option 1

Use all available on-premise Moab nodes, then use available NODUS nodes and when on-premise Moab nodes becomes available after jobs complete (while available NODUS nodes are still in use), start using on-premise Moab nodes again. To achieve the above use case, follow the two steps below on NODUS.

1. Spin up a persistent cluster - Spin up a NODUS cluster with the desired hardware, and Moab will schedule jobs as if they are on-premise. Viewpoint will see the jobs and return `stdout` and `stderr` (job output). Steps to spin up a NODUS cluster in NODUS are explained in the [NODUS Cloud OS User Guide](#).
2. Use your spun up cluster in the step above (backlog cluster) - Activate bursting service on the spun up NODUS cluster to enable the cluster to be used to take only backlog jobs with full bursting functionality. Steps to activate bursting service on a NODUS cluster in NODUS are explained in the [NODUS Cloud OS User Guide](#).

There are two suggested NODUS bursting service configuration options:

- **Min Burst** - Spins up the minimum number of compute nodes required to complete all jobs in the queue, which is ideal for budgeting and controlling cloud costs. Using this configuration, if you have two nodes allocated to a cluster, as an example, when a backlog occurs, it only uses one node.
- **Max Burst** - Spins up enough compute nodes to complete all the jobs in the queue immediately; this gets results as fast as possible. Max Burst is limited by the size of the cluster and will not create new nodes. When using this configuration, backlog jobs run against all allocated nodes.

Backlog Management Option 2

Use all available on-premise Moab nodes, then use available NODUS nodes and when on-premise Moab nodes becomes available after jobs complete, continue using only available NODUS nodes and not available on-premise Moab nodes. To achieve the above use case, follow the configuration step below on Moab.

1. Configure the `moab.cfg` file by adding the following lines:

```
NODEALLOCATIONPOLICY PRIORITY
NODECFG[DEFAULT] PRIORITYF='APROCS - LOAD - 1000*GMETRIC[nodus]'
```

Note: Each reported NODUS cluster node is tagged with `GMETRIC[nodus]=1`.

The above is a sample of one way to configure Moab to respect NODUS as a backlog only cluster. In this configuration, we are using priority to ensure the least priority to NODUS by nature of not having a priority value less than the on-premises hardware.

3.8 Starting Moab NODUS Cloud OS

1. Restart Moab using the command `systemctl restart moab` (must be run as root).

The following commands will assist in confirming the communication between Moab and NODUS is correct:

- `mdiag -n` provides a compute node summary, where both the on-prem (Moab) and NODUS nodes must display.
- `mdiag -t -v` provides partition status, where it must show the system partition settings (including pbs and NODUS).

2. Check that the nodes appear on Viewpoint, which should show both the on-prem (Moab) as well as the NODUS nodes.

Glossary

Bursting: The event of clusters and nodes being deployed to run jobs, then being destroyed.

canceljob: Command that selectively cancels the specified jobs (active, idle, or nonqueued) from the queue.

checknode: Command that shows detailed state information and statistics for nodes that run jobs.

Cluster: A collection of compute instances consisting of a head node and compute nodes.

Cluster Size: The number of compute nodes.

Compute Nodes: The servers, typically designed for fast computations and large amounts of I/O, that provide the storage, networking, memory, and processing resources.

Compute Node Size: An instance type or hardware configuration (for example, n1-standard-2 - vCPU: 2, Mem (GB): 7.50).

Core: An individual hardware-based execution unit within a processor that can independently execute a software execution thread and maintain its execution state separate from the execution state of all other cores within the processor.

Credentials: Authentication information required to access the respective cloud service provider from code.

Custom Job: A job that is customizable and configurable.

Elastic Computing: A feature in Moab that enables the Moab scheduler to take advantage of systems that can temporarily provide additional nodes (for example, to create new virtual machines or borrow physical nodes from another system) to fulfill the workload demand in a timely manner. The Elastic Computing framework can be configured to access multiple cloud providers either on-demand or based on a job backlog.

Elastic Trigger: Enables the Moab scheduler to take advantage of systems that can temporarily provide additional nodes to fulfill the backlog in a reasonable time frame. The elastic trigger calls a script to request additional nodes (dynamic nodes) from an external service.

FQDN (Fully qualified domain name): The most complete domain name that identifies a host or server.

Head Node: The server that manages the delegation of jobs.

Image: A snapshot of an OS.

Job: A workload submitted to a scheduler for the purpose of scheduling resources on which the workload executes when started up by the scheduler. Typically, a user creates a script that executes the workload (one or more applications) and submits the script to the scheduler where it becomes a job.

Job Script: A program to be run on a cluster (generally a shell script).

mdiag: Command that displays information about various aspects of the cluster and the results of internal diagnostic tests.

mpi-benchmarks: A job that tests the performance of a cluster system, including node performance, network latency, and throughput.

mschedctl: Command that controls various aspects of scheduling behavior, including managing scheduling activity, shutting down the scheduler, and creating resource trace files. It can also evaluate, modify, and create parameters, triggers, and messages.

On-Demand Bursting: Unlike backlog bursting, on-demand bursting is not triggered by the amount of work in the job backlog. You can simply request that the job run in the cloud service provider by specifying the preconfigured job template in the Moab config file that contains the trigger defined to call out to NODUS.

On-Demand Cluster: A cluster that carries out a specific job then is removed.

PAM (Pluggable Authentication Module): Used to perform various types of tasks involving authentication, authorization, and some modification.

pbsnodes: Command that marks nodes down, free, or offline. It also lists nodes and their state.

qdel: Command that deletes jobs in the order in which the job identifiers are presented to the command.

qmgr (Queue Manager): Command that provides an administrator interface to query and configure batch system parameters

Reprise License Manager Server (RLM): A flexible and easy-to-use license manager with the power to serve enterprise users.

Resource Manager: Provides the low-level functionality to start, hold, cancel, and monitor jobs. Without these capabilities, a scheduler alone cannot control jobs.

showq: Command that displays information about active, eligible, blocked, and/or recently completed jobs.

showstats: Command that shows various accounting and resource usage statistics for the system.

Stack: An instance of software packages that defines the operating system components.

test-job: A job that is best used to test bursting functionality; it echoes the time and the hostname of the executing machine.

Viewpoint: A web application that interacts with Moab Workload Manager, that enables users to manage jobs and resources without the complexities of maintaining Moab via the command line. Viewpoint uses a customizable portal that enables users to view and configure jobs and to compute node resources, principals, and roles. Viewpoint permissions enable system administrators to specify which pages, tools, and settings that certain users or groups are permitted to use, manage, and view.

Index

- A -

Adaptive Computing
 Sales 3
 Support 3
Availability Zone 7

- B -

Backlog Management Options 12
Bursting Architecture 6
Bursting Cluster 9
Bursting Overview 5

- C -

canceljob (command) 13
checknode (command) 13
chmod (command) 11
Cloud Bursting Architecture 6
Cloud Bursting Overview 5
cluster 7, 9, 11-12
Configuration 4, 8-10
Configuring Moab to Connect to
 NODUS 11
Contrib SSH Key 10
cp template.env .env (command) 11

- D -

Data Transmissions 7
Deploying the Bursting Cluster 9
Destroy Compute Nodes (on-demand
 bursting type) 7
Destroy Full Cluster (on-demand
 bursting type) 7

- E -

elastic 14
Elastic Computing 6, 14
elastic trigger 14
Enabling MOAB to use NODUS as a
 Remote Resource Manager 10
Environment file 11

- F -

FQDN 14

- H -

hardware 12, 14
Head Node 14
hostname 15

- I -

id_rsa 11-12
Installing Moab 8
Installing NODUS 8
instance type 14

- L -

Legal Notices 3
License 15

- M -

Max Burst 7, 12
mdiag -n (command) 13
mdiag -t -v (command) 13
mdiag (command) 13-14
Min Burst 6, 12

Moab HPC Suite Installation and Configuration Guide for Red Hat 6-Based Systems [4](#)

Moab HPC Suite Installation and Configuration Guide for Red Hat 7-Based Systems [4](#)

Moab NODUS Cloud Bursting [5](#)

Moab NODUS Cloud OS Configuration [9](#)

Moab scheduler [14](#)

Moab server [11](#)

Moab Viewpoint Reference Guide [8](#)

Moab Workload Manager [4, 15](#)

Moab Workload Manager Administrator Guide [4](#)

moab.cfg [10, 13](#)

- N -

Native Resource Manager [5](#)

NODUS Cloud OS User Guide [3-4, 8-9, 11-12](#)

NODUS Use Cases [12](#)

- O -

Obtaining NODUS Details [11](#)

Offline Compute Nodes (on-demand bursting type) [7](#)

On-Demand Bursting [7, 15](#)

- P -

pbsnodes (command) [15](#)

pem file [11](#)

Persistent bursting [7](#)

- Q -

qdel (command) [15](#)

qmgr (command) [15](#)

- R -

Red Hat 7 [4, 8](#)

Region [7](#)

Related Documentation [4](#)

Remote Resource Manager [5, 10](#)

Resource Manager [4-5, 10, 15](#)

Revision History [4](#)

root [9, 11, 13](#)

rsa.pub [12](#)

- S -

scheduler [14](#)

Securing Data Transmissions [7](#)

shell [14](#)

showq (command) [15](#)

SSH key [10-11](#)

Starting Moab NODUS Cloud OS [13](#)

stderr [12](#)

stdout [12](#)

Suite Installation (Automated Installer) [4, 8](#)

SUSE [4, 8](#)

systemctl restart moab (command) [13](#)

- T -

Torque [4](#)

Torque Resource Manager [4](#)

Torque Resource Manager Administrator Guide [4](#)

- U -

Use Cases [12](#)

User button [11](#)

- V -

Viewpoint 8, 12-13, 15

Viewpoint Reference Guide 8

Virtual Private Cloud 7

VPC 7

VPN 7