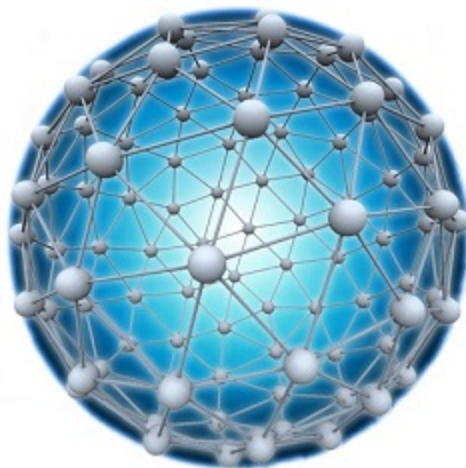


Moab NODUS Cloud OS User Guide 1.0.0

April 2020



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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

Date	Release
April 2020	Moab NODUS Cloud OS 1.0.0

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:

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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.

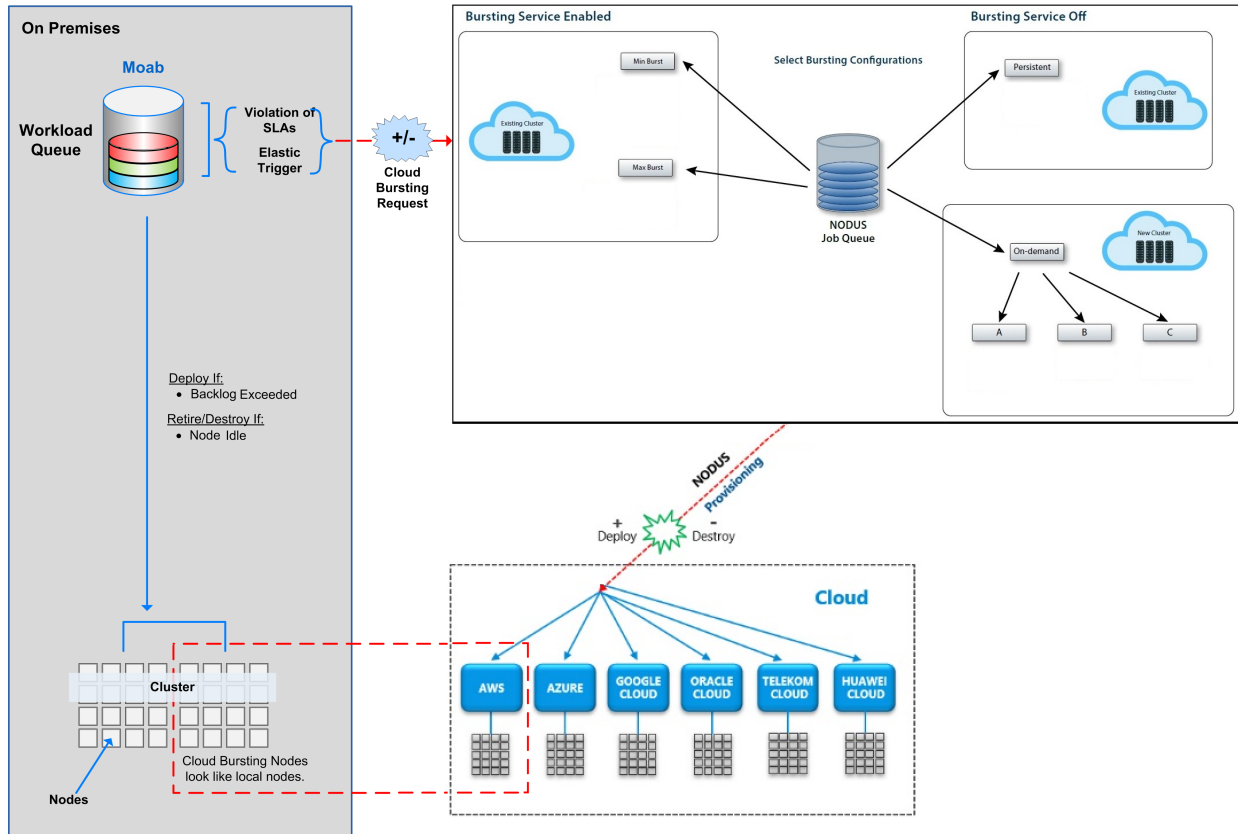
The Moab NODUS Cloud OS solution enables MOAB to use NODUS as a Remote Resource Manager (Native Resource Manager). The Native Resource Manager communicates with NODUS directly. Moab controls job submission as before, using on-premises nodes first and then passes on jobs submitted to available NODUS nodes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

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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] JOBREQUEUEURL=exec://$HOME/contrib/nodus/jobrequeue
RMCFG[nodus] JOBSUSPENDURL=exec://$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 <pem_file> \$MOABHOMEDIR/contrib/nodus/.ssh/id_rsa.pub
<user@nodus_server_ip>

Where:

<pem_file> is the SSH key obtained in the previous section.

<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

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** gives a compute node summary, where both the on-prem (Moab) and NODUS nodes must display.
 - **mdiag -t -v** gives 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.

Appendix A: Sample Screens with Descriptions

This appendix contains some sample screens to assist in the configuration:

- [Moab Viewpoint Showing Available Nodes](#)
- [Service Provider Showing Head Node and Cluster Available](#)
- [Moab Viewpoint Showing a Submitted Job is Running](#)
- [Moab Viewpoint Showing Submitted Job Using On Prem Available Node](#)
- [Moab showq Command Showing Jobs Using On Prem Node](#)
- [Moab checkjob Command Showing Reason Waiting](#)
- [Moab Viewpoint Workload Showing Job as Eligible](#)
- [Moab Viewpoint Showing Nodes Now Running](#)
- [Moab Viewpoint Workload Showing All Jobs Running](#)
- [Moab Viewpoint Showing File Manager Job Output Run](#)
- [NODUS File Manager Output Available for Jobs](#)

Appendix A: Sample Screens with Descriptions

Log in to Viewpoint / Select Nodes / Shows available nodes in Moab and NODUS:

The screenshot displays the 'Nodes' page in the Moab Viewpoint interface. The top navigation bar includes 'HOME', 'WORKLOAD', 'REPORTING', 'TEMPLATES', 'NODES' (selected), 'FILE MANAGER', 'SESSIONS', and 'CONFIGURATION'. The user is logged in as 'centos' and can 'Sign Out'.

The main content area is titled 'Nodes' and features a 'Refresh Interval' dropdown set to '15s'. Below this is a table of nodes:

Node ID	Status	Cores Availab...	Jobs	Utilization CPU...	Time to Live	Operational Task
nodus-cluster-t...	IDLE	1/1	0	0/0	N/A	N/A
riaan-moab	IDLE	12/12	0	0/0	N/A	N/A

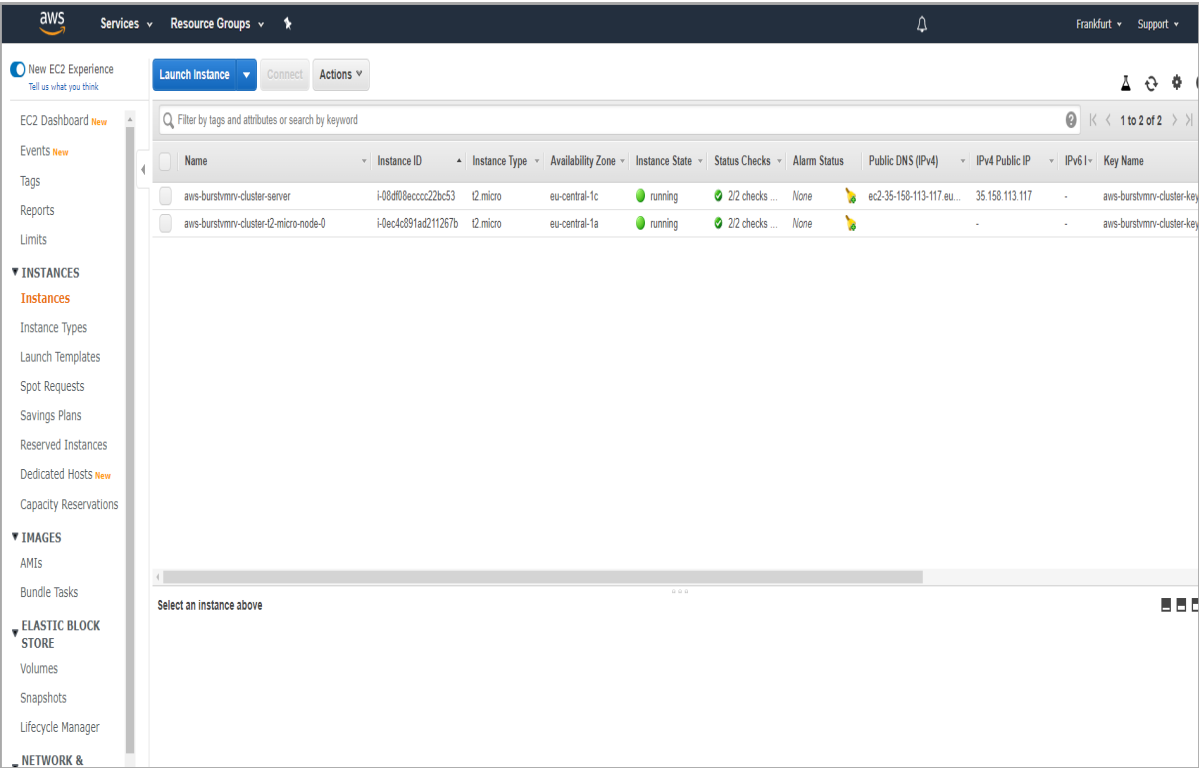
Below the table, there is a 'Show' dropdown set to '10' and 'entries'. Navigation buttons for 'prev', '1' (selected), and 'next' are also present.

On the right side, there is a 'Current Search: 2 results returned' section with a '- Select -' dropdown and a 'Narrow Search' input field with a search button. Below this is a 'Filters' section with a 'Select Status' dropdown, a 'Select Type' dropdown, and three range filters for 'Processors', 'CPU Utilization', and 'Memory Utilization', each with '0' and '∞' values and 'To' labels. 'RESET' and 'FILTER' buttons are at the bottom of the filters.

The footer of the page features the 'Adaptive COMPUTING' logo and a copyright notice: 'Copyright © 2020 Adaptive Computing Enterprises, Inc. All rights reserved.'

Appendix A: Sample Screens with Descriptions

Log in to Service Provider Console / Make sure Head Node and Cluster are available:



Appendix A: Sample Screens with Descriptions

View job submitted from Moab in Viewpoint:

The screenshot displays the Moab Viewpoint interface. The top navigation bar includes 'HOME', 'WORKLOAD' (selected), 'REPORTING', 'TEMPLATES', 'NODES', 'FILE MANAGER', 'SESSIONS', and 'CONFIGURATION'. The 'Workload' section shows a 'Refresh Interval' of 15s and a 'CREATE JOB' button. A table lists jobs with columns for Job ID, Job Name, Submitter ID, Start Date, Submit Date, Queue Status, Cores, Nodes, and Wall Clock. The table contains 18 rows of job data. On the right, a search bar shows 'Current Search: 100 results returned' and a 'Narrow Search' button. Below the search bar are filters for Queue Status, Job Type, and a general selection dropdown, along with 'RESET' and 'FILTER' buttons.

Job ID	Job Name	Submitter ID	Start Date	Submit Date	Queue Status	Cores	Nodes	Wall Clock
Moab.75	sleeptestsh	centos	2020-04-15 15:47:51	2020-04-15 15:47:36	ACTIVE	11	1	00:01:00:00
20.nodus-server	Moab.74	centos	2020-04-15 11:30:29	2020-04-15 11:30:29	COMPLETED	1	0	01:00:00:00
Moab.74	sleep_job_runn...	centos	N/A	2020-04-15 11:29:05	COMPLETED	1	1	99:23:59:59
Moab.73	sleep_job_runn...	centos	2020-04-15 11:27:59	2020-04-15 11:27:45	COMPLETED	7	1	00:01:00:00
Moab.72	sleep_job_runn...	centos	N/A	2020-04-15 11:24:22	COMPLETED	11	0	99:23:59:59
Moab.71	sleep_job_runn...	centos	N/A	2020-04-15 11:13:50	COMPLETED	11	0	99:23:59:59
Moab.70	sleep_job_runn...	centos	N/A	2020-04-15 10:13:48	COMPLETED	11	0	99:23:59:59
Moab.69	sleep_job_runn...	centos	N/A	2020-04-15 10:10:21	COMPLETED	11	0	99:23:59:59
Moab.68	sleep_job_runn...	centos	2020-04-15 10:09:36	2020-04-15 10:09:22	COMPLETED	1	1	00:01:00:00
Moab.67	sleep_job_runn...	centos	N/A	2020-04-15 10:06:23	COMPLETED	12	0	99:23:59:59
19.nodus-server	job_running_2...	centos	2020-04-15 10:03:06	2020-04-15 10:03:04	COMPLETED	1	0	00:01:00:00
18.nodus-server	job_running_2...	centos	2020-04-14 15:49:28	2020-04-14 15:49:27	COMPLETED	1	0	00:01:00:00
17.nodus-server	Moab.66	centos	2020-04-14 15:33:59	2020-04-14 15:33:58	COMPLETED	1	0	01:00:00:00
Moab.66	sleep_job_runn...	centos	N/A	2020-04-14 15:32:38	COMPLETED	1	1	99:23:59:59
Moab.65	sleeptestsh	centos	2020-04-14 15:32:02	2020-04-14 15:31:47	COMPLETED	1	1	00:01:00:00
Moab.64	sleeptestsh	centos	2020-04-14 15:31:58	2020-04-14 15:31:47	COMPLETED	11	1	00:01:00:00

Appendix A: Sample Screens with Descriptions

View nodes in Viewpoint / Job submitted on Moab using on prem available node:

MoabVIEWPOINT

Welcome, centosSign Out

HOMEWORKLOADREPORTINGTEMPLATESNODESFILE MANAGERSESSIONSCONFIGURATION

Nodes

Refresh Interval15s

Node ID	Status	Cores Availab...	Jobs	Utilization CPU...	Time to Live	Operational Task
nodus-cluster-t...	IDLE	1/1	0	0/0	N/A	N/A
riazn-moab	RUNNING	1/12	1	91.67/0	N/A	N/A

Show10entries

prev1next

Current Search: 2 results returned

- Select -

Narrow Search

Filters

Select Status

Select Type

Processors0To

CPU Utilization0To

Memory Utilization0To

RESETFILTER

AdaptiveCOMPUTING

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Appendix A: Sample Screens with Descriptions

Run showq command on Moab / Shows jobs using on prem node with one in backlog waiting for node to run on:

```
[centos@riaan-moab ~]$ showq

active jobs-----
JOBID            USERNAME      STATE  PROCS   REMAINING      STARTTIME
Moab.75          centos        Running  11     00:54:52  Wed Apr 15 15:47:51
Moab.76          centos        Running   1     00:58:55  Wed Apr 15 15:51:54

2 active jobs          12 of 13 processors in use by local jobs (92.31%)
                        1 of 2 nodes active          (50.00%)

eligible jobs-----
JOBID            USERNAME      STATE  PROCS   WCLIMIT      QUEUETIME
Moab.77          centos        Idle    1       1:00:00  Wed Apr 15 15:52:55

1 eligible job

blocked jobs-----
JOBID            USERNAME      STATE  PROCS   WCLIMIT      QUEUETIME

0 blocked jobs

Total jobs:  3
```

Appendix A: Sample Screens with Descriptions

When job is waiting for resource / Use checkjob command in Moab to display why it is waiting (this example shows job can run on NODUS RM):

```
[centos@riaan-moab ~]$ checkjob Moab.80
job Moab.80

AName: sleeptest.sh
State: Idle
Creds: user:centos group:centos
WallTime: 00:00:00 of 1:00:00
SubmitTime: Wed Apr 15 16:08:16
      (Time Queued Total: 00:00:21 Eligible: 00:00:00)

TemplateSets: DEFAULT
NodeMatchPolicy: EXACTNODE
Total Requested Tasks: 1

Req[0] TaskCount: 1 Partition: ALL

Reserved Nodes: (-00:00:06 -> 00:59:54 Duration: 1:00:00)
[nodus-cluster-t2-micro-n:1]

SystemID: Moab
SystemJID: Moab.80

IWD: $HOME
SubmitDir: $HOME
Executable: $HOME/sleeptest.sh

Flags: GLOBALQUEUE, PROCSPECIFIED
StartPriority: 0
IterationJobRank: 1
Reservation 'Moab.80' (-00:00:06 -> 00:59:54 Duration: 1:00:00)
NOTE: job req cannot run in partition pbs (insufficient procs: 1 procs needed, 0 procs available)

nodus-cluster-t2-micro-node-0 available: 1 tasks supported
NOTE: job can run in partition nodus (sufficient procs: 1 procs needed, 1 procs available)
```

Appendix A: Sample Screens with Descriptions

Log into Viewpoint / Look on workload / Job showing as eligible / Backlog / Waiting for node to run on:

The screenshot displays the Moab Viewpoint Workload page. The top navigation bar includes links for HOME, WORKLOAD (selected), REPORTING, TEMPLATES, NODES, FILE MANAGER, SESSIONS, and CONFIGURATION. The user is logged in as 'centos' and can sign out. The main section is titled 'Workload' and features a 'Refresh Interval' of 15s and a 'CREATE JOB' button. A table lists various jobs with their status (ELIGIBLE, ACTIVE, COMPLETED). The right sidebar shows search results (102 results returned) and filter options for Queue Status, Job Type, and a general search bar.

Job ID	Job Name	Submitter ID	Start Date	Submit Date	Queue Status	Cores	Nodes	Wall Clock
Moab.77	sleeptest.sh	centos	N/A	2020-04-15 15:52:55	ELIGIBLE	1	0	00:01:00:00
Moab.76	sleeptest.sh	centos	2020-04-15 15:51:54	2020-04-15 15:51:35	ACTIVE	1	1	00:01:00:00
Moab.75	sleeptest.sh	centos	2020-04-15 15:47:51	2020-04-15 15:47:36	ACTIVE	11	1	00:01:00:00
20.nodus-server	Moab.74	centos	2020-04-15 11:30:29	2020-04-15 11:30:29	COMPLETED	1	0	01:00:00:00
Moab.74	sleep_job_runn...	centos	N/A	2020-04-15 11:29:05	COMPLETED	1	1	99:23:59:59
Moab.73	sleep_job_runn...	centos	2020-04-15 11:27:59	2020-04-15 11:27:45	COMPLETED	7	1	00:01:00:00
Moab.72	sleep_job_runn...	centos	N/A	2020-04-15 11:24:22	COMPLETED	11	0	99:23:59:59
Moab.71	sleep_job_runn...	centos	N/A	2020-04-15 11:13:50	COMPLETED	11	0	99:23:59:59
Moab.70	sleep_job_runn...	centos	N/A	2020-04-15 10:13:48	COMPLETED	11	0	99:23:59:59
Moab.69	sleep_job_runn...	centos	N/A	2020-04-15 10:10:21	COMPLETED	11	0	99:23:59:59
Moab.68	sleep_job_runn...	centos	2020-04-15 10:09:36	2020-04-15 10:09:22	COMPLETED	1	1	00:01:00:00
Moab.67	sleep_job_runn...	centos	N/A	2020-04-15 10:06:23	COMPLETED	12	0	99:23:59:59
19.nodus-server	job_running_2...	centos	2020-04-15 10:03:06	2020-04-15 10:03:04	COMPLETED	1	0	00:01:00:00
18.nodus-server	job_running_2...	centos	2020-04-14 15:49:28	2020-04-14 15:49:27	COMPLETED	1	0	00:01:00:00
17.nodus-server	Moab.66	centos	2020-04-14 15:33:59	2020-04-14 15:33:58	COMPLETED	1	0	01:00:00:00
Moab.66	sleep_job_runn...	centos	N/A	2020-04-14 15:32:38	COMPLETED	1	1	99:23:59:59

Appendix A: Sample Screens with Descriptions

View nodes on Viewpoint / Backlog job now running against available NODUS node:

MoabVIEWPOINT

Welcome, centosSign Out

HOMEWORKLOADREPORTINGTEMPLATESNODESFILE MANAGERSESSIONSCONFIGURATION

Nodes

Refresh Interval15s

Node ID	Status	Cores Availab...	Jobs	Utilization CPU...	Time to Live	Operational Task
nodus-cluster-t...	RUNNING	1/1	0	0/0	N/A	N/A
rian-moab	BUSY	0/12	2	100/0	N/A	N/A

Show10entries

Current Search: 2 results returned

- Select -

Narrow Search

Filters

Select Status

Select Type

Processors0To∞

CPU Utilization0To∞

Memory Utilization0To∞

RESETFILTER

AdaptiveCOMPUTING

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Appendix A: Sample Screens with Descriptions

View Workload on Viewpoint / All jobs running after backlog job given a resource to run on:

The screenshot displays the Moab Viewpoint interface. The top navigation bar includes the Moab Viewpoint logo, a user greeting 'Welcome, centos', a 'Sign Out' link, and settings icons. Below this is a secondary navigation bar with tabs for HOME, WORKLOAD (selected), REPORTING, TEMPLATES, NODES, FILE MANAGER, SESSIONS, and CONFIGURATION.

The main content area is titled 'Workload' and features a 'Refresh Interval' dropdown set to '15s' and a 'CREATE JOB' button. A search bar indicates 'Current Search: 103 results returned'. Below the search bar is a table of jobs with columns: Job ID, Job Name, Submitter ID, Start Date, Submit Date, Queue Status, Cores, Nodes, and Wall Clock.

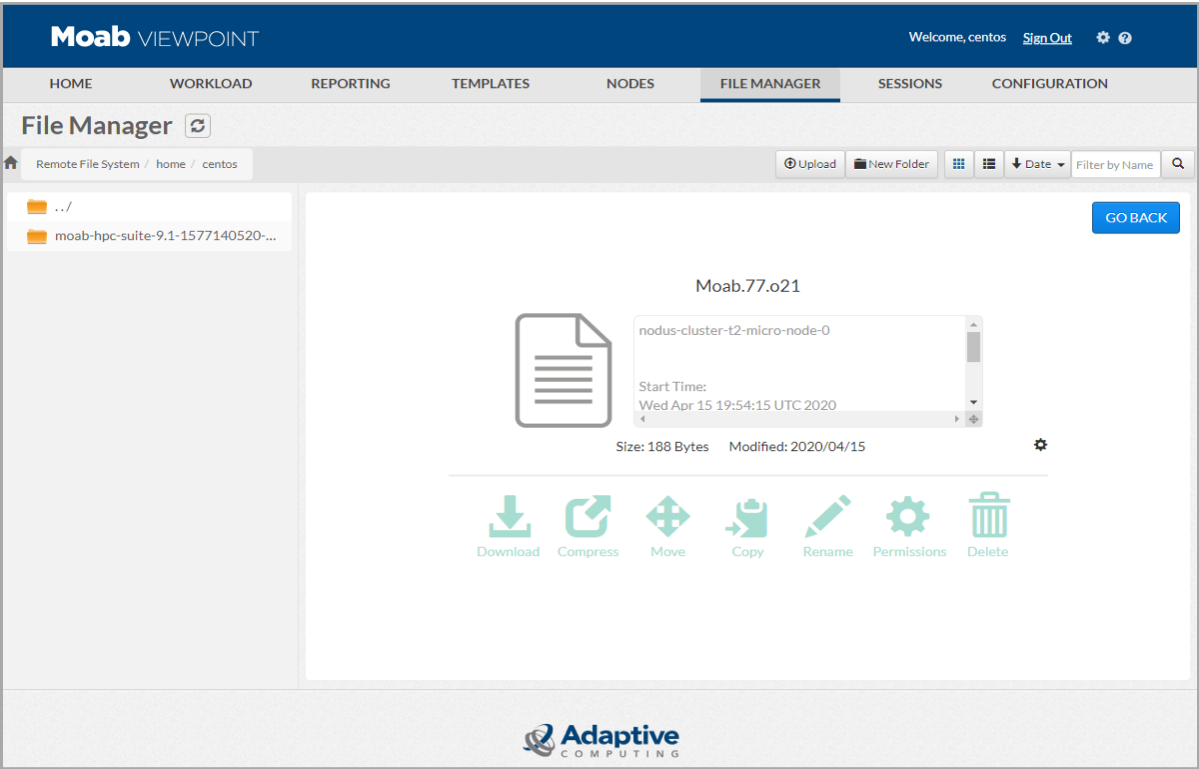
The table lists various jobs, including '21.nodus-server', 'Moab.77', 'Moab.76', 'Moab.75', '20.nodus-server', 'Moab.74', 'Moab.73', 'Moab.72', 'Moab.71', 'Moab.70', 'Moab.69', 'Moab.68', 'Moab.67', '19.nodus-server', '18.nodus-server', and '17.nodus-server'. The 'Queue Status' column shows 'ACTIVE' for some jobs and 'COMPLETED' for others.

On the right side of the table, there are filter controls. A dropdown menu shows '- Select -'. Below it is a 'Narrow Search' input field with a search icon. Further down, there are three more dropdown menus for 'Filters': '- Select Queue Status -', '- Select Job Type -', and '- Select -'. At the bottom of the filter section are 'RESET' and 'FILTER' buttons.

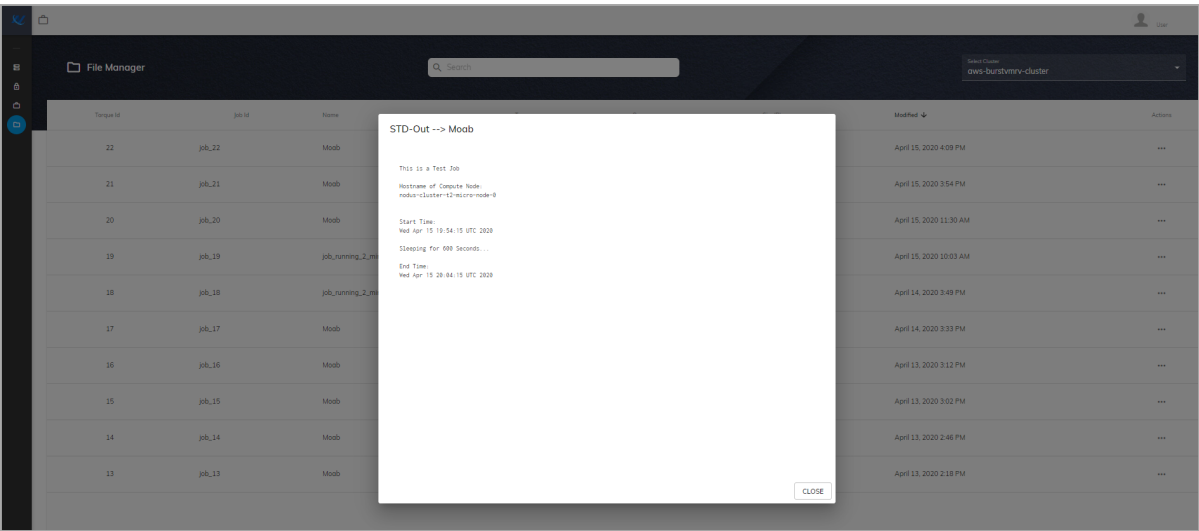
Job ID	Job Name	Submitter ID	Start Date	Submit Date	Queue Status	Cores	Nodes	Wall Clock
21.nodus-server	Moab.77	centos	2020-04-15 15:54:15	2020-04-15 15:54:14	ACTIVE	1	0	00:01:00:00
Moab.77	sleeptest.sh	centos	N/A	2020-04-15 15:52:55	COMPLETED	1	1	00:01:00:00
Moab.76	sleeptest.sh	centos	2020-04-15 15:51:54	2020-04-15 15:51:35	ACTIVE	1	1	00:01:00:00
Moab.75	sleeptest.sh	centos	2020-04-15 15:47:51	2020-04-15 15:47:36	ACTIVE	11	1	00:01:00:00
20.nodus-server	Moab.74	centos	2020-04-15 11:30:29	2020-04-15 11:30:29	COMPLETED	1	0	01:00:00:00
Moab.74	sleep_job_runn...	centos	N/A	2020-04-15 11:29:05	COMPLETED	1	1	99:23:59:59
Moab.73	sleep_job_runn...	centos	2020-04-15 11:27:59	2020-04-15 11:27:45	COMPLETED	7	1	00:01:00:00
Moab.72	sleep_job_runn...	centos	N/A	2020-04-15 11:24:22	COMPLETED	11	0	99:23:59:59
Moab.71	sleep_job_runn...	centos	N/A	2020-04-15 11:13:50	COMPLETED	11	0	99:23:59:59
Moab.70	sleep_job_runn...	centos	N/A	2020-04-15 10:13:48	COMPLETED	11	0	99:23:59:59
Moab.69	sleep_job_runn...	centos	N/A	2020-04-15 10:10:21	COMPLETED	11	0	99:23:59:59
Moab.68	sleep_job_runn...	centos	2020-04-15 10:09:36	2020-04-15 10:09:22	COMPLETED	1	1	00:01:00:00
Moab.67	sleep_job_runn...	centos	N/A	2020-04-15 10:06:23	COMPLETED	12	0	99:23:59:59
19.nodus-server	job_running_2...	centos	2020-04-15 10:03:06	2020-04-15 10:03:04	COMPLETED	1	0	00:01:00:00
18.nodus-server	job_running_2...	centos	2020-04-14 15:49:28	2020-04-14 15:49:27	COMPLETED	1	0	00:01:00:00
17.nodus-server	Moab.66	centos	2020-04-14 15:33:59	2020-04-14 15:33:58	COMPLETED	1	0	01:00:00:00

Appendix A: Sample Screens with Descriptions

View File Manager on Viewpoint / Job output run either on Moab or NODUS are available on Moab:



Log in to NODUS / View File Manager / Output available for jobs run from NODUS directly:



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.

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